The effect of technology transfer program participation on small farms in Chile.

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Abstract

This research examines the effect of a government sponsored technology transfer program for small holder farms in Chile. The effect of family participation in the technology transfer program is evaluated with respect to a number of 'outcomes' including its effect on farm revenues, total family income, and household poverty status. The empirical examination uses maximum likelihood selection and fixed- and random-effects estimation techniques. By estimating the effect of program participation on crop selection, crop yields, farm use of certified seeds, and the scale of farming activities, the research examines the mechanisms through which the program appears to raise farm revenues. Estimation results show program participation had a positive and significant effect on farm revenues and total family income. The program prompted farmers to adopt nitrogen fixing bean crops, but did not have significant effects on crop yields or the likelihood a farm planted certified seeds or applied fertilizer. The primary mechanism through which the program increased farm income was by increasing the intensive scale of farming pursued by participants.

Keywords: Agricultural Extension Services, Program Evaluation, Impact Assessment, Technological Change: Choices and Consequences, Chile, Farm Households, Panel Data.

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1. Introduction and overview.

This paper examines the performance of a Chilean government sponsored technology transfer program (the Programa de Transferencía Technológica (PTT) in Spanish) for small farms using data from a longitudinal survey of households in a single southern province in Chile. The effect of the program, and the role of farm characteristics (i.e. farm size, labor endowment) on farm performance is evaluated using a number of economic welfare and agricultural performance measures. Estimates of farm and total family income serve as measures of the final outcome of PTT participation. Estimates of the scale of farming, crop adoption and yields, and technology use corroborate results from income estimates and indicate how changes in income were attained.

Information concerning the effect of agricultural technology transfer programs in developing economies is of interest to both government policy makers and international donors seeking to allocate limited funds for rural development. The technology transfer program in Chile has been characterized as a model of semi-privatized agricultural extension (e.g., Carney, 1998, Bebbington and Sotomayor, 1998). Within Chile, the incidence of poverty among the small farm households targeted for technical assistance is high. The considerable expenditure on small farm assistance programs also make evaluation of the efficacy of the technology transfer program a question of considerable policy importance. Most developing countries with large traditional farm sectors are facing the issue of how to integrate traditional farms into the broader economy and to alleviate poverty among small farm households. Such programs must be formulated within the framework of liberalized markets and in the context of general economic growth which typify the Chilean economy since the late eighties. These considerations make the examination of the program's effectiveness of broader interest.

To date, examinations of the effect of technology transfer on small farms in Chile have mainly been qualitative in nature (e.g., Falaha-Lumi, 1992, Sotomayor, 1994). Lopez (1994) quantitatively examined the technology transfer program using data from a region that overlaps the area from which

data for the present study is drawn. This study found that the PTT had a positive but not statistically significant effect on family income and the level of farm output. The estimation techniques applied in this study did not control for the self-selection of households into the program.

Data for this study come from a longitudinal survey of roughly two hundred randomly selected small land holding households from Ñuble Province in Chile's Eighth Region. Because the data available for our study has longitudinal information on surveyed farms, we are able to apply panel data based models that offer more 'robust' tests of program effects. By estimating household-specific error or intercept terms, the random- and fixed-effects models can control for unobservable characteristics of farm households in assessing the effect of PTT participation. These unobservable household characteristics, if correlated with the decision to participate in the technology transfer program, will bias estimation results if account of them is not taken. Control of unobservable household characteristics through the random- and fixed-effects specifications has the advantage of requiring less restrictive parametric assumptions than are required for treatment effect estimators that use cross-sectional data. While these procedures have been widely applied in labor economics to assess job training program performance, the present work represents a rare instance where these estimation techniques have been applied to evaluate agricultural extension services in a developing economy setting.

Another advance in the present examination is that we evaluate program performance with respect to a number of outcomes to check the results obtained from single outcome estimates. Outcomes considered include observed farm technology choices that can be directly traced to program activities and objectives, as well as broader outcomes that reflect the ultimate goals of the program. Farms surveyed were interviewed over a span of time (nine years) sufficient to allow the complete effects of the program to occur.

2. The technology transfer program for Chilean small holders.

Agricultural technical training and technology transfer services offered through the PTT are available to farming households with small land holdings and few assets. To participate in the PTT a family can own no more than 12 irrigated equivalent hectares of land and have assets valued no more than 3,500 UF—roughly equivalent to $87,500 US in 1995. The program has the broad objective of improving the agricultural practices applied on farms and ultimately enhancing farm income. The technology transfer program is typical of policy measures pursued under Chile's "Growth with Equity" development strategy which seek to alleviate poverty and foster the integration of groups at the margin of the commercial economy within the framework of a liberalized and market-driven economy. The program's self-financing components and use of private-public partnerships are also typical of this strategy.

Agricultural technical assistance to small farms in Chile has been provided in some form since the 1960's.[1] The present program dates back to technical assistance programs provided to small-to-medium-sized farms beginning in 1978. In the 1980s, the government moved to public financing agricultural extension contracted through private technology transfer organizations. The number of farms participating in the PTT program and expenditures for the program have increased markedly since the mid-1980's, along with direct subsidies to alleviate rural poverty. In 1989, approximately 23,000 small farms participated in the technology transfer program. This was equivalent to 16.4 percent of the estimated total number of small farms in Chile. The technology transfer program was not available in many localities in 1986-87. In 1990, funding to the program was roughly $16 US million, and it served about 34 thousand farms.[2]

A shortcoming in the data available for this study is that only allows characterization of household participation in technology transfer programs as a simple dummy variable rather than measures the actual

[1] Several works in Spanish give detailed descriptions of the programs to assist Chilean peasant farms and review the changes the PTT has undergone since its inception (Berdegué, 1994, Leiva and Sotomayor, 1994).

[2] MIDEPLAN, 1991.

services received or defining the particular program in which the household took part. Agricultural extension service providers sought broad common objectives and programs provided similar training and services. These included: training on cultivation techniques for new crops and practices to improve yields for existing crops, education regarding pest management and pesticide use, and technical assistance on the construction of small scale capital improvements for farms. Services provided include: assisting participants in applying for government-financed farming credit, providing livestock vaccinations, and periodic farm visits by PTT staff. Program consultants also act as sources of information about agricultural market trends and other government programs to assist poor rural families. Program staff sometimes act as intermediaries between groups of small farms and agricultural enterprises selling fertilizer and seed or purchasing output. In each community served, PTT activities occur through committees of about twenty families from the locality. Committees meet about six times a year, and training and other program activities are conducted during meetings.

The day-to-day operation of the program at the local level depends primarily upon the non-governmental organizations and agricultural consultancies under government contract to program agricultural technology transfer services. Program administrators from the National, Regional, and Provincial offices focus their activities on program formulation and contract review. The Provincial and local offices of the sub-ministry in charge of the program are more closely involved in the daily operation of the program through their monitoring and support of activities carried out by contracted service providers. Local government administrators are particularly active in the area of agricultural credit extension. Government administrators guide the activities of service providers through curriculum development, contract approval and renewal, assisting in coordination between the program service providers and other programs, and imposing staffing and performance requirements. However, the organizations contracted maintain considerable latitude in the development of their particular program foci. There is considerable diversity in the approaches adopted by different service providers to achieve

program goals. Agricultural research, mainly in the form of on-farm demonstrations or experiments, forms an important component in some programs. This researcher observed little direct involvement of the national agricultural research institutions in this work. This characterization of the program is based on the researcher's experiences in working with program administrators and operators during 1993 and 1995 which provided a grassroots perspective on the structure of the program.

3. Modeling the effect of the technology transfer on agricultural households.

The decision to participate in the PTT program is modeled as resulting from a household's assessment of their welfare as participants in the program compared with the level of welfare they obtain if they do not participate in PTT. Households participate in the PTT because they determine their utility as participants is higher than the level of utility they would obtain as non-participants. The costs and benefits of PTT participation depend, in turn, on many of the same characteristics that determine a household's income. A farm's benefit from program participation depends upon the need the farm operators have for the training and services provided by the program, and the farm's capacity to apply the technologies introduced in the PTT. Farm adoption of PTT technology, in turn, depends upon the amount of land a family owns, its capital holdings, and similar characteristics. The cost of participation is primarily the lost labor time and costs associated with transport to program meetings, and charges for specific goods and services provided. Unmeasured household characteristics such as ambition and social capital will bear heavily on the benefits derived from the program. Survey data cannot accurately quantify such household characteristics. This makes it essential that statistical techniques be employed that control for such unobservable characteristics.

The estimation proceeds from the structural equations for farm income:

$$Y^{Farm} = \sum_{j=1}^{K} Y_j = \sum_{j=1}^{K} p_j \Psi(L_t) F_j(L_j, H_j, T_j, K_j; Z) \qquad (1)$$

Farm income is a function of prices (p_j), the quantity of each of k crops produced by the farm, labor input from family (L) and hired non-family (H) sources, the amount of land cultivated (T), and the amount of capital (K) applied to the production of each crop j, a technical efficiency parameter (Y) defining the farm productivity which depends upon the amount of family labor time devoted to PTT activities (L_t), and other exogenous farm characteristics (Z). We assume productive inputs and outputs are non-joint. The expression values agricultural output at market prices. The values of goods used only for home consumption are imputed using the price of the nearest neighbor that reported selling the good.

Estimation of equation (1) directly raises a number of problems. Variable input levels are likely endogenous with the level of farm production. Estimating equation (1) would require estimation of each of K crops separately, while available data only provides information on aggregate levels of the inputs per farm. Treating PTT participation as an exogenous variable leads to omitted variables bias due to self-selection of families into the program.

While levels of labor, land, and capital actually applied by households in farming are likely endogenous with farm income, a household's endowments of these inputs can be considered predetermined. Farm production of k distinct crops is collapsed into a single production function defining the value of agricultural output of the farm. Data do not permit identification of the labor time devoted to PTT activities (L_t) so program participation is reduced to a single dummy variable (D) that takes on a value of one if the household participated in the PTT program and a zero otherwise. With these changes, expression (1) simplifies to: $$Y^{Farm} = \Psi D \cdot F(\overline{L}, \overline{T}, \overline{K}, Z) \qquad (2)$$

For simplicity, we assume the production technology is characterized by a Cobb-Douglas production function. This functional form captures the expected concavity between inputs and the level of output. It is adequate for the present purpose since our intention is to develop an expression for farm income that is amenable to estimation: $$Y^{Farm} = \Psi D \overline{L}^{b_1} \overline{T}^{b_2} \overline{K}^{b_3} Z_1^{b_4} Z_2^{b_5} \cdots Z_O^{b_O} \qquad (3)$$

Finally, we take the natural log of both sides of expression (3) making it linear in logs.

4. Treatment effect estimation procedures.

The principal statistical problem faced when estimating the effect of program participation when households can self-select into the program is the potential for omitted variables bias. If program participants have unobserved characteristics which are correlated with their decision to participate in PTT and these are also correlated with farm income (or other outcome measures), estimates of program effect computed from the estimated coefficient on the dummy variable defining household participation status will be biased.

We apply two estimation techniques to account for the effect of self-selection of families into the PTT in assessing the effect of participation in the program: 1. a fixed-effects estimator, and 2. a random-effects estimator.[3] The alternative estimates allow us to check the sensitivity of results to the specification and to compare results with those of previous studies. The random-effects estimator includes a household-specific error term, and the fixed-effects estimator includes a household-specific intercept term to characterize the effect of unobserved household characteristics on program outcomes. A disadvantage of the random-effects estimator is that it requires the assumption that individual effects are uncorrelated with other regressors. The Hausman test examines the validity of this assumption. We report the Hausman specification test statistics in all panel data based estimates.

When household specific-effects are included, the estimated coefficient and asymptotic t-test for the dummy variable indicating farm participation in the PTT program will provide an unbiased measure of the impact of the program—provided the unobserved differences across households are constant over time and can be characterized as household-specific errors in the regression equation.

[3] The maximum likelihood form of a Heckman two-step estimator for estimation of the program participation and farm income outcomes as endogenous variables using cross-sectional data from each year of survey was also estimated but is not reported due to space.

Because approximately sixteen percent of the households interviewed in 1986-87 attired from the panel raises the question of whether attrition biased results obtained from panel estimates. We examined whether attrition biased estimates using a maximum likelihood estimation selection model of farm income (1986-87) with selection on attrition. We also computed an estimation model using 1986-87 data which controlled simultaneously for self-selection into the PTT and attrition using the multinomial logit selection model developed by Lee (1983). Estimation results are not reported here in the interest of space, but results suggest attrition bias is not present.

5. Overview of the survey area and data examined in estimations.

The data for the present study come from a random sample of roughly two hundred households in Ñuble Province that is part of the Eighth Region in central-southern Chile. The survey was administered in 1987 to collect information on farm/household characteristics and the agricultural activities pursued during the 1986-87 agricultural year (July 1 to June 30). The follow-up survey was conducted in 1995, collecting information for 1994-95. Of the 208 households identified in 1986-87 survey: 176 completed the follow-up survey, 21 were known to have abandoned the farm they owned or rented in 1986-87, two refused to be interviewed, and 16 households could not be located. These 16 households also probably left their farms, but this could not be confirmed from interviews with former neighbors. Some information on the 21 families known to have left their farms was collected from interviews with their former neighbors. Among the 174 households that completed both the initial and the follow-up survey, more than thirty percent took part in the PTT each year. Table 1 summarizes data from the survey.

Table 1. Summary statistics on variables used in evaluation of the effect of the PTT.

		Ag.Yr. 1986-87		Ag.Yr. 1994-95	
Variable	Units	Mean	Std.Dev	Mean	Std.Dev
PTT participant	0/1	0.309	--	0.322	--
Assoc. of sugar enterprise	0/1	0.150	--	0.155	--
Household head's age	Years	53.382	14.964	58.239	13.725
Household head's schooling	Years	3.780	3.270	3.710	3.310
Dependency ratio	Ratio (children/adults)	0.377	0.479	0.307	0.440

Labor endowment	Fulltime equiv.mnths.	15.566	7.280	14.546	6.957
Land owned	Irrig. equivalent has.	3.114	4.412	2.292	3.548
Pct. income from agriculture	Percentage	0.713	0.323	0.539	0.358
Value equipment/machinery	Pesos (x 100,000)	9.827	22.747	13.957	29.227
Own some type of transport	0/1	0.469	--	0.672	--
Agricultural income	Pesos (x 100,000)	17.997	32.575	14.950	22.061
Total income	Pesos (x 100,000)	22.166	33.281	17.938	22.589
Extreme poverty (Cash)	0/1 (cash inc./capita)	0.522	--	0.276	--
Extreme poverty (Total)	0/1 (total inc./capita)	0.459	--	0.201	--
Regular poverty (Cash)	0/1 (cash inc./capita)	0.657	--	0.535	--
Regular poverty (Total)	0/1 (total inc./capita)	0.614	--	0.460	--
Cultivates vegetables	0/1	0.098	--	0.563	--
Use of certified wheat seed	0/1	0.199	--	0.379	--
Wheat yield	Quintiles per ha.	18.808	13.334	27.119	17.283
Land cultivated	Physical has.	11.325	12.009	10.869	12.354
Source: Nuble Panel Survey.		(N=174)		(N=174)	

6. Estimation results.

Estimates of the effect of farm participation in PTT on farm income are reported on Table 2. We discuss fixed-effects estimates, but they are not reported. Random- and fixed-effects estimates of farm income were similar. The fixed-effects panel model explained more of the variance in farm income. The Hausman test statistic supports use of the random-effects estimator. Estimates show the PTT participation had a positive and statistically significant effect on farm income. PTT participation caused a 47.5 percent increase in household farm income according to the random-effects estimator.

The fixed-effects estimator attributed a 43.5 percent increase in farm income from PTT participation. In terms of the effect of participation on the level of farm income, results imply participants increased their farm incomes by 59,000 pesos in the random-effects and by 52,000 pesos in the fixed-effects estimators (roughly equivalent to $193 and $130 US, respectively).[4] These increases were close to the average cost of the PTT (about $150 US, MIDEPLAN, 1991).

Estimated equations showed a positive and statistically significant effect of farm association with the quasi-governmental sugar enterprise on farm income. The magnitude of this increase was greater

than that obtained for the PTT. Other variables with statistically significant effects on farm income were: labor endowment, amount of land owned, and ownership of private transportation.

The fourth column of Table 2 summarizes estimates of the effect of PTT participation on total family income. Results are similar to those of farm income estimates—participation in the PTT had a positive and statistically significant effect on total family income. The Hausman test fails to reject the null hypothesis that individual effects are uncorrelated with other regressors.

We present estimates of the effect of PTT participation on other outcome measures (in order): poverty status, farm adoption of selected crops, crop yields, use of certified seeds, and the intensive scale of farming activity. Based on estimation results just discussed, we employ only panel data estimators and set aside concern about attrition bias. Considering these additional outcomes provides an opportunity to verify the results obtained from the estimates of farm income. Estimates of the effect of PTT participation on farm crop selection, yields, technology applied, and scale of farming activities also provide insight into the relative importance productivity increases, changes in

Table 2.Summary of program effect estimates: Farm and total family Income, and poverty status.

LHS/Dependent variables (N=348) Estimation Coefficient (Estimation Standard Error) RHS variables	Log (Farm Income)	Log (Total Income)	Per capita income below poverty line
Constant	---	---	1.259 *
	---	---	(0.775) /2
Time dummy variable	-0.241	0.306	-0.545 ***
	(0.575)	(0.448)	(0.203)
Participant in technology transfer program (0 or 1)	0.475 ***	0.294 ***	-0.209
	(0.145)	(0.116)	(0.189)
Associate of quasi-public sugar enterprise (0 or 1)	1.511 ***	1.316 ***	1.702 ***
	(0.233)	(0.171)	(0.402)
Age of head of household	0.057	0.089	-0.462
	(0.272)	(0.196)	(0.375)
Years of education of household head	-0.136	-0.012	0.065
	(0.104)	(0.076)	(0.138)
Family dependency ratio (children/adults)	0.061	-0.029	-0.160

[4] To approximate the implied effect of the coefficient in terms of the change in the level of the left hand side variable, we apply the conversion: $b_{i(level)} = e^{(\hat{b}_i - \frac{1}{2}Var(\hat{b}_i))} - 1$ (Kennedy, 1981).

	(0.106)	(0.085)	(0.152)
Household labor endowment (months avail. For work)	0.342 **	0.584 ***	0.105
	(0.170)	(0.130)	(0.231)
Land endowment (irrigated equivalent hectares owned)	0.484 ***	0.153 ***	0.181 **
	(0.064)	(0.048)	(0.079)
Value of farm equipment/machinery held by household	0.072	0.088 **	-0.079
	(0.050)	(0.039)	(0.064)
Household owns some type of private transport (0 or 1)	0.264 *	-0.095	0.068
	(0.149)	(0.124)	(0.213)
Distance to the Provincial capital	---	---	0.521 ***
	---	---	(0.207)
12 dummy variables identifying locality of farm /1	---	---	---
Goodness of fit measures and other diagnostics R^2	0.598	0.440	---
Cragg-Uhler R^2	---	---	0.340
Maddela R^2	---	---	0.254
McFadden R^2	---	---	0.213
Log-Likelihood Ratio Test statistic X^2 [11 d.f.]	---	---	102.129
Lagrange Multiplier Test [2 d.f.]	5.350 *	25.520 ***	---
Panel--Hausman test (fixed vs. random effects) [9 d.f.]	6.28	3.85	---
Probability Hausman test statistic	0.711	0.921	

Notes: n.r. (not reported for ease of exposition).

/1 None of the coefficients estimated for the localities were statistically significant in 1986-87.

/2 Asymptotic standard error reported.

*** statistically significant at α=.01

** statistically significant at α=.05

* statistically significant at α=.10

cropping systems, and increases in the intensity of farming activity in farm income increases.

Having found farm participation in the PTT had a positive and statistically significant effect on farm and total family income, a remaining question is whether the PTT was successful in assisting the needy households. This can be considered by examining the effect of PTT participation on the poverty incidence using a probit model with a random-effects error structure (Butler and Moffit, 1982).[5] The monthly per capita income levels defining the 'extreme' and 'general' rural poverty lines are compared to

[5] For completeness, a fixed-effect model based on the logit distribution proposed by Chamberlain (1984) was also estimated, but is not reported.

per capita monthly income to determine household poverty status.[6] Estimates were highly statistically significant according to goodness of fit measures. The random-effects model correctly predicted the poverty status of 75 percent of the households. As shown on Table 2, participation in the PTT was found to reduce the probability that the household's per capita income was below the poverty line, but the estimated coefficient was not statistically significant. This result was obtained regardless of whether the estimation considered the general or extreme poverty line, or cash or imputed income. There was a statistically significant decline in poverty incidence among surveyed farms over time. Other variables found to have statistically significant effects on poverty were: association with the sugar enterprise, the age of the household head, and the size of a family's landholding. With the income increases brought to PTT participant farms, these results imply that the program has not been successful in targeting its services.

6.1 Non-income measures of the effect of PTT participation.

PTT participation was estimated to have a positive and statistically significant effect on the number of hectares planted as reported on Table 3. The estimated marginal effect of PTT participation on the land cultivated was an increase in the planted area by 33.7 percent or 0.39

Table 3. Estimates of program effect on other outcome measures.

LHS/Dependent variables Estimation Coefficient (Estimation Standard Error) (N=348) RHS variables Estim. Proc.	Log (Hectares cultivated) R.E.	Use of certified seed in wheat crop R.E. Probit	Cultivate vegetable(s) R.E. Probit	Log (wheat yield) R.E.
Constant	0.148	0.210	-1.195	2.295
	(0.440)	(1.119) /1	-(0.757) /1	(0.509)
Time Dummy Variable	-0.357 ***	1.140 ***	1.686 ***	0.346 ***
	-(0.090)	(0.357)	(0.270)	(0.116)
PTT participant	0.337 ***	0.254	0.385 *	0.224 *
	(0.109)	(0.262)	(0.221)	(0.120)

[6] The 'extreme' rural poverty line represents the cost of purchasing a bundle of goods required to maintain a nutritionally adequate diet. We used Chilean rural poverty lines from 1993, deflating the values to their equivalent value in 1986-87 and 1994-95 using the Chilean consumer price index.

Sugar enterprise associate	0.332 **	0.603 *	-0.387	0.345 **
	(0.172)	(0.366)	-(0.350)	(0.178)
Age of head of household	-0.132	-1.611 ***	-0.569	0.119
	-(0.215)	-(0.599)	-(0.381)	(0.243)
Household head education	-0.094	-0.206	0.135	-0.090
	-(0.078)	-(0.226)	(0.135)	-(0.082)
Dependency ratio	0.147 *	0.208	0.229	-0.035
	(0.080)	(0.231)	(0.160)	-(0.092)
Labor endowment	0.601 ***	0.125	0.301	0.004
	(0.130)	(0.366)	(0.222)	(0.149)
Land endowment	---	0.529 ***	-0.005	0.043
	---	(0.177)	-(0.083)	(0.062)
Value of farm capital	0.126 ***	0.177 **	0.062	0.044
	(0.037)	(0.090)	(0.071)	(0.042)
Private transport owned	0.398 ***	-0.027	-0.018	-0.126
	(0.121)	-(0.352)	-(0.222)	-(0.142)
Rho	---	-0.615 **	0.391	---
	---	-(0.257)	(0.313)	---
Goodness of fit measures: R^2	0.295	---	---	0.133
Cragg-Uhler R^2	---	0.432	0.362	---
Maddela R^2	---	0.305	0.260	---
McFadden R^2	---	0.297	0.238	---
Log-likelih. ratio test [11 d.f.]	---	90.806 ***	104.986 ***	---
Lagrange Multip. Test [1 d.f.]	23.820 ***	---	---	1.140
Hausman test [9 d.f.]	43.120 ***	---	---	10.500

Notes:

/1 Asymptotic standard error.

		Predicted		Predicted	
		0	1	0	1
Actual	0	39	37	185	48
	1	23	149	37	78

hectare. Other variables having significant effects on cultivated area were: sugar enterprise association, the household dependency ratio, labor endowment, and ownership of transport and capital equipment.

Farm use of certified high yielding varieties of wheat seed provides an indicator of the technical level of the farms and success of the PTT in disseminating new technologies. According to the estimate, PTT participation increased the likelihood of certified seed use, but the effect was not statistically significant. Certified seed use among surveyed farms increased over time, and the trend was statistically significant. Association with the sugar enterprise was estimated to increase the likelihood of certified seed

use significantly. Older farm operators were significantly less likely to use certified seeds. Larger farms and farms with more capital were more likely to use certified seed.

The PTT encourages farms to adopt new crops in place of wheat and other traditional crops. Table 3 shows PTT participation had a positive and statistically significant effect on the likelihood of vegetable cultivation. Farms in the PTT were 13.1 percent more likely to cultivate vegetables.

Estimates show PTT participation increased wheat yields. The estimated coefficient on the dummy variable defining PTT participation was significant at a .06 level of significance. On average, PTT participation raised the wheat yield by 24 kilos. There was a trend toward increasing yields between 1986-87 and 1994-95. The only other right hand side variable estimated to have a significant effect on wheat yields was farm association with the sugar enterprise.

7. Conclusions and implications of the research.

This research provides evidence that the technology transfer program for small farms in Chile had a positive and statistically significant effect on participants' incomes. Results control for self-selection of households into the PTT and are consistent across alternative specifications of the estimation equation. The estimated increase in income accruing to families participating in the program was more than the average expenditure per farm on the program. The positive effect of program participation was obtained using a number of outcome measures. The effect of program participation on household poverty status was generally not statistically significant, suggesting program services need to be better targeted to the most needy households.

Examination of intermediate program outcomes such as crop adoption, use of particular agricultural technologies, crop yields, and scale of agricultural activity pursued by farms confirm the favorable finding regarding the program's efficacy. These provide insight into the mechanisms through which income increases were obtained. Income increases of PTT participant farms appear to have been caused by increases in the intensity of farming activity carried out by participants. This is

shown by the statistically significant effect of PTT participation on the area planted and the amount of labor applied to farming among participant households. Evidence of program success in prompting participants to move away from traditional cropping patterns and to adopt crops with more favorable economic prospects and less deleterious effects on soil quality was less clear. Results concerning the PTT's effectiveness in increasing crop yields and agricultural practice were also mixed.

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