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ABSTRACT

This paper reviews studies that have attempted to measure the impact on farmer knowledge, technology adoption, productivity and profits of public sector investments in agricultural extension programs. Forty-seven studies undertaken in 17 countries plus one international study covering 24 developing countries are reviewed. A number of these studies appeared to be subject to substantial bias because extension measures were endogenous to farmer behavior, i.e., extension contacts were chosen by farmers. Most studies measured positive impacts of extension. Those estimates least subject to bias, i.e., where extension variables were measured as services supplied to a region, were most consistent in showing impact. Only ten studies report estimated returns to investment in extension. These did report relatively high rates of return and demonstrated that agricultural extension in a number of countries has been a high pay-off public investment.

The Economic Impact of Agricultural Extension: A Review

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The history of economic development shows that few countries have achieved sustained economic growth without first, or simultaneously, developing their agricultural sector.[1] In most developing countries, agriculture is the most important economic activity providing income, employment, and foreign exchange. Without an efficient agricultural sector, a country is severely constrained in its ability to feed itself or import foreign products for domestic consumption and development.

Rapid technological advances in agriculture have occurred since World War II. These advances have induced great changes in agricultural production and also highlighted the importance of a rapid and efficient transfer of advanced knowledge to the farmer. Effective agricultural extension can bridge the gap between discoveries in the laboratory and changes in the individual farmer's fields. In addition to information about cropping techniques, optimal input use, high yield varieties, and prices, extension agents also inform farmers about improved record keeping, thus facilitating a shift to more efficient methods of production. By accelerating the diffusion process of improved technology, extension brings about a faster growth of yields and rural incomes.

Agricultural extension services not only convey information from research centers to farmers, but also can facilitate a reverse flow of information as well. In many countries extension services function as farmer organizations, expressing farmer concerns to the public agencies designed to serve farmers. Extension programs are also education programs. Even in situations where little new technology is available to farmers, extension programs can aid in the development of managerial skills.

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Extension services may be provided by private firms (supplying inputs to farmers and purchasing their products) or by public sector agencies. The case for public sector investment in extension has long been recognized in most countries. The argument is based on the public good nature of many aspects of agricultural knowledge.

The potential scope for a pay-off to investment in public sector extension will depend on the effective "gap" between current farm productivity and the potential productivity given the existing "best technology" and "best management" for farms in a particular region. Effective agricultural extension can close both the technology and management gaps. As these gaps are reduced, the marginal returns to extension are diminished. If further research generates new technology, or changes in market conditions require adjustments in farmers' operations, the market and technology changes provide a role for continuing extension.

The definition of the roles and responsibilities of agricultural extension agents have changed over time. After World War II, most developing countries established formal agricultural extension programs. In most of these programs, agricultural extension agents not only had educational duties, but frequently supplied inputs and credit as well. Many extension systems were built with insufficient attention to the skill level of field agents. In some systems, the bulk of the field staff had little scientific or technical training and virtually no farm experience. Budgetary instability often meant that field staff received little logistic and transportation support. By the mid-1970s many agricultural extension observers recognized that program effectiveness was hampered by these skill and support problems.

During the late 1970s the World Bank encouraged a restructuring of traditional agricultural extension practices. In an effort to make these systems more effective, the training and visit (T&V) system was established. At present more then 40 countries have adopted this approach.

Under the T&V system, agents meet with selected "contact" farmers or farmer groups and follow a regular schedule for visits. The agents also meet with their colleagues and supervisors at the regional level to discuss problems and their solutions. The system requires agents to have two primary duties: first, to transfer agricultural information and second to report farmers' problems. Management education is a secondary objective. The T&V system also provides for better communications between research and extension.

From 1965 to 1986 the World Bank funded 460 projects that involved agricultural extension in 79 countries. The Bank's lending to extension aspects of the projects totaled $1.8 billion dollars. While large, this figure represents only 4.5% of total World Bank lending to agriculture and rural development projects. Nevertheless, Bank lending did account for approximately 20 percent of the total support for agricultural extension in developing countries in 1985.[2]

Table 1 summarizes comparative data concerning extension and research spending as a percent of agricultural product for groups of countries covering the years 1959, 1970 and 1980.[3] It also shows expenditures per scientist year and per extension worker. The table shows that low income countries were spending approximately twice as much on extension as research (as a percent of the value of agricultural product) in 1959. By 1980, most developing countries were spending as much on extension as on research. The table also indicates that extension staff were, and remain, low cost relative to scientists in the lower income countries. Developing countries appear to have seen higher investment opportunities in research than in extension over this period.[4]

Table 1

Research and Extension Expenditures as a Percent of the Value of Agricultural Product

Country Group	Public Sector Ag. Research Expenditures			Public Sector Ag Extension Expenditures		
	1959	1970	1980	1959	1970	1980
Low Income Developing	.15	.27	.50	.30	.43	.44
Middle Income Developing	.29	.57	.81	.60	1.01	.92
Semi-Industrial	.29	.54	.73	.29	.51	.59
Industrialized	.68	1.37	1.5	.38	.57	.62
Planned	.33	.73	.66	-	-	-
Planned Excl. China	.45	.75	.73	.29	.33	.36

Research and Extension Expenditures Per Worker

(,000 Constant 1980 dollars)

Country Group	Research Expenditures Per Scientist Year			Extension Expenditures Per Extension Worker		
	1959	1970	1980	1959	1970	1980
Low Income Developing	34	40	47	2	2	2
Middle Income Developing	42	44	47	7	7	6
Semi-Industrial	41	45	46	10	10	11
Industrialized	55	80	93	16	25	29
Planned	33	32	31	-	-	-
Planned Excl. China	31	25	30	13	13	14

While worldwide investment in agricultural extension is quite substantial, there has been a relatively small body of thorough economic research of extension impact until fairly recently. Very few studies of agricultural extension impact on farm productivity, technology adoption, and farmer knowledge had been done prior to 1970. Several studies were undertaken in the 1970s and a few more in the 1980s. The purpose of this paper is to review and summarize these studies.

The review is organized in four parts. Part I discusses methodological problems of measuring extension impact. Part II summarizes studies that measured the relationship between extension programs and knowledge, and adoption of particular technologies. Part III reviews studies that have sought to estimate the relationship between extension programs, farm productivity, input demand and farm profits. Part IV summarizes the computed returns to extension reported in the studies reviewed earlier, and the last part presents conclusions.[5]

Part I

Methodological Issues in Extension Impact Measurement

The sequence of extension impact can be described generally as follows: first, extension information must be communicated. Second, a process of knowledge formation or observations of the experiments made by other farmers usually leads to farmer experimentation. If the innovation appears to be productive and relevant to the needs of the particular farmer, gradual adoption of the new practice may take place. With the adoption of improved technology, complementary changes in other input levels may take place. Output and profits will be expected to increase.

Correspondingly, the studies under review in this paper sought to measure the impact of public agricultural extension programs activities in the following four areas: 1) farmer knowledge, technology and farm practices; 2) adoption or use of technology and practices; 3) farm productivity and efficiency and; 4) farm output supply and factor demand.

Ideally, extension impact should be estimated in a framework resembling a simulated experiment. However, it is difficult to find situations where an actual experiment has been undertaken. Consequently, the approach commonly used is a statistical analysis relying on data measuring extension activities at the farm level. Alternatively, the statistical analysis can be undertaken where observations refer to aggregate extension services supplied to a given region in a specific time period. There are potential biases in the estimation of extension's effect on production depending on the level of analysis.

Farm level studies can be subject to two serious estimation problems: farmer self-selection and indirect information flows. The aggregate level approach is also potentially subject to estimation problems because of its residual nature. However, the aggregate approach has provided the bulk of the extension impact estimates of reasonable reliability.

An experimental design approach requires data collected before and after an extension investment is initiated, both for the area where the investment is made and for an identical area where no investment is made, as indicated in the matrix below.[6] In reality, few projects are designed so that an identical "control" area is available, and typically "before project" data sets cannot be obtained. Only one study of extension impact following an experimental approach has been undertaken.[7] Normally, the lack of perfect data forces various compromises and approximations.

Matrix for Experimental Approach

	Before Investment	After Investment
Without Investment	The situation before the time the investment is introduced in an area identical to that where the project is planned.	The situation after the investment has been introduced in an area identical to that where the investment was undertaken.
With Investment	The situation in the area where the investment is planned before it is undertaken.	The situation in the area of the investment after it has been implemented.

Studies assessing extension impact at the individual farm level that utilize a farm level measure of extension may be affected by two basic estimation problems. The first is the problem of farmer self-selection. A researcher seeking to measure the impact of agricultural extension by identifying the extension variable as some form of extension contact typically treats the extension variable as exogenous. However, it is likely that one of the characteristics of more productive farmers is the desire to acquire information about changing farm conditions or new technologies. Such farmers may be inclined to attend more demonstration days, read more literature, and seek out extension contact. Analogously, extension agents themselves may also seek out contacts with better farmers.

In such a case, the extension contact variable is endogenous, and the estimates of extension impact on farmers' performance are likely to be biased upward, as some of the better performance attributed to extension would in fact be the result of the self-selection in the group which tends to interact with extension (or by extension agents themselves. The problem of self-selection can, in principle, be handled econometrically, but this has rarely been done.

The second source of potential bias is the problem of indirect or secondary information flows where knowledge which originates from extension contacts is passed on to other farmers who do not directly interact with extension personnel. The extent of inter-farmer communications is substantial, as demonstrated in Table 2, which documents farmer's main sources of information.

It is clearly shown that most farmers in areas receiving extension services report that other farmers are their main source of information. Except for the contact farmers in an Indian T&V extension area who were singled out for extension contact by the nature of the program, direct contact with extension personnel is not the major source of information. In the extreme case, information may be diffused instantaneously (to other farmers) from farmers who were informed by extension agents. In such a case, there may be no difference in performance between farmers interacting directly with extension and other farmers, and an estimate of extension impact based on individual extension contacts would erroneously indicate zero extension effect. Generally the presence of inter-farmer communications tends to cause an understatement of extension effects when the approach of defining extension impact by the number of direct contacts is used.

The problems highlighted above can be effectively solved, or at least

Table 2

Relative Importance of Sources of Agricultural Information (%)

Main or Most Influential Information Source	Tiawan[1]		Paraguay[2]	India[3]		
	Shangfung	Liupao		Non T&V	T&V Area: Contact Farmers	T&V Area: Non Contact Farmers
Other Farmers	51.2	49.7	41	46	22	46
Extension Personnel	35.6	24.4	21	2	44	13
Media	4.7	3.5	8	23	16	20
Research Centers/Personnel	—	—	1	0	2	2

1 Herbert Lionberger and H.C. Chang. [1970] Farm Information for Modernizing Agriculture: The Tiawan System. New York: Praeger Publishers. pp. 282-283.

2 Robert Evenson. [1988] "Estimated Economic Consequences of PIDAP I and PIDAP II Programs for Crop Production." Yale University Growth Center. Unpublished Paper.

3 Gershon Feder, Slade, R. and Sundaram, A. [1986] "The Training and Visit Extension System: An Analysis of Operations and Effects." Agricultural Administration. Vol. 21. p.48.

reduced in severity, when the extension variable is specified at a village or area level. This varible is then exogenous to individual households and internalizes the inter-farmer communications. However, our review of empirical studies suggests that many of the farm level studies may be affected by the estimation problems cited above, and it is thus not clear in which direction the results may be biased.

Studies in which the extension variable is defined as an aggregate over a community or a region could be subject to misinterpretation if the allocation of extension supply is influenced by unobservable characteristics of the area. This causes a confounding of the extension effect with other relevant factors. For example, if authorities tend to direct extension efforts to more fertile or better irrigated areas, attribution of productivity superiority to extension would be wrong unless the other factors distinguishing the areas are accounted for in the analysis.

Functional forms and econometric procedures in extension impact studies differ according to the performance indicator selected for the study. Studies of knowledge and adoption of technology (and practices) generally utilize a dichotomous dependent variable method - a probit or a logit analysis. Studies of input use, output supply, and productivity impact have generally employed a linear regression including one or more extension variables, although tobit equation were utilized occasionally. Several studies have used a productivity decomposition approach which entails two stages. In the first stage, a total factor productivity index is computed, normally using a Divisia type index. In the second stage the total factor productivity indexes are regressed on extension and other variables. The total factor productivity index is a measure of production efficiency. The purpose of the measure is to account for growth and efficiency. In contrast to the production function, the calculation allows the production parameters to differ for every data observation.[8]

"Duality-based" systems of output supply and factor demand estimates are of recent origin and may utilize flexible functional forms in which extension variables are incorporated in each equation in the system.

Because the total factor productivity is the "residual" of the difference between the change in outputs minus the change in inputs, it will have substantial measurement and other errors. Care must be taken to define the variables under consideration accurately and to include all relevant factors of production. When infrastructural or technology variables are regressed using total factor productivity as the dependent variable, it is important that the variables be consistent with timing and locational relationships between the units measuring the dependent and the independent variables.

It is worth noting that the interpretations of extension impact differ significantly between the production function, output supply, productivity decomposition, and the duality approaches. Consider the aggregate production function (1) including an extension variable:

(1) $\ln(Y) = a + b \ln(X_1) + c \ln(X_2) + d \ln(Ext)$

In this expression, d measures the impact on output holding the levels of inputs (X_1 and X_2) constant.

(2) $\ln(Y) = a + b \ln P_1 + c \ln P_2 + d \ln(Ext)$

In expression (2) the function estimated is a supply function rather than a production function. Input levels are not being held constant, and since the effect of price changes or input use is accounted for through the price variables P_1 and P_2, the parameter of the extension variable measures both the direct impact on output through improved technology, and the indirect impact through increased input use.

The productivity decomposition equation is:

(3) $\ln(Y) - S1 \ln(X_1) - S2 \ln(X_2) = a' + b' \ln(Ext)$

In this expression the impact is measured on output per unit of composite input. Thus, input levels are not held constant.

The duality based system entails estimating the following system:

(4) $Y = F_y(P_y, P_{x1}, X_2, Ext)$

$X_1 = F_{x1}, (P_y, P_{x1}, X_2, Ext)$

where X_2 is a fixed factor of production. The extension impact on output supply (Y) and on the demand for (X_1), hence on variable productivity, is estimated holding constant the level of fixed factor X_2. However, the full extension impact may include an impact on the level of the fixed factor.

Part II

Extension Impact on Knowledge and on Adoption of Technology and Management Practices.

An obvious starting point in the evaluation of extension impact is to determine whether farmers with access to extension services have a greater knowledge of improved agricultural practices. Unfortunately, it is typically difficult to measure the impact of agricultural extension on the knowledge level of certain practices, and few studies have done so. Nevertheless, the study of extension impact on knowledge has an advantage over adoption impact studies because adoption is dependent in part on transitory factors (e.g., shortage of certain complementary supplies, credit, prices) which may vary systematically across locations, and which may bias estimates of extension effects. Knowledge acquisition is not hindered by such problems and may therefore be a better measure of extension effectiveness. While many studies of technology adoption and diffusion have been undertaken, relatively few have specifically sought to measure the impact of extension on adoption. This section reviews the results of two studies of knowledge acquisition and 10 studies of agricultural technology adoption.

The knowledge studies reported in Tables 3 and 4 were conducted in India. Rates of change (in the percent of farmers knowledgeable about specific practices between 1978 and 1982) were compared for non-contact farmers in a district with a T&V program (i.e., heavy investment in extension) and for all sample farms in a nearby district which did not have a T&V program, (i.e., it had a less intensive extension operation). The T&V program was introduced in 1979. It is important to note that the non T&V district was comparable in most respects to the T&V district, yet it was separated by a large river, and the data indicate no significant communications between farmers across the districts. Two alternative measures of the rate of change in knowledge were

Table 3

Knowledge of HYV Paddy Practices amongst Non-contact farmers in Karnal (T&V) and all farmers in Muzaffarnagar districts. [1]

Practice	T&V District (high extension) % Knowledgeable N=138		Non T&V District (low extension) % Knowledgeable N=56		Higher Diffusion Path for T&V District	
	1978	1982	1978	1982	Logistic	Negative Exp
1 Best Spacing	58	81	46	75		*
2. Number of Seedlings per station	54	97	38	67	*	*
3. Chemical Treatment of Seed	23	29	0	2		
4. Utility of Weedicids	19	38	5	14		*
5. Salt Treatment of Seeds	12	14	34	48		
6. Method of Nitrogen Application	62	78	45	73		
7. Utility of Pesticides	22	41	9	13	*	*
8. Utility of Phosphate	51	73	34	61		*
9. Utility of Potash	14	24	16	21	*	*
10. Utility of Zinc Sulphate	49	75	32	61		*

1 Gershon Feder and Slade, R. "Comparative Analysis of Some Aspects of the Training and Visit System of Agricultural Extension in India." The Journal of Development Studies. Vol. 22. No. 2. January 1986. p.422. Two estimates are made for the knowledge diffusion paths, logistic and negative exponential.

Table 4

Knowledge of HYV Wheat Practices amongst Non-contact farmers in Karnal (T&V) and all farmers in Muzaffarnagar districts. [1]

Practice	T&V District (high extension) % Knowledgeable N=166		Non T&V District (low extension) % Knowledgeable N=92		Higher Diffusion Path for T&V District	
	1978	1982	1978	1982	Logistic	Negative Exp
1. Varieties of Late Sowing	63	94	84	95	*	*
2. Seeding Rate Late Sown Varieties	28	47	89	100	n.a	n.a.
3. Seeding Rate Normally Sown Varieties	55	87	28	30	*	*
4. Correct Spacing	42	71	77	80	*	*
5. Chemical Treatment Against Fungi	2	10	10	14	*	*
6. Chemical Treatment Against Termites	3	13	8	9	*	*
7. Method of Nitrogen Application	46	82	66	71	*	*
8. Utility of Phosphate	56	97	78	87	*	*
9. Utility of Potash	50	72	59	56	*	*
10.Utility of Zinc Sulphate	31	60	2	5	*	*

1 Gershon Feder and Slade, R. "Comparative Analysis of Some Aspects of the Training and Visit System of Agricultural Extension in India." The Journal of Development Studies. Vol. 22. No. 2. January 1986. p.423 Two estimates are made for the knowledge diffusion paths, logistic and negative exponential.

computed. For paddy producers, the non-contact farmers in the T&V district increased their knowledge more rapidly than the non-T&V farms in 7 out of 10 practices. For wheat producers, knowledge increase was more rapid for the T&V farmers in 9 of 10 practices.

In another study of extension impact on knowledge in northwest India, Feder and Slade (1984) utilized a logit technique to estimate whether farmers in villages supplied with extension services had higher levels of knowledge of two improved practices than in villages not visited by extension. The study thus avoided the problems of endogeneity of the extension variable. The results indicated a significant extension impact on knowledge of one practice (utilization of a trace element) and a positive but only marginally significant effect on the knowledge of another practice (seed treatment).[9]

The impact of agricultural extension on the adoption of technology, or a package of technologies, has been the subject of a number of studies. Typically, the analysis of adoption accounts for a variety of factors which affect farmer's behavior such as the characteristics of the technology (particularly its inherent profitability or economic superiority over an alternative technology), the characteristics of the potential adopter, and environmental or infrastructure variables.

The dependent variables in adoption studies which are based on individual farm data are typically dichotomous and are thus analyzed with logit or probit models. In both cases the coefficient of the extension variable reflects the impact of extension on the probability of adoption. In studies where the unit of observation is a community (e.g., village, district), the percentage of adopters is typically the dependent variable and, with a proper logistic transformation, extension impact can be estimated using a simple linear regression.

Most adoption studies in the economics and sociology literature do not include variables that specify extension services. The ten studies summarized in Table 5 are among the few which accounted for extension effects. Estimates of the impact of extension on adoption rates varied in statistical significance, but many of these studies confirmed the hypothesized positive impact. Most of the results reported in Table 5 were obtained utilizing a household level extension variable, which subjects the estimates to positive bias. However, four of the studies which used a properly specified exogenous extension variable indicate a significant extension impact on adoption.

Table 5: Agricultural Extension and Adoption of Technology

Study	Type	Extension Variable	Coefficient	t value	Dependent variable definition	Comments
USA Huffman (1974)	Adjustment function	Average time spent per farm by state and federal extension staff assisting farmers with grain crop production problems.	1.959	2.075	ln $[(x_t - x_{t-1})/(x_t^* - x_{t-1})$ Where x^* is demand for an optimum quantity of fertilizer per acre as a function of real factor prices and environmental variables. x is actual quantity of fertilizer used.	Extension contact positively and significantly increased the rate of adjustment to an optimal fertilizer level. Other variables included number of acres of corn per farmer, weighed index of schooling and an education-extension interaction variable.
Ethiopia Aklilu (1980)	Logistic function	Number of extension personnel in area.	.0687	6.13	log of percent of area fertilized in each project area.	The number of extension personnel significantly increases the rate at which innovations are adopted.
Thailand Jamison and Lau (1982)	Logit	Extension availability in the village.	.876	2.831	Probability of adoption of chemical inputs. Other variables included price of labor, output and chemical inputs capital, land, age, and credit.	With different specifications for different measures of education, extension was still found to affect the probibility of adopting a new technology in a positive and statistically significant manner. Its effect is between one-third and two-fifths of the effect of more than four years of formal education.

Study	Type	Extension Variable	Coefficient	t value	Dependent variable definition	Comments
USA Rahm and Huffman (1984)	see comments	Dummy variable=1 if farm operator attended meetings, field days or demonstrations sponsored by the extension service.	-.05	-.97	The absolute difference between whether the innovation was adopted and the probability of adoption determined by probit analysis.	If the absolute difference between whether the innovation was adopted and the probability of its adoption was small, the authors conclude that the decision was made efficiently. Since the extension variable reduced the absolute difference, extension enhanced the efficiency of the adoption decision. Other variables included farmer experience and poor health.
India Feder and Slade (1984)	Logit	Extension exposure dummy variable=1if the village was visited by extension.	2.037	1.95	Probability of pesticide adoption.	Extension exposure had a significant effect, increasing the probability of adoption of pesticides and weedicides and the knowledge of improved practices.
			2.486	2.37	Probability of weedicide adoption.	
Nepal Jamison and Moock (1984)	Logit	Dummy=1 for recent contact with extension agent.	.407	1.01	Probability of chemical fertilizer adoption.	In the case of chemical fertilizer,the indirect effects of extension seem to be as strong as the direct effects
	Logit	Households in Panchayat with recent extension contact. (proportion)	1.007	1.06	Probability of chemical fertilizer adoption.	

Study	Type	Extension Variable	Coefficient	t value	Dependent variable definition	Comments
Nepal Jamison and Moock (1984) cont.	Logit	Households in Panchayat with recent extension contact. (proportion)	.425	.390	Probabiltiy of wheat cultivation as of the 1977-1978 season.	
	Logit	Dummy=1 for recent contact with extension agent.	.853	1.62	Probabiltiy of wheat cultivation as of the 1977-1978 season.	
Nepal Shakya and Flinn (1985)	Probit	Extension visits per year. Farm level.	.0256	1.79	Probabiltiy of modern variety rice adoption.	Other variables included farm size, adult family labor, education, rice area irrigated and credit. Access to credit and full irrigation are are important determinants of modern variety adoption.
	Tobit	Extension visits per year. Farm level.	6.644	4.46	Probabiltiy of adoption and fertilizer use on rice.	
Peru Cotlear (1986)	Logit	Dummy variable recent contact with an extension agent. Modern region. Household level.	3.28	.39	Probability of HVY seed adoption.	Other variables included education, migration, age farm size and credit use.
			.39	1.29	Probability of recommened use, or more, of fertilizer.	
		Data from specification including farm size and credit use.	.10	.43	Probability of tractor use.	Older farmers tended to be more conservative and less likely to adopt biological and chemical inputs.
			1.98	.32	Probability of pesticide adoption.	

Study	Type	Extension Variable	Coefficient	t value	Dependent variable definition	Comments
Peru Cotlear (1986) cont.	Logit	Dummy variable recent contact with an extension agent. Intermediate region. Household level.	.31	1.58	Probability of HVY seed adoption.	
			.05	.24	Probability of recommened, use or more, of fertilizer.	
			-.22	-.81	Probability of tractor use.	
			1.55	.37	Probability of pesticide adoption.	
	Logit	Dummy variable recent contact with an extension agent. Traditional region. Household level.	.68	.52	Probability of HVY seed adoption.	
			extremely small		Probability of recommened use, or more, of fertilizer.	
			-3.66	-.40	Probability of tractor use.	
			.57	.98	Probability of pesticide adoption.	

Part III

Agricultural Extension and Farm Productivity

Once information about improved technology is acquired and adoption takes place, the end result is that input use will change and output will increase. More specifically, farm productivity, output per unit of input, will increase. This section reviews studies attempting to estimate extension impact on farm productivity or output. These studies are organized into three groups so as to facilitate an assessment of econometric validity:

1) Studies where productivity observations are individual farms and where the extension variables is also farm specific. (Table 6)

2) Studies where productivity observations are on individual farms, but extension variables are not farm specific, i.e., they measure extension services supplied to a village or region. (Table 7)

3) Studies where both productivity observations and the extension variable are on a group or aggregate of farms or regions. (Table 8)

As noted in the methodology section, the studies in the first groups may be subject to two sources of bias; from self-selection and inter-farmer communication flows. Studies in the second group could be subject to misinterpretation if unobserved (to the researchers) community or regional characteristics are correlated with the extension variable.

Since the dependent variable is a measure of productivity, the studies reviewed sought to control for factors other than extension which affect productivity either through a simulated experimental design or by including variables such as research, schooling and infrastructure. In some studies, interaction terms were included to measure the interrelations between extension and other program variables. Extension services may complement some activities, such as research, and may substitute for other factors, such as formal schooling.

Table 6: Studies with Farm Specific Extension and Productivity Variables

Study	Definition of Extension Variable	Extension Coefficient	"t" ratio	R-squared	Comments
Botswana Lever (1970)	Number of years of extension association	21.327	reported as significant	.058	Linear regression. Dep. variable is gross output. Most of the coefficients with other tests were not significant. Very low R-squared. N=786. Production function.
Japan Harker (1973)	Use of agricultural magazines, estension agents and agricultural broadcasts.	r=0.14	(p<0.001)	0.378	The author used a path analysis. The coefficient is a standardized partial correlation coefficient. Dependent variable= gross farm sales. N=971. Production function.
Kenya Moock (1973)	Factor analysis was applied to measures of extension contact. The rotated factor scores were multiplied by the standardized observations and the products summed.	.0027	.77	.642	Dependent variable= maize output in bags per acre. Further analysis provides some evidence of the greater effectiveness of group extension compared with individual extension. N= 72,88 Productivity decomposition.
Brazil Patrick and Kehrberg (1973) (Regions)	Number of direct contacts between extension agents and farmers/year. (Paracatu)	.00056	.20	.59	For all these results, the coefficientrepresents percent change in value added due to a unit change in extension. Dependent variable= In value of farm production minus value of purchased non-labor inputs. Paracatu IRR= 42 Canceiço IRR= 500+ Resende IRR=13 São Francisco IRR =350 Viçosa=115 . IRR were those reported for aver: number of contacts.
	(Conceiçao de Castelo)	.009	2.65	.82	
	(Alto Sao Francisco)	.004	.98	.44	
	(Vicosa)	.003	1.03	.62	
	(Resende)	.001	1.1	.55	

Study	Definition of Extension Variable	Extension Coefficient	"t" ratio	R-squared	Comments
Keyna Hopcraft* (1974)	Extension vists, indicator:				
	(1-3)	0.153	1.67	.56	Dependent variable = ln bags of maize produced.Other Variables included land, labor and purchased inputs. N= 674. Production function.
	(4-)	0.272	2.72		
	(>7)	0.035	0.47		
	Farmers training center course indicator				
	(1 course)	-0.014	0.12		
	(≥2 courses)	0.135	1.23		
	Demonstrations Indicator:				
	(1 or 2)	0.393	4.68		
	(≥ 3)	0.197	1.83		
Keyna Moock (1976)	ln Index of five binary indicators of extension contact- visits, courses and attendance of demonstrations.	.030	2.82	.705	The elasticity reported is for males with three years or less of schooling. The effect vanishes for men with four years or more of schooling and is not present in the case of women.Dep Variable is ln maize output/acre. Productivity decompostion.
Brazil Pachico and Ashby* (1976)	Number of direct contacts between farm operator and government extension agent.	-0.010	-2.50	.65	ln value of farm production. N= 101 Production function.
Philippines Halim* (1976)	Number of weighted extension contacts. 1963	.00663	3.44	.77	Dependent variable= ln average annual rice production; net farm earnings. N=220 Production function.
	Number of weighted extension contacts. 1968	.004	2.40	.7	
	Number of weighted extension contacts. 1973	.000	-.77	.8	

Study	Definition of Extension Variable	Extension Coefficient	"t" ratio	R-squared	Comments
Philippines Capule (1977)	Total time in hours spent by the farmer in extension contact with sales agents, farm demonstrations, Masaganan supervisors and general extension agents.	-.00038	-.573	.732	Dependent variable=ln total rice output in cavans. Another specification also showed that extension had no significant effect on output. N=438 Production function.
Malaysia Jamison and Lau (1982)	Exposure to adult agricultural extenstion classes.	.237	1.73	.69	Dependent variable = ln Paddy output in gantangs. N=403 Production function.
Nepal Pudasaini (1983) Hill region	Number of extension contacts.	.212	.986	.538	Dependent variable=ln quintals of maize produced. Negative coefficients for gross sales and value added.(neither significant) N=149. Production function.
Terai region	Number of extension contacts.	.004	.138	.857	Dep. variable=ln quintals of rice produced. Extension had no significant impact in either region N=205
Nepal Jamison and Moock (1984) Early Paddy	Dummy recent contact with extension agent.	.007	.11	.696	The reported results come from the first specification. The results of the other specifications did not differ greatly.
Late Paddy	Dummy recent contact with extension agent.	.084	1.01	.811	Dep variable= ln output in kgs. Early paddy N= 443 Late Paddy N=284 Wheat N=343
Wheat	Dummy recent contact with extension agent.	.074	1.13	.761	Production function.

Study	Definition of Extension Variable	Extension Coefficient	"t" ratio	R-squared	Comments
India Feder, Slade and Sundaram (1985)	Farmers whose main source of information was an agricultural extension agent. (As opposed to other sources or no advice)	.190	3.119	.26	Dependent variable was a log of a yield index. Farmers who receive their information from extension agents have significantly higher yields than farmers who depend on other sources. The coefficients reported reflect a sample that includes irrigated and unirrigated farms. N=1500+ Productivity decompostion. IRR ranged from high to low.
Malawi Perraton Jamison and Orivel (1985)	Number of extension visits.	313.2	3.45	.60	Dependent variable= maize production in kgs. Linear equation. 150 farmers only 22 of which were visited by extension workers.
Peru Cotlear (1986)	Dummy variable;1 if there was recect extension contact, 0 otherwise.	.07	.58	.860	Dependent variable=ln output in kgs of potatoes harvested. The results reported come from one of the four specifications.
Modern region	Dummy variable; 1 if there was any contact 3 years before the survey, 0 otherwise	-.10	-1.15		The other specifications did not differ greatly. Modern N= 254 Intermediate N=151 Traditional N=150
Intermediate region	Dummy variable;1 if there was any recent extension contact, 0 otherwise.	.27	3.14	.821	Production function.
	Dummy variable; 1 if there was any contact 3 years before the survey, 0 otherwise	.01	.16		

Study	Definition of Extension Variable	Extension Coefficient	"t" ratio	R-squared	Comments
Peru Cotlear (cont.) Traditional region	Dummy variable;1 if there was any recent extension contact, 0 otherwise.	.15	.89	.736	
	Dummy variable; 1 if there was any contact 3 years before the survey, 0 otherwise	.04	.39		

Table 7: Farm Level Productivity Variable; Non-farm specific Extension Variable

Study	Definition of Extension Variable	Extension Coefficient	"t" ratio	R-squared	Comments
Korea Hong* (1975)	In investment in extension	3.24	6.0	.85	Dep Variable= In value of rice production. N= 895. A log linear equation also showed significant results. Production function.
Thailand Jamison and Lau (1982)					
Farmers using Chemical inputs	Number of extension visits to village.	-.123	-1.53	.78	Dependent variable = In output in kgs. Negative effect may be due to extension agents pre-maturely coaxing farmers to use chemical fertilizers. N=91. Production function.
Farmers using Non-chemical Inputs	Whether extension was available to the village.	.085	2.22	.81	Dependent variable = In output in kgs. N=184. Production function.
Nepal Jamison and Moock (1984) Early Paddy	Households in panchayat with recent extension contact (proportion)	.202	.12	.696	Dependent variable=In output in kgs. The reported results come from the first specification. The results of the other specifications did not differ greatly.Early Paddy N=443. Production function.
Late Paddy	Households in panchayat with recent extension contact (proportion)	.122	.59	.811	The influence on wheat seems most powerful. The coefficient suggests tha a 10% increase in extension coverage is associated with a 4% increase in wheat output. Late Paddy N=284: wheat N=343. Production function.
Wheat	Households in panchayat with recent extension contact (proportion)	.414	2.51	.761	

Study	Definition of Extension Variable	Extension Coefficient	"t" ratio	R-squared	Comments
India Feder, Slade and Lau (1985) Wheat	Dummy variables 1=traditional extension 0=training and visit	-.0892	2.086	.94	Measurement of disembodied productivity differential. The T&V system represents a 9.33% higher output. Subtracting estimated baseline differential suggests a gain to extension from 6% to 7.2% Dependent variable= ln output. N= 365. Production function
Rice	Dummy variables 1=traditional extension 0=training and visit	-.0739	1.415	.97	The estimated disembodied productivity differential is 7.39%. N= 305. Production function
Peru Cotlear (1986)	Proportion of households in the village who have received extension contact in the last three years.	.30	.86	.860	Dependent variable= ln output in kgs of potatoes. A 10% increase in old extension coverage = a 7% increase in farmers potato output. N= 254. Production function.
Modern region	Households in village who have received extension contacts 3 years before the survey. (proportion)	.71	2.36		
Intermediate region	Proportion of households in the village who have received extension contact in the last three years.	-1.0	-.59	.821	N= 151
	Households in village who have received extension contacts 3 years before the survey. (proportion)	-3.65	-.73		

Study	Definition of Extension Variable	Extension Coefficient	"t" ratio	R-squared	Comments
Traditional region	Proportion of households in the village who have received extension contact in the last three years.	3.19	1.98	.736	The authors feel these results are too high, possibly due to the fact that there were only four villages. N= 150 Production function.
	Households in village who have received extension contact 3 years before the survey. (proportion)	2.89	2.64		
Thailand Chou and Lau (1987) Chemical Farms	Dummy 1= if extension services were available in the farmer's village.	-0.057	-1.214	Not reported	Dep. variable = ln of rice output in kgs. N= 174 Production function.
Non-chemical Farms		.006	.219		In the report the authors criticized their own measure of the extension variable, but it was the best available. N= 388
Côte d'Ivoire Deaton and Benjamin (1988) Cocoa	Dummy variable=1if a local extension agent was available. Household data.	.023	.20	.180	The availability of an extension agent showed no discernable influence on output. N= 340. Production function.
Coffee	Dummy variable =1 if a local extension agent was available. Household data.	.109	.80	.125	The dependent variable for both these studies was ln of output per hectacre of mature trees (coffee or cocoa). N= 416

Study	Definition of Extension Variable	Extension Coefficient	"t" ratio	R-squared	Comments
Paraguay Evenson [1988]	Total hours of extension worker time devoted to crop production on the crop in question per hectacre.				
Cotton		.02	sig at 5%	.292	Significant production/extension related impacts are measured for all major crops. Most farms producec all major crops. For minor crops, peanuts, sugar and tomatoes, generally produced by fewer than 16% of the farms, no significant imp: was found.
Manioc		.038	sig at 1%	.221	
Maize		.053	sig at 1%	.371	
Poroto		.027	sig at 5%	.157	

Table 8: Aggregate Farm and Extension Supply Variables

Study	Definition of Extension Variable	Extension Coefficient	"t" ratio	R-squared	Comments
India Evenson and Jha (1973)	Measure of the maturity of the extension program interacting with state and out of state research.	.0017	2.83	.587	Dependent variable was a total factor productivity index. Extension contributed significantly to agricultural productivity change only through interaction with research programs. N=285
India Evenson and Kislev (1975)	Presence of an IADP program.	14.2	5.92	.51	Dependent variable= foodgrain yield index. Additional data show that IADP complement research to increase yields, but substitute research in terms of total factor productivity. N=140 districts.
USA Huffman (1976b)	Annual average number of one-tenth man days spent on crop and livestock activities by agricultural extension agents per farm	.015	3.61	98	Dependent variable= ln gross product measured as the value of sales, home consumption, rental value of farm dwellings, govt. farm payments and net increase in farm inventories. N=276 counties.

Study	Definition of Extension Variable	Extension Coefficient	"t" ratio	R-squared	Comments
USA Evenson (1978)	Measure of extension spending per commodity per region x measure of applied research.	.406	6.21	.651	Linear model where the dep variable is a total factor productivity index measuring productivity change. Education-Extension interaction variable was negative. The Exten-ion variable alone showed no significant impact.
USA Huffman (1981)	Ln aggregate days of agricultural extension input.	.751	3.07	.978	At sample mean, the value of the estimated coefficient of extension was .051. Dependent variable=ln value of all farm products sold. N=295.
	Share of Black extension in total extension.	-.126	-2.91	.978	The coefficient represents the relative difference in the product-ivity of a unit of Black extension compared with a unit of White extension, supporting the hypothesis of discrimination against Southern Black Farmers in quality and quantity of public agriculture N=295.
Bangladesh Pray and Ahmed (1985)	Extension expenditure per district.				Research and HYV variables included. All crops Dependent Variable= ln output. Production function.
1951-1961		.042	1.4	.76	
1977-1981		.116	1.7	.85	

Study	Definition of Extension Variable	Extension Coefficient	"t" ratio	R-squared	Comments
Philippines Librero and Perez (1987)	Deflated extension expenditures for corn. 1972=100. Second stage regressions were run to attempt to explain the residuals as a function of research and extension expenditures.	.07	2.25	.204	In total volume as dependent variable using simple lag estimation. No significant impact at year 10. N=27
		.10	2.37	.212	Dependent variable= In total value of production. Simple lag estimation time =0. No significant impact at year 10. N= 27.
		.03	1.94	.131	Dependent variable=In corn yield. Simple lag method t=0. Using a different specification there was significant impact at year 10. N= 27
Thailand Setboonsarng and Evenson (1987)	Deflated extension expenditures per farm-4 regions.	.0031	sig	.782	Dependent variable= yield of Rice. Cross section study of 19 zones; 1953-1977. Research, irrigation and weather variables included. N= 474. T extension variable interacted negatively with national research and positivel with irrigation.
Brazil Avila, Cruz and Evension (1987)	Deflated Extension expenditures per farm.	-.0000089	not sig.	.45	Time series census data for 1970, 1975, 1980. Recorded at the municipal level. Net extension elasticity = .003 Regional estimates showed no extension impact in center West. Estimates here are for all Brazil. N=11627. Positive interactio with private sector research and negative interactionwith field crop research.

Study	Definition of Extension Variable	Extension Coefficient	"t" ratio	R-squared	Comments
24 Countries Evenson (1987)	Extension expenditure per geo-climate region.				
<u>Cereal Crops</u>					This study used international data from 8 African, 8 Latin American and 8 Asian countries. The major purpose was to measure international agricultural research systems and national research system's impacts on cereal extension. Research interaction was generally positive. Dependent variable= Yield, area and area change. N=640 in each study. Grains included rice, wheat, corn, sorghum and millets. Staples included cassava, potatoes, groundnuts, beans sweet potatoes. For cereal crops, Latin American extension and international research. African extension interacted negatively with national research, but positively with international research. Asian research interacted negatively with national research and positively with international research.
Latin America		.0745	sig at 1%	.99	
Africa		.0128	sig at 10%	.94	
Asia		.1921	sig at 1%	.98	
<u>Staple Crops</u>					
Latin America		-.024	sig at 1%	.98	
Africa		.1198	sig at 1%	.94	
Asia		.0685	not sig	.98	

Table 6 summarizes 15 studies where both productivity and extension variables are at the farm level. In these studies the extension measure is typically some form of contact by the farmer with an extension agent or program. It should be noted that if these contacts have been initiated by the extension agents, then the problem of self-selection bias may not be serious, but one should be careful to establish whether extension agents' initiative is random or systematically related to unobserved farmer-characteristics. The latter case would be a source of bias.

Most studies are based on a single cross-section sample observed in a relatively small region. If a "t" ratio of 1.67 or more is viewed as a cutoff for statistical significance, this set of studies does not provide overwhelming evidence of extension impact. Of the 35 coefficients reported in the 15 studies, only 9 meet this test of significance, although most coefficients are positive. However, the coefficients may be subject to upward or downward bias due to problems highlighted above, and the tests may not be valid.

Table 7 summarizes studies where the productivity observation was an individual farm, but the extension variable was not farm specific. Rather, it was a village specific (or some other area) measure of services supplied or available to farms. Only one study, Evenson (1988), utilized a continuous measure of extension services supplied.[10] The other studies represented extension supply in a dichotomous manner. Of the eight studies in Table 7, several report separate estimates for different regions and crops. Six of the studies report a significant impact of extension, although not for all regions or crops. Two (Chou and Lau [1987] and Deaton and Benjamin [1988]) report non-significant results.

In the Peru study, Cotlear [1986] found extension impact in the modern and traditional regions, but not in the intermediate region. An impact was measured for farms not using chemical inputs, but not for farmers in the chemical using sample in Thailand in Jamison and Lau [1982]. In the Paraguay study, Evenson [1988] found impacts for major crops, but not for minor crops (due partly to sample size).

The Feder-Slade study for India differs from the other studies in this set by relying on a combination of a cross-section reflecting the situation several years after T&V extension was introduced in one area but not in another, and an average productvity differential between the two areas before any extension changes. The estimates are thus based on a change in productivity with and without increased extension over time.

Table 8 summarizes 10 studies where productivity is measured at the aggregate level - usually at the district, county or state level. Extension measures for these studies are extension supply per unit of area, per farm or per region. Since these studies cover relatively large regions, and since most are cross-section or time series studies, it cannot be presumed that technology availability is constant for all observations. In addition, regarding studies across regions, it is not always clear whether the allocation of extension supply is random in a way which does not cause bias. Many of these studies include research variables and, in some cases, schooling and infrastructure variables in a general productivity decomposition specification. The primary concern in these studies is to identify the impacts on productivity of all program variables, and most have focused primarily on the research variables rather than on the extension variables. A number of these studies utilized interaction variables between extension and research or education. These studies show a consistent pattern of positive and significant extension impacts, except for Avila, DaCruz and Evenson [1987]. The Evenson [1987] study is unique in utilizing international (cross-country) data.

Conclusions can be made concerning extension interaction with research and schooling. In general, studies where interaction with schooling is incorporated show a negative relation. The productivity impact of agricultural extension appears to be highest in low education settings. Several of the farm level studies also suggest that extension is more effective in low infrastructure-low school settings.

The evidence on interactions with research is mixed. In Brazil, extension interacted positively with private research and perennial crop research, but negatively with field crop research. In the international study interactions were generally positive in the cereal grains but not for the staple crops.

In recent years, cost and production problems in agriculture have increasingly been analyzed utilizing the profits function based system of output supply and factor demand equations. Typically these studies have a short time horizon because they treat the land base (including irrigation and buildings) of the farm as fixed. From a conceptual perspective, these methods are best suited to farm level data. However, since the price variation required to identify these models is generally inadequate in cross-section farm level data sets, the studies of factor demand and output supply have had limited success in farm level data sets.

Cross-section time series data sets generally do provide the price variation for estimation of such systems. However, for these data sets, it is difficult to argue that technology availability is constant across observations. Therefore, researchers introduce variables to control for the impacts of research, extension, schooling, and infrastructure.

Table 9 summarizes the extension impact estimates based on four studies that utilize this methodology. For comparative purposes, research impacts are also summarized. In each study research and extension variables were included

Table 9: Studies of Extension Impacts on Output Supply Variable Factor Demand and Variable Farm Profits

(Elasticities)

Estimated Impact on Output Supply	North India[1]	Brazil[2]	Philippines[3]	Thailand[4]	Thailand[5]
Rice	.332*			.011	
Wheat	-.315*				
Corn-Sorghum	.862*	.022		.487	
Other Crops	.326	.082		.631	
Livestock		.077			
Total	.145	.050	.095	.409	
Impact on Factor Demand					
Labor	.142*	.020	.157	-.041	
Machinery	-1.18*	.016	.347	.425	
Fertilizer	-1.56*	.133	.217	.292	
Animal Power	.253*		-.016		
All Factors	.012	.036	.079	.211	
Impact on Profits	.133	.014	.016	.198	-.252 .174

1 R.E. Evenson, " Ressearch, HYV's, Output Supply and Variable Factor Productivity in North Indian Agriculture", in Research, Productivity and Incomes in Asian Agriculture. Ch 7. R.E. Evenson , Carl Pray and Jaime B. Quizon, eds. Draft 1987. Cornell Univ. Press (forthcoming 1989).

2 R.E. Evenson, Elmar R. daCruz, and A. Flavio Dias Avila, "Brazilian Agricultural Research: New Results from Census Data". Economic Growth Center. Yale University. Winter 1988.

3 R.E. Evenson and Jaime B Quizon, "Infrastructural Techonology and Output Supply in Philippine Agriculture". in Research, Productivity and Incomes in Asian Agriculture. Ch 8. R.E. Evenson , Carl Pray and Jaime B. Quizon, eds. Draft 1987. Cornell Univ. Press (forthcoming 1989).

4 R.E. Evenson and Suthad Sotboonsarng. "Infrastructure, Output Supply and Factor Demand in Thailand's Agriculture." in Research, Productivity and Incomes in Asian Agriculture. Ch 9. R.E. Evenson , Carl Pray and Jaime B. Quizon, eds. Draft 1987. Cornell Univ. Press (forthcoming 1989).

5 D. Jamison and L. Lau. Farmer Education and Farm Efficiency. Johns Hopkins Univ Press. (1982) p. 179. A positive effect was found for Non-chemical farms and a negative effect for farms where the farmer used chemical inputs.

in each equation in the system. For example, in the North India study based on district level data, each of the four variable input equations (rice, wheat, coarse cereals, and other crops) and each of the four variable input equations (labor, machinery, animal power, and chemicals) include extension variables. Thus one can compute the impact of a change in extension on each output and on total variable inputs, holding prices and fixed factors constant. With this information it is possible to compute the extension impact on variable farm profits. This impact is not the same as the impact on productivity summarized in Table 8 because these studies do not allow for an extension impact on the fixed factors.

Each of these studies reports positive impacts for both research and extension on farm profits. Given the nature of the studies, the results should be considered with more than the usual caution. All four studies showed that extension stimulated both more inputs and more outputs. The profit impacts in the North India and the Thailand studies are quite high. The impacts in Brazil and the Philippines are relatively low. Each study included research variables and the estimated effects of the research variables are often in a direction opposite from that reported for extension. This was particularly true in North India where research and high yielding varieties increased the demand for fertilizer and farm machines. The extension estimates suggest that extension plays a role of blunting and moderating the impact of technology.

PART IV

Economic Returns to Agricultural Extension

Several of the studies reviewed above indicated that extension significantly increases agricultural productivity. But for policy purposes, this information is not sufficient as the cost of extension needs to be compared to the benefits, and the return to extension education needs to be ranked relative to other public investments. Only eight of the studies reviewed in this paper undertook a calculation of net returns to extension. These studies pertain to four specific countries, and one study utilized cross-country data to calculate returns at a multi-country (regional) level (Table 10).

Aside from the problems related to the attribution of productivity effects to extension, an analysis of costs and benefits faces additional difficulties because the benefits and costs accrue over time. Given that the productivity impact which provides the basis for calculating the gross benefits is typically estimated at a point in time, the researcher is often obliged to assume a certain simple distribution of benefits over time. This is done by extrapolating from the static impact parameter which is estimated econometrically. With all the qualifications borne in mind, the results are still of much interest to policy-makers and development planners because scarce public investment funds can be used for various other infrastructure investments servicing agriculture or other sectors.

Only one developed country (U.S.A.) has been the subject of an extension cost-benefit analysis, indicating very high returns (100 percent or more). At a more detailed level, it is apparent that returns differ when extension investment is differentiated by crops. For example, a cross-country study (Evenson, 1987) indicates that in Latin America returns to extension efforts in cereals are high, while they are low for staple crops.

Table 10: RATES OF RETURN TO INVESTMENT IN EXTENSION

Study	Type of Study	Rate of Return (%)
BRAZIL		
Patrick & Kehrberg (1973)	Farm level with farmer specific extension variable	
Region:		
Paracatu		42
Conceieo de Castelo		500+
Resende		13
Francisco		350
Vicosa		115
INDIA		
Feder, Lau & Slade (1987)	Farm level with regional extension variable	More than 15 with 90 percent probability
INDIA		
Evenson & Jha (1973)	Aggregate	14
INDIA		
Evenson & Kislev (1975)	Aggregate	15
PARAGUAY		
Evenson (1988)	Farm level with aggregate extension variable	75-90
U.S.A.		
Huffman (1976b)	Aggregate	110
U.S.A.		
Evenson (1978)	Aggregate	100+
U.S.A.		
Huffman (1981)	Aggregate	110
INTERNATIONAL		
Evenson (1987)	Aggregate	
Cereals:		
Latin America		80+
Africa		34
Asia		80+
Staple crops		
Latin America		Negative
Africa		80+
Asia		80+

Rates of return in most of developing countries included in the review were much higher than standard cut-off points for viable investments: 75-90 percent in Paraguay, 13-500+ in Brazil, and 34-80+ in a group of countries in Asia, Africa, and Latin America which were included in a cross-country international study (except for the case of staple crops in Latin America mentioned above). Of the three studies covering India, the two pertaining to earlier decades report a net return of 14-15 percent, while a study based on data from the period 1978-1983 suggests that the return in one area in Northwest India was higher than 15 percent with 90 percent probability. This latter statement introduces an important issue in interpreting the numerical significance of the reported rates of return. As noted above, the calculation of the rate of return relies on an estimated parameter of output or productivity impact. Since there is a 50 percent probability that it is smaller, the same conditional statement applies to the reported rate of return. The proper interpretation of the calculated rate of return is thus of a statistical mean. However, policymakers are often more concerned with the downside risk of large public investments, and information about the likelihood of the net returns to exceed some satisfactory benchmark is of much value to them. The study of returns to extension in North India reported by Feder, Lau and Slade thus indicates a high probability of the return exceeding 15 percent, while the return based on the point-estimate of extension impact on productivity (which is comparable to the notion of return used by the other studies reviewed) would be much higher, in excess of 100 percent.

PART V

Summary and Conclusions

This review covered studies addressing several aspects of extension impacts. Two studies examined the effect on knowledge diffusion, eight dealt with impact on adoption of improved technology, fifteen farm level studies analyzed productivity impact with extension defined as a farm level variable while eight studies utilized an exogenous extension variable, ten productivity studies used aggregate output and extension variables and five studies focused on the extension impact on farmers' profits (Table 11). Some may perceive this as a significant body of literature. However, given that an extension organization exists in almost every country, and in view of the large volumes of public funds directed to extension, there is scope for much more empirical work on this issue. This conclusion is reinforced when it is observed that many of the studies reviewed in the preceding sections focus on the same countries (only 17 different countries were represented). Furthermore, many of the results may be subject to econometric deficiencies.

The majority of the studies (thirty-three of the forty-seven reviewed) show, at least for some of the versions presented, a significant and positive extension effect. However, there is some variability in the results such that within a given study some of the areas or some of the crops studied seem to be significantly affected by extension while others are not. It would have been of much value to know the reasons for the lack of extension impact in these instances, but such analysis is typically not provided. Some hypothetical explanations can be offered (e.g., lack of relevant technology to be diffused, a temporarily depressed agricultural economy, or ineffective extension activities) but in the absence of an empirical discussion these are not of much practical value.

Table 11

Summary of Impact Estimates

Type	No. of Studies reviewed	No. Showing Positive Impacts	No. of Estimates: Positive and Significant	No. of Estimates: Positive Non-significant	No. of Estimates: Negative
Knowledge	2	2	22	1	8
Adoption	8	5	7	13	3
Productivity Impact					
a. Farm Level Prod & Extension	15	9	14	17	4
b. Farm Level Prod, Ext Supply	8	6	11	7	4
c. Agg Product, Ext Supply	10	9	14	3	2
Profits Impact	5	5	3	2	0

As is apparent from the review, the identification of extension effects is a complicated task, both because there are many other factors and infrastructural variables that affect agricultural performance, and because the extension input itself is difficult to measure and requires utilization of proxies. Much extension impact is cumulative and can be captured only partially in econometric studies which typically focus on a point in time. Some of the methodological problems in estimating extension effects were highlighted in the review. These can be avoided in future studies by proper attention to the possibility of self-selection in observed extension-farmer interactions and awareness of the prevalence of inter-farmer information flows. Attention should also be given to the possibility that the allocation of extension efforts by governments is not random across areas or communities. Such tendencies could distort results and can be subjected to formal testing.

While there is convincing evidence that extension efforts can have a significant effect on output, there is limited evidence regarding the profitability of investment in extension from a social welfare perspective. Nonetheless, the few studies which were undertaken demonstrate that investment in extension can have very high rates of return in both developing and developed countries. Given the limited number of such studies, it was not possible to establish empirically the circumstances which are conducive to extension effectiveness, although common sense can suggest a number of these such as a continuous flow of research-generated improved technology or availability of complementary inputs.

FOOTNOTES

1. World Bank 1982. World Development Report, 1982. New York: Oxford University Press. p. 40.

2. Based on authors' estimation. Data on World Bank lending for agricultural extension came from M. Baxter, J. Howell and R. Slade. 1988. Form and Function in Agricultural Extension: Evidence From the World Bank and Other Donors, p. 16-18 and Appendix, especially Table 13.

3. Boyce, J.K and R.E. Evenson. National and International Agricultural Research and Extension Programs. (New York: The Agricultural Development Council, 1975), and M. Ann Judd, James K. Boyce, and Robert E. Evenson, "Investing in Agricultural Supply," Discussion Paper No. 422, Yale University, Economic Growth Center, 1983.

4. See Evenson, R.E. "The International Agricultural Research Centers: Their Impact on Spending for National Agricultural Research and Extension." (Consultative Group on International Agricultural Research, Study Paper No. 22, The World Bank, and M. Baxter, J. Howell and R. Slade, Form and Function in Agricultural Extension: Evidence From the World Bank and Other Donors. Draft, May 1988, for an analysis of sources of support for agricultural extension.

5. Complete references are provided in the Appendix. We were unable to locate the studies marked with an asterisk. For the sake of completeness they are copied in this review as reported in Jamison and Lau 1982.

6. Feder, G. and R. Slade. "Methodological Issues in the Evaluation of Extension Impact," in Investing in Rural Extension: Strategies and Goals. Gwyn Jones (ed.). Elsevier Applied Sciences Publishers. pp. 255-267, 1986.

7. Feder, G., L. Lau and R. Slade. "Does Agricultural Extension Pay? The T&V System in Northwest India." American Journal of Agricultural Economics, Vol. 69, No. 3, pp. 678-686, 1987.

8. See Evenson, R.E. "Productivity Decomposition: Methods for Evaluation of Agricultural Systems Impacts." in R.E. Evenson, E.R. DaCruz, A.F. Diaz Avila, V. Palma, eds. (1983). Evaluation of Agricultural Research: Methodologies and Brazilian Applications. Joint Publication of Empresa Brasileira de Pesquisa Agropecuaria. EMBRAPA and Economic Growth Center, Yale University.

9. Feder, Gershon and R. Slade. "The Acquisition of Information and the Adoption of New Technology." American Journal of Agricultural Economics, Vol. 66 No. 3, pp. 319. Extension exposure significantly affected the probability of knowledge of zinc sulphate.

10. The measurement was average extension agency hours per farm.

11. The Jamison and Lau (1982) Thailand study found a positive profits impact for extension on non-chemical farms and a negative effect for farms where the farmer used chemical inputs. They hypothesized that the extension agents may have emphasized maximizing output rather than profits or prematurely coaxed the farmers to use chemical fertilizers. Research variables not included. Since the Brazil, Philippines and Thailand studies utilized extension research interaction variables it is difficult to determine the statistical significance of the estimates (joint tests are not reported). The overall profits impact of extension in the Brazil and Philippines studies was not significant.

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APPENDIX

Information on Data Sources[1]

Brazil Patrick and Kehrberg (1973)	1969 survey of farmers in five areas. This study is limited to commercial farmers (normally > 5 hectares) The areas were: Paracatu N=86-beef and traditional agriculture, Canceiçao de Castelo N=54 coffee, corn and beans, Viçosa N=337 - coffee, dairy and horticulture crops, Resende N=62 milk production and Alto São Francisco N=82 cattle, corn, and beans.
Brazil Pachico and Ashby* (1976)	1970. Sample of farm households in four communities of southern Brazil collected by University of Rio Grande de Sul. Mixed field crop and livestock. N=101.
Brazil Evenson daCruz and Avila (1987)	Municipio level data from sensuses of 1970, 1975, 1980. Regional estimates were obtained. Productivity indexes were computed for each county and used in a productivity decomposition study. Output and input quantity and price indexes were compiled for output supply-factor demand studies.
Botswana Lever (1970)	Data collected by the District Agricultural Office at Lobatsi between 1960 and 1967. N=786.
Côte d'Ivoire Deaton and Benjamin (1988)	Côte d'Ivoire living standards survey, 1985. Cocoa farmers N=340. Coffee farmers N=416.
Ethiopia Aklilu (1980)	Data were collected on fertilizer use in 20 Minimum Package Program areas located in different provinces of the country. Extension agents used model farmers and trial and demonstration fields. Four observations were recorded, 1971-1974.

[1]We were unable to locate the studies marked with an asterisk. They are copied as reported in Jamison and Lau (1982)

India Feder, Slade and Sundaram (1985)	State monitoring and evaluation reports of 12 of 13 Indian states where T&V has been in place since 1977. Both large and small farms. N=1,500+ The coefficient reported in the output studies reflects a sample that includes irrigated and unirrigated farms.
India Feder,Slade and Lau (1985)	Farm level survey data 1982/1983 from the Haryana and Uttar Pradesh States. Crop: Rice and Wheat. N=365.
India Feder and Slade (1984)	Sample of 548 rice farmers in Northwest India. Practically all farmers in the sample grow high-yield rice varieties under irrigation. No year given for the study.
India Evenson and Kislev (1975)	Aggregate data (1960-1970) from 140 IADP districts controlling for 14 geo-climate regions. Seven Indian states. N=140. Mostly foodgrains. The IADP program included credit and inputs as well as extension services.
India Evenson and Jha (1973)	Aggregate data extracted from official censuses World Bank studies, and work prepared previously by the authors. Output was measured by a total factor productivity index for 15 states covering the years 1952-1971.
India Evenson (1987)	Productivity indexes based on state data were computed using the Tornquist-Divisia methods. Data from 10 states , 1957-1975 were utilized in a productivity decomposition analysis.
Japan Harker (1973)	1966. Representative sample of 971 middle-aged rice farmers in central and southern Honshu, Shikoku, and in the Fikuoka areas of Kyushu. Rice.
Kenya Moock (1973)	Survey data from Vihiga Division, Keyna collected from 1970-1971. A random survey in 1970 was used to provide comparative measures. Two surveys were conducted in 1971, one defined by a Special Rural Development Program.

Keyna Moock (1976)	A sample of 152 maize farmers in Vihiga, Keyna. The data were recorded during the principle planting season of 1971.
Keyna Hopcraft* (1974)	1969-1970. Subsample of stratified random sample of 1,700 small farms collected for the Small Farm Enterprise Cost Survey. Maize, livestock and tea.
Korea Hong* (1975)	1961. Subsample of random census sample of 1,200 farm households in nine provinces. Rice and other crops.
Malawi Perraton, Jamison and Orivel (1985)	Subsample of data collected by the Ministry of Agriculture's Agro-Economic survey of 1978 crop. Mostly small landholders. Crop: Maize. Two samples of N=150
Malaysia Jamison and Lau (1982)	Subsample of data from written records of a FAO/World Bank survey Muda River, Keda and Perlis States. Nov 72-73. Crop: Rice N=800
Nepal Pudasaini(1983)	Random sample of 205 farmers of the Bara district and 149 farmers of the Gorkha district representing the terai and hill regions respectively. Crops: Maize and Rice
Nepal Jamison and Moock (1984)	Random survey of rural households of two administrative districts, Bara and Rautahat, both located in the Nepal Terai. The production data cover the 1977-1978 agricultural year and relate to three principle crops: early paddy, late paddy and wheat. Maximum sample size= 683.
Nepal Shakya and Flinn (1985)	Field survey of 177 farmers of which 79 grew modern variety rice. 1979 data from the eastern Tarai of Nepal.

Pakistan Pray and Ahmed (1987)	District data for the 1951,1960, 1977 and 1981 periods were compiled for crop production and inputs. An aggregrate production function was fit for the 1951-1960 period and the 1977-1987 period.
Paraguay Evenson (1988)	Randomized samples of farms in the Paraguayan minifundio region conducted in 1987. This survey contains data for 147 farms in 4 provinces and 7 extension agencies. Crops: Cotton, Monioc, Maize, Peanuts, Poroto, Potato, Sugar, Tomato.
Peru Cotlear (1986)	Survey sample of 555 rural households in three ecologically similar regions. Nine villages were located in a modern region, five in an intermediate region, and four villages were located in a traditional region. The data refers to the 1982-1983 agricultural year with emphasis on the potato.
Philippines Halim* (1976)	1963,1968,1973. Subsample of an earlier random sample of households in twenty-eight representative rice producting barrios of Laguna district.
Philippines Librero and Perez (1987)	Secondary aggregate data from various sources including the National Corn Research and Development Programs, Bureau of Plant Industry and Office of Budget and Management. The data are from the years 1956-1983. Crop: Corn.
Philippines Evenson and Quizon (1987)	Regional data for 9 regions, 1948-1984 were compiled for outputs and inputs. Fisher chained quantity and price indexes were compiled for output supply-factor demand analysis.
Thailand Jamison and Lau (1982)	Interviews conducted from stratified random sample of 22 villiages in the Chaing Mai Valley Farms not employing chemical fertilizer or other chemical inputs are referred to as "non-chemical". Extension services were available to roughly half of the farms in the sample. N=275 Crop: Rice 1972-1973

Thailand Chou and Lau (1987)	Four surveys of rural households (Chaingmai valley) engaged in the cultivation on rice paddy for 1972, 1975, 1976, 1978. The surveys differ in the amount of information collected and the number of households surveyed.
Thailand Evenson and Setboonsarng (1987)	Regional data for 19 regions, 1967-1980 were compiled for outputs, inputs and prices. Fisher chained index methods were used to construct aggregates.
USA Huffman (1974) (1977)	County aggregate data taken primarily from census of Agriculture data and USDA publications from 1959-1964. Crop: U.S. corn. Illinois, Indiana, Iowa, Minnisota, and Ohio. The 1977 paper uses the same data but with a larger sample and more rigorous statistical methods. From this study the author extimates a rate of return.
USA Evenson (1978)	Aggregate data taken from USDA statistics 1870-1971. Products included livestock, cereal and feed grains, cotton tobacco, vegtables, fruits and nuts.
USA Evenson (1978)	USDA data from 1879-1971. Statistical decomposition of productivity change in a time series by region. Crops: LIvestock, Cereal, feedgrains, cotton, tobacco, vegetables,fruits and nuts
USA Huffman (1981)	County aggregates for 295 counties of North Carolina, South Carolina, Mississippi, and Alabama. Most of the data are from the Census of Agriculture, 1964. Extension data are from 1960.
USA Rahm and Hüffman (1984)	A random sample of 869 Iowa farms in 1976 having farm sales or value of production greater than $2,500. The innovation under question was the adoption of reduced tillage practices.

24 Countries Evenson (1987)	Aggregate data from 24 countries on 13 commodities. Data on spending from a study done by the author and J.K. Boyce and M. Ann Judd. Production data mostly from USDA. Crops: Sorghum, Rice, Cereals, Cassava, Potatoes, maize, millets, wheat, and groundnuts. This study provided the data for the IRR calculations reported at the Buenos Aires conference. (see bibliography)