Chapter 12

LINKING SMALLHOLDERS TO THE NEW AGRICULTURAL ECONOMY: THE CASE OF THE *PLATAFORMAS DE CONCERTACIÓN* IN ECUADOR

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Smallholders and the New Agricultural Economy

Agricultural producers in developing countries, including smallholders, are increasingly relying on market transactions to procure agricultural inputs and concomitantly linking to long and complex value chains for high-value fresh and processed products. In these high-value markets, greater emphasis is being placed on private grades and standards for food quality and safety, leading to new organizational and institutional arrangements within the food-marketing chain (Reardon and Berdegué 2002; Dolan and Humphrey 2004). The growth of a dynamic food-marketing sector and the changes it implies for agriculture and related systems could potentially increase farm income and improve food security, particularly among smallholders (Eaton and Shepherd 2001; Winters, Simmons, and Patrick 2005). However, access to input and output markets has proven difficult for many smallholders, who often remain at the margin of this new agricultural economy (Little and Watts 1994; Berdegué et al. 2003; Reardon et al. 2003; Johnson and Berdegué 2004). The process may in fact exacerbate poverty levels if smallholders are unable to take advantage of new market opportunities or benefit from increased labor demand. Additionally, agricultural market integration has been associated with negative environmental and health impacts, due to increased pesticide use and a deterioration of the crop genetic-resource base (Barrett, Barbier, and Reardon 2001; Dasgupta, Mamingi, and Meisner 2001; Pingali 2001; Singh 2002; Winters, Simmons, and Patrick 2005).

In seeking ways for smallholders to access high-value markets while minimizing negative consequences, there has been a growing recognition that standard production-oriented interventions designed to enhance productivity are insufficient unless they are accompanied by actions that target other parts of the production–distribution–retail chain. One intervention that has used

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this broader approach in the Andes is the *Plataformas de concertación* (multistakeholder platforms, or *Plataformas*), which seeks to link smallholders to high-value agricultural markets (Devaux et al. 2009). The *Plataformas* are alliances between small-scale farmers and a range of agricultural support-service providers.[1] The main objectives of the *Plataformas* are to increase yields and profits of potato-producing smallholders in order to reduce poverty and improve food security (Pico 2006). The program provides participants with new technologies and high-quality seeds in addition to facilitating access to high-value potato markets. Through the *Plataformas*, smallholder potato producers are directly linked to restaurants, supermarkets, and processors that are willing to pay a premium for potatoes that meet their grades and standards. By establishing direct linkages between farmer organizations and purchasers, the *Plataformas* have reduced the number of intermediaries within the value chain, providing smallholders with the opportunity to benefit from the changes in agricultural marketing systems.

The objective of this chapter is to understand whether, and to what extent, participating in the *Plataformas* impacts farmers' well-being through enhancing the earnings from potato production in poor areas of Ecuador where potatoes are a key staple crop. The mechanisms by which program objectives have been achieved, and secondary environmental and health effects, are also analyzed. The results, although context specific, provide insights into the challenges of linking smallholders to high-value markets and of the possibility of meeting these challenges. The remainder of the chapter is organized as follows. Next, we present the logic of the *Plataformas* intervention. The methodological approach used is then described, followed by a description of the context and the data. Then we present the results, followed by a discussion of lessons learned and conclusions.

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[1] The *Plataformas* program in Ecuador has been coordinated by the National Autonomous Institute for Agricultural Research (INIAP) through the Fortalecimiento de la Investigación y Producción de Semilla de Papa (FORTIPAPA; Strengthening of the Research and Production of Potato Seed) project working with local NGOs—Central Ecuatoriana de Servicios Agropecuarios (CESA); MARCO (Minga para la Acción Rural y la Cooperación); the Instituto de Ecología y Desarrollo de las Comunidades Andinas (IEDECA)—and other partners, including research centers and universities. It has been supported by the International Potato Center (CIP) through the Papa Andina Partnership Program, funded by the Swiss Agency for Development and Cooperation (SDC).

Linking Farmers to Markets: The Logic of the *Plataformas* Approach

While there are multiple structures for organizing production, the new institutional economics literature posits that the one that emerges is that which minimizes overall costs including transaction costs (Williamson 1985). Such costs include standard production costs, but also the ex ante costs of drafting, negotiating, and safeguarding agreements, as well as ex post costs of maladaption, setup, and running of governance systems and bonding costs of securing commitments (Dietrich 1994). For agricultural industries where crops are sold in high-value markets or for processing, timely delivery and quality standards are often crucial to the decision of how to organize production. Using the open market for obtaining these commodities may involve high transaction costs and therefore may have limited appeal (Winters, Simmons, and Patrick 2005). Agribusinesses may then seek alternative structures for organizing production, such as through vertical integration or contract farming, if they view creating such a relationship as the least-cost alternative option.

The manner in which smallholders fit into a specific agricultural value chain depends on the costs that determine its organization. The primary cost advantage of smallholders is in their ability to supply cheap labor for labor-intensive crops. In such cases, it may be worthwhile for an agribusiness to deal with numerous smallholders, since overall costs include a large share of labor costs. The agribusiness may choose to contract smallholders or groups of smallholders directly to minimize transaction costs. To ensure smallholder participation, some cost advantage or price premium must be paid to contracted smallholders. If the crop is not labor-intensive and it is possible to contract a smaller number of largeholders thereby minimizing transaction costs, this is a more likely outcome. If, alternatively, the agribusiness chooses to purchase the commodity in the open market, since it is the lowest-cost option and allows the agribusiness to meet its quality and timing needs, intermediaries are likely to play the role of obtaining the necessary product and providing it to the agribusiness. While these intermediaries may purchase the crop from smallholders, it will be at going market rates and provide no price premium or cost benefit to smallholders unless they are large enough suppliers that they can influence overall price.

The motivation for linking smallholders to agribusinesses is the presumed price premium for selling in these markets and thus overall income gains. When smallholders have no apparent comparative advantage in production, the challenge is to create that advantage or to reduce the transaction costs associated with purchasing from large numbers of farmers producing small quantities. Linking smallholders to high-value purchasers is likely to require organizing smallholders to overcome transaction costs, as well as providing them with the necessary information to meet market requirements. While this adds costs for smallholders, since they must take the time to organize and obtain information, it lowers the costs to the industry.

This is exactly the logic of the intervention undertaken through the creation of the *Plataformas*; namely, reducing transaction and production costs so smallholders can be a low-cost option for high-value purchasers, and providing smallholders with the necessary tools to meet quality and quantity demanded. The primary mechanism by which the *Plataformas* reduce transaction costs is through providing support for smallholders from a range of agricultural support-service providers including the National Autonomous Institute for Agricultural Research (INIAP), nongovernmental organizations (NGOs), researchers, universities, and local governments, and through fostering organization among smallholders. This support network comprises the *Plataformas*. The support and organization enable smallholders to improve production generally and meet the needs of high-value markets, allowing them to sell directly to restaurants, processors, and supermarkets. The *Plataformas*, therefore, reduces costs for two types of transactions: (1) between farmers and final purchasers; and (2) between farmers and suppliers of services (inputs, seeds, and technical assistance).

More specifically, the *Plataformas* ensure seed provision and seed inventories are matched to detailed production plans established during regular meetings held among farmers, coordinating NGOs, and other stakeholders in order to achieve monthly quotas for delivery to clients. Further, the *Plataformas* provide training through Farmer Field Schools (FFS) to enhance productivity and promote integrated pest management (IPM) techniques with the aim of improving quality and quantity of production while promoting decreased use of pesticides (or at least limited increases). Farmers are also trained to oversee quality control during harvesting and commercialization, and to identify potential clients who can make a verbal commitment to buy their produce as long as the required standards are met.

Our main interest in evaluating the *Plataformas* project is to determine the feasibility of linking smallholders to the new agricultural economy in a context in which they have little obvious comparative advantage. The approach seeks to lower transaction costs and to improve overall cost-effectiveness through creating a support system to facilitate smallholder entry into this market. The three hypotheses we wish to test are: (1) participating in the *Plataformas* has increased farmers' welfare as measured by potato yields and gross margins; (2) greater potato sales and higher prices are the primary mechanism through which the program has improved welfare; (3) although high-value markets require high product quality, participation has not led to health or environmental degradation as measured by levels of agrochemicals used, their toxicity, precautions taken in their applications, and changes in varietal use. The methods for testing these hypotheses are discussed in the next section.

Empirical Approach and the Search for a Counterfactual

The key to identifying and measuring the impact of *Plataformas* participation is to have a proper counterfactual—that is, a comparison (control) group that is similar to the intervention (treatment) group in all ways except that it did not receive the intervention. The empirical problem faced in this analysis is thus the typical one of missing data to fill in the counterfactual; that is, it is not known what the outcomes for participants would have been had they not participated. In experimental studies, households are randomly assigned to treatment and control ex ante and, given a sufficiently large sample size, it is reasonable to assume that the treatment and control are alike in all ways except in receiving the intervention. When assessment studies are set up ex post (after project implementation) and not as part of project design, experiments are not possible and nonexperimental methods must be used to identify impact. This section describes the steps taken to ensure quality data to construct a proper counterfactual was collected, followed by a description of the empirical approach used in the analysis.

Data Collection

The data used in this analysis come from household- and community-level surveys that were administered from June to August 2007 in the Ecuadorian provinces of Chimborazo and Tungurahua. Before administering the surveys, a series of steps were taken to facilitate an evaluation of the program. First, participating communities (treatment communities) were identified in each province and information on these communities was obtained. Second, using the 2001 Ecuador census data (INEC 2001), the treatment communities and a set of potential control communities with similar geographic, agroecological, and sociodemographic characteristics were identified. This provided a list of all possible treatment and control communities to be included in the survey. Third, using propensity-score matching (PSM) (described more fully below), control communities that were most comparable to treatment communities were identified—that is, control communities with similar propensity scores to the treated communities were kept as the potential set of communities for the sample. Fourth, the resulting list of potential control communities was discussed with key local organizations that had a central role in the *Plataformas* to determine if they were indeed comparable to the treatment communities. Some of the key characteristics considered were similarities in agricultural production, agroecological traits, and levels of community and farmer organization. Thus, the PSM selection was fine-tuned by local agronomists and leaders of organizations that had local knowledge. Through this process, the best control communities were identified. Further, treatment communities with distinct characteristics with no comparable control communities were excluded from the sample. The final community list contained 35 communities (18 treatment and 17 controls).

Within each treated community, there are community members who participate in the program and others who do not (nonparticipants). There are two concerns about including nonparticipants in the treatment communities as part of the counterfactual. First, they may have chosen not to participate and therefore may be fundamentally different from the participants. The fact that participant and nonparticipants self-select can lead to a potential bias in estimates of impact since the estimates may reflect fundamental differences between the two groups rather than the impact of the program. Second, since they live near beneficiaries they may obtain indirect benefits from the program (spillover effects). For both these reasons, using solely these households as a control group is potentially problematic. Yet, this is likely a useful group because their observable characteristics are probably similar to participants and so they were included in the sample. The final sample, therefore, includes three sets of households: (1) *beneficiaries* of the program, (2) nonbeneficiaries in the treatment communities (referred to as *nonparticipants*), and (3) nonbeneficiary households in the control communities (referred to as *noneligible*). Lists of households from each of these subgroups were provided by *Plataformas* coordinators and community leaders. Households were randomly selected to be included in the sample. The final sample includes a total of 1,007 households of which 683 reside in treatment communities (324 beneficiaries and 359 nonparticipants) and 325 in control communities (noneligible). Of those, full information on the potato-production cycle is available for 660 households.[2]

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[2] In this region, potato production can be conducted year round. Treated and nonbeneficiary households appear to be equally likely to have completed the production cycle and there are no systematic differences found between households that have completed the production cycle versus those that had not yet completed it, suggesting this should not influence results.

This sampling strategy allows for different comparison groups, each offering interesting insights. The ideal comparison group partly depends on whether there are spillover effects on nonparticipants. If there are such effects, including nonparticipants in the counterfactual would lead to an underestimation of program impact (Angelucci and Attanasio 2006). If spillover effects are substantial it may be desirable to include nonparticipants as treated households (intent to treat group: ITT) to get the total effect (direct and spillover effect) of the program and use only noneligible households as a counterfactual. These different options are considered below.

Empirical Approach

With the available data, four methods are used to identify impact: ordinary least squares (OLS), propensity-score matching (PSM), propensity score weighted least squares (WLS), and instrumental variable (IV) regression. The reason for these multiple methods is to ensure a reasonable level of confidence in our impact estimates. The methods and underlying assumptions are presented below. The approach also includes exploring alternative counterfactual groupings to determine the role of spillover effects. Ultimately, we argue that results are consistent when using approaches based on selection on observables (PSM and WLS), as well as when using an approach that deals with unobservables (IV). Further, we argue that spillover effects are minimal and that the main source of potential bias is related to program selection of beneficiaries.

The first approach is a standard OLS regression framework where the program impact on outcome variable Y_i can be determined by:

$$Y_i = \beta X_i + \alpha d_i + \varepsilon_i \qquad (1)$$

where $d_i = 1$ if households participate, 0 otherwise;
X_i is a set of exogenous variables including socioeconomic characteristics of the households, agroecological conditions, geographic and location effects, and so forth;
α measures the treatment effect for household i;
β defines the relationship between X_i variables and Y_i; and
ε_i is the error term.

This formulation assumes that the outcomes are linear in parameters and that the error term is uncorrelated with the exogenous variables X_i and with treatment. Conditional on these X variables, if the control group is like the treatment group in all characteristics except for having received the program, α, the measure of treatment's effects provides an unbiased estimate of the program effect. However, d_i may be correlated with the error term ε_i leading to a biased estimate of the treatment effect α since it may capture not just the impact of the program but differences between treated and control households (Ravallion 2005). If the source of the problem is program-placement bias—differences due to characteristics of the household the program deemed desirable—the differences are more likely to be observable. If self-selection bias is the issue—certain types of households chose to enter into the program—the differences are more likely to be unobservable.

Assuming the source of bias is observable, a way to obviate the problems outlined above is offered by our second method, the PSM approach. The main contribution of PSM[3] is to construct a control group that has similar observable characteristics (X_i) to the treated group, through a predicted probability of group membership calculated through a logit or probit regression, and then compare the outcomes. Given the unconfoundedness assumption (Rosenbaum and Rubin 1983) or selection on observables assumption (Heckman and Robb 1985), if we call YT_i the value of the outcome for the treated household and YC_i the value of the outcome for the control, these are independent of the treatment (d_i) but conditional on a set of observable characteristics X_i.

$$(Y_{Ti}, Y_{Ci} \perp d_i) \mid X_i \tag{2}$$

Since matching on X_i is the same as matching on the probability of being treated $P(X_i)$ (Rosebaum and Rubin 1983), all dimensions of X_i can be summarized into a predicted probability of being treated:

$$P(X_i) = Pr(d_i = 1 \mid X_i) = h\,(x'_i b) \tag{3}$$

where h is the standard normal distribution function.

Households in the untreated group that have a very similar probability of participating would be used as controls for their treated counterparts. So the effect of the treatment on the treated α can be defined as:

$$\alpha = E(Y_{Ti} - Y_{Ci} \mid P(X), d = 1) \tag{4}$$

Conditioning on the propensity score results in the balancing of covariates across treatment and control groups, thus focusing the analysis on the area of common support by dropping those observations without a clear match. Further, PSM evades the arbitrary linear-in-parameters form of an OLS approach (Ravallion 2005). Heckman et al. (1996), Heckman, Ichimura, and Todd (1998), and Dehejia and Wahba (1999, 2002) show that PSM does

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[3] See, for example, Heckman, Ichimura, and Todd (1998); Imbens (2004); Ryan and Meng (2004); Ravallion (2005).

well in replicating experimental results provided researchers have access to a rich set of covariates or control variables and use the same survey instruments. These two requirements are fulfilled in this case since the collected data, as described in the next section, are rich in information, and were obtained using the same survey for treatment and control households. In the PSM approach, a common method of determining the statistical significance of results is to use bootstrapped standard errors since it provides reliable standard errors for all of the matching estimators and also accounts for the fact that the balancing score is estimated (Diaz and Handa 2006). Bootstrapped standard errors are therefore used to test the significance of the PSM estimates of impact.

An alternative to PSM, particularly when control and treatment, although not randomly assigned, are reasonably comparable, is a WLS method using weights calculated by the inverse of the propensity score (Sacerdote 2004; Todd, Winters, and Hertz 2010). Weighting by the inverse of the estimated propensity score has been demonstrated to achieve covariate balance and, in contrast to matching and stratification/blocking, uses all observations in the sample (Sacerdote 2004). Following Hirano and Imbens (2001), weights are calculated as follows:

$$\omega(T, C) = \frac{d_i}{p(X_i)} + \frac{(1 - d_i)}{1 - p(X_i)} \tag{5}$$

where $p(X_i)$ are the estimated propensity scores calculated as in equation (3), above.

Using equation (5), the weights created can be used to adjust the distribution of the two populations of interest (participants and nonparticipants) to help account for the area of common support. The weights imply a greater emphasis on those treated households with lower scores and control households with higher scores. Further a regression framework as expressed in equation (1) can be used where X_i is included as a set of covariates and where standard tests of significance can be used (Robins and Rotnitzky 1995; Hirano and Imbens 2001). This approach retains full information from all households, while using weights ensures no correlation between treatment and covariates leading to a consistent estimate of the average treatment effect (Imbens 2004).

Each of these three approaches relies on an assumption of exogeneity, namely that program participation is exogenous to outcomes given a rich set of observable covariates X_i. When this assumption holds, treatment effects can be estimated without bias using observed estimands. Although we are reasonably confident that this assumption holds, to explore the possibility of estimates being biased by unobservable differences between treatment and control groups, an IV approach is also used. An IV approach allows relaxing the exogeneity assumption, but requires identifying an instrument, Z_i, which is correlated with program participation but uncorrelated with the error term (that is, would not capture the bias associated with unobservable differences between treatment and control). In an IV approach, two stages are estimated as follows:

$$\begin{aligned} &\text{Stage 1:} \quad d_i = \delta Z_i + \varphi X_i + v_i \\ &\text{Stage 2:} \quad Y_i = \beta X_i + \alpha d\_hat_i + \varepsilon_i \end{aligned} \tag{6}$$

where

δ defines the relationship between instrument Z_i and *Plataformas* participation;

φ defines the relationship between instrument X_i and *Plataformas* participation;

d_hat_i is predicted participation in the *Plataformas* as estimated from the first stage;

v_i is the error term in the first stage;

and remaining variables are as previously defined.

The first stage is estimated as a linear probability model. Angrist (2000) suggests this approach when the first stage is a limited dependent variable model and argues that it is consistent and safer since predicting using a probit in the first stage is only consistent if the model is exactly correct. The main advantage of using an IV approach, when a valid instrument can be found, is that it deals with potential bias from observable and unobservable differences in control and treatment. In addition, the method can be used to test the exogeneity assumption used in PSM and OLS (Ravallion 2005).

To summarize, for the indicators analyzed (Y_i) that test the hypotheses noted in the previous section, these four empirical approaches are employed. This allows for a clear assessment of the impact of the program. The next section presents the data used to conduct these analyses.

Data

Two survey instruments (household and community) administered in the field were developed using qualitative information gathered by means of value-chain analysis, stakeholder consultations, and focus-group discussions.

Several revisions of the survey instruments were done based on field testing and conversations with key informants from the two study regions. The household survey included demographic information, economic and financial conditions of the households, social capital information, and agricultural production data, including detailed information on potato production. The community survey included information on the overall community population characteristics, access to infrastructure, and community organization.

Household Characteristics

Table 12.1 presents descriptive statistics of household characteristics along with *t*-test of difference for equality of means for the various counterfactual groups. Beneficiaries are contrasted with nonparticipants and noneligible households, as well as with the whole group of nonbeneficiaries (that is, nonparticipants plus noneligibles). The *t*-test of difference for equality of means provides evidence of significant differences among the groups, offering an initial assessment of which group may represent a better counterfactual. The table presents statistics for 660 households used in the analysis for which full information on an entire production cycle is available.[4] In the interest of space, the details of the descriptive statistics are not discussed and we focus only on a few key characteristics, and overall on the evidence regarding whether the survey design and data collection created a reasonable counterfactual. The exception is the social-capital variables which played a key role in the formation of the *Plataformas* and are therefore discussed in more detail.

Examining the first three sections of Table 12.1, the results suggest that households in the sample have many of the characteristics of smallholders in the Andes. They have limited amounts of land (2.58 hectares of land with less than half dedicated to potato cultivation), which tend to be spread across a few (about three), often steep plots. Household heads tend to be indigenous (62 percent) and have limited levels of education (around five years) with an average family size of nearly five members. Asset ownership is generally limited and diverse, so a PCA has been conducted to construct variables for assets ownership, grouped as durable assets, agricultural assets, and livestock. Although households tend to own their own homes and have access to a water system (95 percent), many have limited access to a sewage system (7 percent) and modern methods of cooking (54 percent cook with electricity or gas). Among the land, sociodemographic, and welfare variables, most do not show

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[4] See footnote 2.

TABLE 12.1 Descriptive statistics

Variable	Whole sample	Beneficiaries	Nonparticipants	$P(\lvert T\rvert > \lvert t\rvert)$	Non-elig.	$P(\lvert T\rvert > \lvert t\rvert)$	All nonbeneficiaries	$P(\lvert T\rvert > \lvert t\rvert)$
Land								
Altitude (m.a.s.l.)	3,458	3,448	3,461	.701	3,466	.617	3,463	.613
Land owned (ha)	2.58	2.55	2.04	.106	3.14	.115	2.59	.891
Owned plots (no.)	2.97	3.25	2.55	.001***	3.11	.502	2.83	.016**
Black soil (%)	79	77	80	.407	81	.240	81	.242
Flat land (%)	39	38	40	.446	40	.516	40	.420
Irrigated land (%)	57	54	57	.499	61	.135	59	.214
Sociodemographic								
Family size	4.71	4.79	4.77	.905	4.57	.241	4.67	.448
Average education HH head	4.96	5.24	4.91	.342	4.74	.169	4.82	.176
Indigenous HH head (%)	62	58	59	.766	68	.020**	64	.133
Female HH head (%)	12	12	12	.766	13	.827	12	.939
Age of HH head	42.3	42.2	40.33	.143	44.38	.105	42.35	.901
Dependency share (%)	29	29	31	.332	27	.399	29	.929
Welfare								
Durable assets	0.013	0.040	–0.025	.474	0.025	.874	0.00	.623
Agricultural assets	–0.005	0.129	–0.095	.033**	–0.048	.125	–0.07	.014**
Livestock	0.067	0.063	–0.036	.297	0.174	.300	0.07	.950
Own house (%)	86	84	88	.234	87	.374	87	.223
Concrete/brick house (%)	87	83	90	.041**	90	.043**	90	.015**
Access to water system (%)	95	92	94	.413	97	.016**	96	.060*
Access to sewage system (%)	7	6	7	.743	7	.600	7	.627

Variable	Whole sample	Beneficiaries	Nonparticipants	P(|*T*| > |*t*|)	Non-elig.	P(|*T*| > |*t*|)	All nonbeneficiaries	P(|*T*| > |*t*|)
Cook with electricity/gas (%)	54	57	54	.518	52	.285	53	.323
Distance to closest city (km)	29.38	27.13	25.46	.171	35.53	.000***	30.49	.025**
Social capital								
Participate in nonagricultural association in community (%)	83	82	83	.815	84	.639	84	.684
Participate in agricultural association in community (%)	23	43	14	.000***	14	.000***	14	.000***
Nonagricultural associations in community								
Membership (max. no. years)	9.54	9.97	8.60	.129	10.06	.921	9.33	.405
Meetings (no./year)	32.46	32.32	33.18	.808	31.88	.892	32.53	.944
Agricultural associations in community								
Membership (max no. years)	6.57	3.96	10.03	.000***	11.06	.000***	10.56	.000***
Meetings (no./year)	16.56	16.82	12.77	.189	19.45	.433	16.16	.794
Before *Plataformas* (five years prior to surveys)								
Agricultural associations in community (%)	8	7	8	.938	8	.918	8	.920
Membership (max. no. years)	17.29	15.20	17.00	.585	18.88	.311	17.94	.404
Meetings (no./year)	14.74	21.30	12.69	.144	12.69	.167	12.69	.084*
Outside associations								
Nonagricultural associations (%)	17	17	18	.887	16	.782	17	.969
Agricultural associations (%)	7	4	5	.512	7	.231	6	.773
Observations	**660**	**217**	**222**		**221**		**443**	

Source: Authors' calculation using survey data.

Note: HH = household; probability: * ≤.1,** <.05, *** <.01.

statistically significant differences between the beneficiary group and any of the nonbeneficiary groupings. The few variables that are significantly different have similar magnitudes and could potentially be controlled for in the analysis. In general, the first part of Table 12.1 shows that the most similar possible control group would be the group of nonparticipants, since they have the fewest differences from the beneficiaries. However, even the noneligible group seems to be reasonably comparable to the beneficiaries. The entire group of nonbeneficiaries thus is a reasonable counterfactual and it offers a greater number of farmers highly comparable to the beneficiaries.

Moving to the social capital section of Table 12.1, a broad set of variables is presented since social capital was a key element in the *Plataformas* program. These show that participation in nonagricultural community associations is quite high (83 percent) and over three times the membership in agricultural community associations. While membership in nonagricultural associations is not different across the groupings, the membership in an agricultural association does show statistically significant differences: while 43 percent of beneficiaries belong to an agricultural association, the percentage adds up to 14 percent for both nonparticipants and noneligibles. At first glance, these results would indicate that there is something fundamentally different about the group of beneficiaries who participate in an agricultural association at higher rates than the possible control groups. However, while the *Plataformas* allowed all individuals and households to participate in the program, the program gave preference to those in associations. Thus, before joining the *Plataformas*, farmers may have been members of existing associations, may have joined existing ones, or may have formed new groups. This may explain the differences in the percentages of those who belong to an agricultural association across the three groups compared in Table 12.1.

A way to corroborate this hypothesis is to use data on the number of years that farmers have belonged to an agricultural association. If beneficiaries joined, or formed an agricultural association to qualify for the *Plataformas*, the maximum number of years belonging to such an association would be expected to be less than five years before the implementation of the surveys, which is when the *Plataformas* were introduced in Tungurahua and Chimborazo. We would expect then that beyond five years prior the survey, the levels of social capital would be very similar across groups.

To this end, the bottom part of Table 12.1 presents an additional set of social-capital variables. First, there are no statistically significant differences in the number of years of membership and frequency of meetings for participation in nonagricultural associations. However, for agricultural associations, while the number of meetings per year is not significantly different, membership is a relatively new event for beneficiaries who have been members for 3.96 years on average, as opposed to 10.03 years for nonparticipants, and 11.06 years for noneligibles. This seems to confirm that many beneficiaries recently joined an agricultural association. Another way to corroborate this is by looking at the rate of participation for those who have been part of an agricultural association for more than five years. The next set of variables confirms this as 7 percent of beneficiaries belonged to an agricultural association for more than five years versus 8 percent for nonparticipants and for noneligibles with all differences being statistically insignificant. Looking at the maximum number of years of membership for this subgroup, the data show that there are no differences across groups. Lastly, the final set of variables shows no statistically significant differences between beneficiaries and possible control groups in the rate of participation with outside agricultural and or nonagricultural associations. Based on this information, it is reasonable to assume that the differences that exist today across the groups are likely due to joining the *Plataformas*, which implies the willingness to create or strengthen social capital. Hence, potential unobservable differences, if existing, are likely to be captured by the social-capital variables that best proxy this selection criterion.

Indicator Variables

To test the hypotheses being tested, the following three sets of indicators are analyzed: (1) *primary indicators,* expressed by log of total harvest per hectare and gross margins per hectare; (2) *mechanisms* through which primary objectives were reached, or why they were not reached; and (3) *secondary indicators* arising from participation, particularly related to use, knowledge, and practice of precautionary measures in agrochemical applications, and other environmental impacts. Table 12.2 presents these indicators.

Among the primary indicators, the amount of potato produce harvested per hectare is the most direct indicator of productivity. The log of the quantity harvested is used and analyzed due to the expectation that the data are log normal. On average, the harvest per hectare is 7,006 kg or 7.94 in logarithms. Gross margins express returns to fixed factors of production, which provide a good indication of profitability, and are calculated as the total value of harvest minus the total variable costs incurred for their production. On average farmers earn US$112 per hectare of potatoes harvested.[5]

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[5] All monetary indicators are in US dollars.

TABLE 12.2 Program impact indicators

Indicator	Whole sample
Primary indicators	
Log of total harvest (kg/ha)	7.94
Gross margins (US$/ha)	112.72
Mechanisms	
Total potatoes sold (share of harvest)	0.45
Value of potatoes harvested ($/ha)	763.49
Price of potatoes sold ($/kg)	0.11
Time of transaction (hours)	1.29
Input costs ($/ha)	650.77
Cost of paid labor ($/ha)	97.48
Cost of seeds purchased ($/ha)	48.55
Value of seeds planted ($/ha)	181.45
Secondary indicators	
Preventive fungicide applied (kg or l/ha)	3.15
Curative fungicide applied (kg or l/ha)	4.16
Insecticides applied (kg or l/ha)	2.22
Cost of chemical fertilizer ($/ha)	124.68
Cost of organic fertilizer ($/ha)	46.04
Applies traps (%)	26.7
Environmental impact quotient	95.24
Can identify most toxic products (%)	34.1
Always uses plastic poncho (%)	13.0
Always uses mask (%)	6.4
Berger index of diversity	1.45
Most used variety—Fripapa (%)	29.0
Observations	**660**

Source: Authors' calculation using survey data.

There are multiple mechanisms through which farmers could increase yields and the income they generate from potato production. One key mechanism is through improved returns to potato production that can be obtained through selling more potatoes, getting a higher price for those potatoes, or requiring less time to sell. Four indicators for this mechanism are presented: (1) percentage of potato sold per hectare, (2) value of potato production, (3) price of sale, and (4) time required for sales transactions. Households on average sell almost half of their potato harvest (45 percent), which has a total value of $763 per hectare and sells at a price of about $0.11 per kg. On average, it takes 1.29 hours to sell their potatoes. The *Plataformas* also worked on the input side of the supply chain, introducing and supplying the most market-demanded varieties of which INIAP-Fripapa (hereafter referred to as Fripapa) represents the main variety. Changes in gross margins could reflect a change in input costs, while changes in yields could be due to additional input use and/or better farming practices. Four cost indicators are used to explore this mechanism. The average total input cost for households is $650 per hectare, of which $97 is paid labor costs per hectare, and $49 purchased seeds per hectare. The average value of seeds planted, however, is over three times that amount at $181 per hectare, suggesting that much of the seed is not purchased.

The secondary indicators capture the possible side effects of participation. The first set, which incorporates both health and environmental impacts, is the use of agrochemicals. To avoid increased agrochemical use and minimize their negative effects, FFS introduced an IPM approach that combines good management practices, including the use of insect traps for Andean weevil (*Premnotrypes vorax*), with the use of low-toxicity pesticides. Nevertheless, to comply with standards required, farmers might be inclined to use more pesticides and chemical fertilizers to make sure harvested output is of a required physical quality (Orozco et al. 2007). To explore these possibilities, the amount of preventive and curative fungicides, the amount of insecticides, and the costs of chemical fertilizers are considered. Further, alternatives to chemical inputs, namely the cost of organic fertilizer and use of traps, are also examined.

FFSs teach the different risks associated with the toxicity of agrochemicals, how to recognize toxicity levels of a product, and what precautions to use. The expectation is that participants use less-toxic pesticides, and that farmers recognize toxicity levels and take more precautions when applying agrochemicals. The methodology proposed by Kovach et al. (1992) was used to assess the environmental impact of pesticides. The environmental impact quotient (EIQ), which accounts for the toxicity level of the active ingredients of each agrochemical, was gathered and aggregated according to the field rate and concentration of each, obtaining the total environmental impact (TEI) per ha. The average value of the TEI is 95.

An indicator of knowledge of toxicity level is also included, and on average 34 percent of farmers can identify the most toxic products. A selected set of indicators for the use of protective gear is also reported. Data show that the percentage of households that use protective measures is in general very low, with 13 percent of farmers interviewed using plastic ponchos and only 6 percent using masks.

The final secondary indicators are related to the rate of agrobiodiversity maintained at the household level—that is, how the composition and share of potato varieties change due to market participation. The *Plataformas* focus on commercial varieties, and theory suggests that as farmers shift to market varieties and begin to specialize, the overall number of varieties cultivated is reduced (Pingali and Rosegrant 1995; Pingali 2001) even though this does not necessarily imply genetic erosion (Smale 1997). The Berger–Parker index of inverse dominance, which expresses the relative abundance of the most common species (Magurran 1988; Baumgärtner 2006), is reported.[6] Also included is the share of potato area planted with the Fripapa variety, a key variety promoted through the *Plataformas*, which at the time of the survey was the dominant variety in 29 percent of cases.

Analysis and Results

As noted, the approach used to select communities for inclusion in the sample focused on establishing a good counterfactual. To avoid remaining biases requires controlling for any further differences between treatment and control groups. Discussions with key informants and program leaders suggested that social capital is the key factor of program participation, and the data presented earlier support this. In particular, whether a household participated in an agricultural association for more than one year appears to capture the differences between treatment and control households. Since this is closely related to participation in the Plataforma, controlling for this variable in the regression model or using it in PSM should ensure controlling for those unobservables that may have driven certain households to participate. The assumption is that this variable is correlated with unobservables related to being an "organization joiner," which compels households to join the program, and thus any bias associated with self-selection should be eliminated. This variable is included in each of the regressions.

Since there remains the possibility of potential unobservable differences and, therefore, biased impact estimates, an IV approach is also employed as per equation (6). Finding a suitable and valid instrument is often a challenge, but a common solution used in impact evaluation is to use the intention to treat (ITT), since all households in the treated communities had the option to enter the program but not everybody participated (Galasso, Ravallion,

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[6] Additional diversity indexes (Shannon and Margalef) were used with similar results; these are not presented here.

and Salvia 2001; Ravallion 2005; Oosterbeek et al. 2008). Provided that we control for location-specific effects which might have a direct effect on outcomes, this should be a good predictor of participation. The eligibility criteria are shown to be, indeed, a valid instrument in our case being the instrument (ITT) highly significant in the first stage and the instrumented variable highly significant in the second stage. We also checked the null hypothesis that the instrument is weak and reject this hypothesis as it passes the rule of thumb that the F statistic for excluded instruments is higher than 10. Lastly, the endogeneity test accepts the null hypothesis that *Plataformas* can be treated as exogenous to our specification, thus supporting the exogeneity assumption needed in the PSM and WLS.[7]

For each of the four specifications presented, all nonbeneficiaries are used as the potential counterfactual group and results are reported in Table 12.4. In general, the four approaches provide robust results suggesting impact estimates are accurate. Since all nonbeneficiaries are used for this first set of results, they may be lower bound estimates due to the possibility of spillover effects of the program on nonparticipants in the treatment communities. Even if there are spillover effects, they are likely to be small, since nonparticipants would not have obtained the benefits of market access, which appear substantial, and instead are only likely to receive indirect benefits from improved access to seed and transmission of new production technologies. Nonetheless, to make sure no spillover effects are found, we consider additional counterfactual groups within the WLS framework. These include noneligibles, nonparticipants, as well as the ITT group (beneficiaries and nonparticipants) contrasted with the noneligibles. The benefit of this last approach is that it potentially captures both direct and spillover effects. These results are presented in Table 12.5. Before proceeding with a discussion of these two sets of results, the probit on participation is first examined.

Participation in the *Plataformas*

Table 12.3 reports the results of the probit on *Plataformas* participation with marginal effects calculated at the sample mean. The model accurately predicts

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[7] With regard to the identification strategy, no tests for overidentification can be run since, given one instrument, the equation is exactly identified. To verify the endogeneity assumption, a test under the null hypothesis that the specified endogenous regressors (participation in the Plataforma) can actually be treated as exogenous has been run. The test statistic is distributed as chi-squared with degrees of freedom equal to the number of regressors tested and defined as the difference of two Sargan–Hansen statistics: one for the equation with the smaller set of instruments, where Plataforma is treated as endogenous; and one for the equation with the larger set of instruments, where Palataforma is treated as exogenous.

TABLE 12.3 Probit on *Plataforma* participation

LR chi²(26) = 84.37
Prob > chi² = 0.0000
Log likelihood = –375.80489 Pseudo R^2 = 0.1009

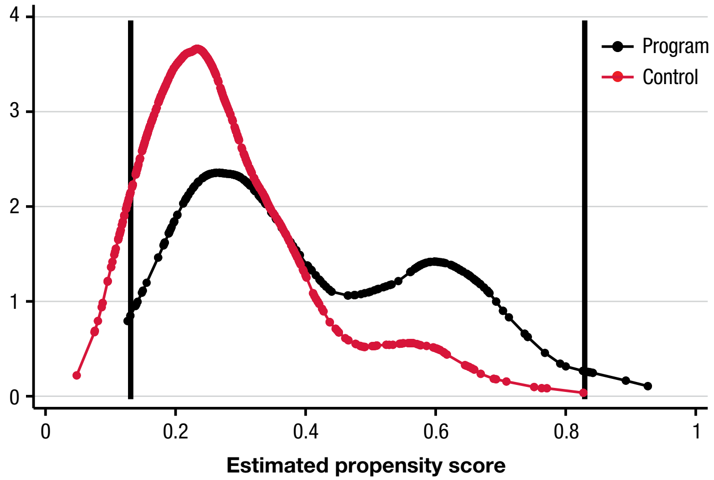
Parameter	dF/dx	P>|z|
Land owned (ha)	–0.004	.506
Owned plots (no.)	0.031	.003***
Black soil (%)	–0.048	.451
Flat land (%)	–0.068	.216
Irrigated land (%)	–0.076	.156
Family size	0.010	.369
Average education of HH head	0.006	.338
Indigenous HH head	–0.027	.549
Female HH head	0.011	.860
Age of HH head	0.000	.964
Dependency share	0.056	.631
Livestock	–0.015	.488
Agricultural assets	0.041	.068*
Durable assets	–0.004	.876
House	–0.043	.500
Concrete/brick house	–0.131	.051*
Access to water system	–0.200	.025**
Sewage	–0.087	.258
Cook with electricity/gas	0.076	.084*
Distance to closest city (km)	–0.003	.049**
Altitude	0.000	.846
Chimborazo	–0.065	.307
Agricultural association (>1 year)	0.327	.000***
Nonagricultural association	–0.015	.774
External agricultural associations	–0.021	.786
External nonagricultural associations	–0.007	.901
Observations		660
Sensitivity (%)		34.56
Specificity (%)		90.07
Positive predictive value (%)		63.03
Negative predictive value (%)		73.75
Correctly classified (%)		71.82

Source: Authors' calculation using survey data.
Note: HH = household.

71.8 percent of outcomes and shows the importance of a number of variables. The differences are as expected and reflect those reported in Table 12.1. Membership of an agricultural association within the community for more than a year is significant and has the expected sign.

Using the probit results, propensity scores are calculated for the treatment and control group. Figure 12.1 shows the kernel-density estimates of the distribution of estimated propensity scores for each group. The scores obtained are almost entirely in the area of common support, suggesting that nonbeneficiaries represent a reasonable counterfactual to the treated population.[8] Furthermore, Appendix Table 12A.1 reports the punctual test of means showing a dramatic reduction of significant differences between the two groups and demonstrating the capability of the method to balance the baseline covariates and to make the two groups highly comparable. Nevertheless, the difference in mean propensity score across the treatment and control groups (mean of 0.37 in the treatment group versus 0.29 in the control group, P <.000) implies that simply conditioning on *X* through an OLS specification

FIGURE 12.1 **Kernel distribution and common support area across the two groups**



Source: Authors' calculation using the "Linking small farmers to the new agricultural economy data" set.
Note: The common support area is marked within the black vertical lines.

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[8] Figures assessing the common support for all possible counterfactual options were also constructed but are not reported as they all consistently suggested a similar area of common support, indicating high similarity across groups. For simplicity, only one figure is presented. The consistency of the common support across potential control groups is corroborated in the results of the various analyses presented in this section.

might not yield the correct average treatment effect if this effect is in fact heterogeneous. Given these results, PSM, WLS, and IV estimates are considered to ensure an unbiased estimate of impacts.

Assessing Results

Table 12.4 presents the results of the analysis using the OLS, PSM, WLS, and IV approaches reporting the impact estimate of *Plataformas* participation (α) on the indicator of interest (Y_i). Table 12.5 reports results using the WLS, which we think best represents and approximates impacts, for the alternative counterfactual groups. The results are remarkably consistent across specifications (Table 12.4) and make sense for the different counterfactual groupings (Table 12.5), indicating that the program effects are well identified.

Table 12.4 shows that both primary indicators, log of yields and gross margins, are positively and significantly influenced by participation in the program with the estimated differences being similar and significant across specifications. Gross margins per hectare are around \$200 higher for participants, which are substantial given average margins are only around \$100 per hectare (see Table 12.2). The findings in Table 12.5 suggest results are similar even when using different counterfactual groupings. The results using the nonparticipants suggest there are few or no spillover effects and indicate that participating in the *Plataformas* program is associated with a successful welfare improvement for beneficiary farmers.

The mechanisms leading to these results show that beneficiaries sell more of their harvest compared to nonbeneficiaries and at a significantly higher price, thus obtaining a greater value. Prices obtained are indeed about \$3 per metric quintal more than nonbeneficiaries, corresponding approximately to 30 percent higher price if looking at the differences in prices (Table 12.2). The results on the difference in the time taken for the transaction are mostly insignificant, although the IV results suggest they are lower. Table 12.4 shows that, overall, total input costs do not appear to be significantly higher for the beneficiaries; however, seeds purchased and used are significantly higher for treated households and for most specifications so are labor costs (the exception being the IV results).

Moving to the secondary indicators of Table 12.4, the increased use of some inputs suggests possible environmental and health problems if it is linked to increased use of agrochemicals. The evidence is somewhat mixed, but does not seem to imply a widespread problem. Beneficiaries do not use significantly more fungicides, but do use more insecticides (although not according to the IV results) and chemical fertilizers. Findings suggest, however, that

TABLE 12.4 Impact of *Plataformas*

Indicator	OLS		PSM, kernel		PS weighted LS		IV	
	Diff.	P>|z|	Diff.	P>|z|	Diff.	P>|z|	Diff.	P>|z|
Primary indicators								
Log of total harvest (kg/ha)	0.55	.000***	0.55	.000***	0.58	.000***	0.85	.003***
Gross margins (US$/ha)	215.19	.008***	237.56	.002***	184.82	.010***	243.33	.069*
Mechanisms								
Total potatoes sold (share of harvest)	0.08	.002***	0.09	.005***	0.09	.001***	0.10	.070*
Value of potatoes harvested ($/ha)	362.50	.010***	419.47	.001***	368.07	.001***	365.62	.111
Price of potatoes sold ($/kg)	0.03	.000***	0.03	.000***	0.03	.000***	0.04	.000***
Time of transaction (hours)	0.02	.909	0.011	.947	–0.02	.876	–0.62	.041**
Input costs ($/ha)	147.31	.272	181.91	.250	183.25	.075*	122.29	.562
Cost of paid labor ($/ha)	49.30	.028**	72.25	.008***	44.10	.039**	–11.36	.823
Cost of seeds purchased ($/ha)	45.51	.008***	51.45	.003***	37.86	.022**	71.62	.016**
Value of seeds planted ($/ha)	87.59	.009***	93.04	.007***	91.44	.008***	117.24	.058*
Secondary indicators								
Preventive fungicide applied (kg or l/ha)	–0.50	.485	–0.36	.588	–0.28	.636	–2.16	.172
Curative fungicide applied (kg or l/ha)	–0.25	.802	0.10	.905	–0.51	.651	–5.41	.147
Insecticides applied (kg or l/ha)	1.00	.098*	0.92	.120	1.21	.051*	0.52	.538
Cost of chemical fertilizer ($/ha)	38.50	.033**	44.66	.011**	40.67	.020**	63.33	.063*
Cost of organic fertilizer ($/ha)	15.50	.262	18.45	.352	16.50	.162	51.30	.016**
Applies traps (%)	0.50	.000***	0.50	.000***	0.51	.000***	0.57	.000***
Total environmental impact quotient (TEI/ha)	–31.03	.343	–28.45	.401	–22.71	.356	–116.69	.081*
Can identify most toxic products (label color) (%)	37	.000***	39	.000***	36	.000***	46	.000***
Always uses plastic poncho (%)	7	.026**	7	.044**	7	.035**	7	.218
Always uses mask (%)	4	.059*	5	.055**	4	.085*	2	.560
Berger index of diversity (%)	0.00	.969	0.01	.909	0.00	.933	0.04	.724
Most used variety—Fripapa (%)	35	.000***	36	.000***	35	.000***	30	.000***
Observations	**660**		**660**		**660**		**660**	

Source: Authors' calculation using survey data.

Notes: Diff. = difference in means; probability: * ≤.1, ** <.05, *** <.01.

TABLE 12.5 Comparison of alternative control groups (using propensity-score weighted least squares)

Indicator	Participants vs nonbeneficiaries		Participants vs noneligible		Participants vs nonparticipants		ITT vs noneligible	
	Diff	P>|z|	Diff.	P>|z|	Diff.	P>|z|	Diff.	P>|z|
Primary indicators								
Log of total harvest (kg/ha)	0.58	.000***	0.73	.000***	0.47	.002***	0.47	.005***
Gross margins (US$/ha)	184.82	.010***	170.68	.034**	186.11	.028**	110.69	.077*
Mechanisms								
Total potatoes sold (share of harvest)	0.09	.001***	0.10	.003***	0.09	.004***	0.07	.014***
Value of potatoes harvested ($/ha)	368.07	.001***	417.54	.001***	414.76	.000***	232.51	.019**
Price of potatoes sold ($/kg)	0.03	.000***	0.03	.000***	0.03	.000***	0.02	.019**
Time of transaction (hours)	–0.02	.876	–0.15	.404	0.13	.462	–0.28	.049**
Input costs ($/ha)	183.25	.075*	246.86	.020**	228.65	.002***	121.82	.124
Cost of paid labor ($/ha)	44.10	.039**	38.90	.164	66.03	.001***	8.71	.688
Cost of seeds purchased ($/ha)	37.86	.022**	49.76	.002***	39.80	.064*	34.88	.005***
Value of seeds planted ($/ha)	91.44	.008***	108.84	.004***	85.80	.007***	59.68	.026**
Secondary indicators								
Preventive fungicide applied (kg or l/ha)	–0.28	.636	–0.40	.551	0.31	.582	–0.68	.271
Curative fungicide applied (kg or l/ha)	–0.51	.651	–1.33	.408	1.04	.066*	–1.71	.227
Insecticides applied (kg or l/ha)	1.21	.051*	1.15	.052*	1.36	.031**	0.47	.196
Cost of chemical fertilizer ($/ha)	40.67	.020**	53.07	.008***	34.68	.075*	37.12	.018**
Cost of organic fertilizer ($/ha)	16.50	.162	36.52	.001***	2.82	.855	29.11	.010***
Applies traps (share)	0.51	.000***	0.54	.000***	0.49	.000***	0.29	.000***
Total environmental impact quotient (TEI/ha)	–22.71	.356	–29.67	.277	16.98	.176	–35.30	.135
Can identify most toxic products (label color) (%)	36	.000***	39	.000***	34	.000***	24	.000***
Always uses plastic poncho (%)	7	.035**	5	.159	7	.073*	3	.280
Always uses mask (%)	4	.085*	3	.295	5	.049**	1	.576
Berger Index of diversity (%)	0.00	.933	–0.02	.752	–0.02	.735	–0.02	.751
Most used variety—Fripapa (%)	35	.000***	32	.000***	36	.000***	14	.000***
Observations	**660**		**438**		**439**		**660**	

Source: Authors' calculation using survey data.

Notes: Diff. = difference in means; ITT = intention to treat group; probability: * ≤.1, ** <.05, *** <.01.

farmers are using less-toxic chemical mixes given that they are using more chemicals and the EIQ ratio is not significantly different from zero in any of the specifications, except for the IV where it is negative and moderately significant. The finding is also supported by the evidence that beneficiaries can identify toxic products better than nonbeneficiaries. This is most likely due to the training participants received in FFS. Additionally, traps for the Andean weevil are more commonly used by beneficiaries than nonbeneficiaries. Lastly, program participants are generally more likely to use protective gear as evidenced by a greater use of a plastic ponchos and masks (this result, however, does not hold for the IV result which is insignificant).

With respect to the potential losses of agricultural biodiversity as market demand pressurizes farmers to abandon traditional varieties, the evidence does not support this hypothesis as indicated by the insignificant impact on the agrobiodiversity indicator reported. Participants do seem to have switched to the Fripapa variety. Thus, *Plataformas* farmers seem to maintain the same diversity level although changing the primary market variety grown.

Linking Different Farmers to Market

Different organizations implemented the field training in the FFS in the two regions of Chimborazo and Tungurahua, however all trainers used the same methodology and curriculum. Likewise the process of incorporating farmers to the *Plataformas* was the same in both regions. Although Chimborazo and Tungurahua are both relatively poor areas, it is important to note that there are significant differences between the two. Data from the Ecuadorian National Institute of Statistics and Census shows that about 54.1 percent of the population in Chimborazo lived in consumption poverty in 2006, while only 36.2 percent lived in poverty in Tungurahua (INEC, 2005–2006). These differences are reflected in our own data where land variables as well as sociodemographic indicators suggest that, although both provinces are rather poor, farmers in Tungurahua are, on average, better off than their counterparts in Chimborazo owning more land and generally having higher socioeconomic indicators. It is reasonable to assume that these differences may be reflected in divergent results in the two regions.

To determine how well the *Plataformas* perform in each area, the analysis is done for each region. Table 12.6 shows results for the two provinces and seems to suggest that the effects of the *Plataformas* participation are stronger for farmers in Chimborazo who have clearer direct impacts: larger and strongly significant gross margins and a higher impact on harvest. In Tungurahua, on the other hand, while the signs for these indicators

TABLE 12.6 Impact by region (using propensity-score weighted least squares)

Indicator	Tungurahua		Chimborazo	
	Diff.	P>|*t*|	Diff.	P>|*t*|
Primary indicators				
Log of total harvest (kg/ha)	0.30	.060*	0.86	.000***
Gross margins (US$/ha)	25.53	.686	366.47	.004***
Mechanisms				
Total potatoes sold (share of harvest) (%)	7	.034**	9	.027**
Value of potatoes harvested ($/ha)	116.98	.151	672.28	.000***
Price of potatoes sold ($/kg)	0.02	.006***	0.04	.001***
Time of transaction (hours)	–0.14	.391	0.03	.925
Input costs ($/ha)	91.45	.109	305.80	.043**
Cost of paid labor ($/ha)	3.26	.776	95.31	.027**
Cost of seeds purchased ($/ha)	29.85	.021**	24.52	.375
Value of seeds planted ($/ha)	55.72	.001***	110.23	.032**
Secondary indicators				
Preventive fungicide applied (kg or l/ha)	0.20	.831	–0.51	.462
Curative fungicide applied (kg or l/ha)	–1.56	.363	–0.10	.949
Insecticides applied (kg or l/ha)	1.21	.107	1.23	.150
Cost of chemical fertilizer ($/ha)	29.51	.173	68.09	.022**
Cost of organic fertilizer ($/ha)	4.78	.445	22.21	.339
Applies traps (share)	0.55	.000***	0.46	.000***
Total environmental impact quotient (TEI/ha)	2.35	.944	–30.14	.310
Can identify most toxic products (label color) (%)	36	.000***	43	.000***
Always uses plastic poncho (%)	10	.047**	8	.054**
Always uses mask (%)	6	.056*	3	.415
Berger index of diversity	–0.07	.332	0.09	.132
Most used variety—Fripapa (%)	31	.000***	34	.000***
Observations	314		329	

Source: Authors' calculation using survey data.

Note: Probability: * ≤.1, ** <.05, *** <.01.

are positive, only the log of harvest per hectare is significantly (at 10 percent level of confidence) larger for participants. However, this difference does not translate into significantly higher gross margins. This is likely due to a combination of factors led by a smaller difference in productivity between beneficiaries and nonbeneficiaries but also by smaller differences in price of potato sold, in the percentage of produce sold, and in the value of produce harvested, although for both the former indicators differences are significantly higher for beneficiaries in both regions. It is interesting to note that beneficiary farmers in Tungurahua purchased a greater amount of seeds spending more than the control group, while the remaining input costs do not signficantly differ, as opposed to Chimborazo where participant farmers spent significantly higher amounts for inputs particularly in terms of hired labor. For the secondary indicators, the differences between the two groups are similar in both regions with the only exception of costs of chemical fertilizers that are significantly greater for participants in Chimborazo. Overall, *Plataformas* farmers are successfully adopting the new production approach in both regions, even though participation seems to be having a greater effect on participants in Chimborazo. These differences may suggest that poverty levels and/or financial constraints are more of an issue for farmers in Chimborazo. If this is the case, we might conclude that program participation is more effective for less endowed and more financially constrained farmers. However, it may be that other regional factors are playing a role.

To explore better whether the differences in results are due to greater benefits going to smallholders and less endowed participants, additional analyses by landholding size are included. Keeping in mind that generally all farmers have relatively small landholdings, we divide landholdings into small (less than 1 hectare), medium (1 to 5 hectares) and large (more than 5 hectares) landholdings. The results presented in Table 12.7 show that medium farms have been able to gain the largest benefits of the program, obtaining significantly higher yields and productivity which translates into higher gross margins. These have been achieved through a larger percentage of potato sold as well as through higher price gains of the produce sold, even though higher input costs, for both seeds and fertilizers, have been incurred. Beneficiaries with very small farms managed to harvest more than their control group and sold a significantly higher amount and share of potatoes, however these did not translate into higher gross margins. This is due to significantly higher input costs which did not lead to a high enough productivity increase, suggesting that landholding, and thus smaller total amounts harvested and sold, are insufficient to compensate the sunk costs participant farmers incur in production. To achieve higher benefits they would need either to further increase productivity or to cut costs. Importantly, it should be noted that small farmers experienced a significantly shorter time to sell their produce. Looking at relatively larger farmers, significantly higher gross margins seem to be due mostly to economies of scale. What seem to have played a major role for larger farms are the reduced per unit costs supported for each type of input and

TABLE 12.7 Impact by land size (using propensity-score weighted least squares)

Indicator	Small farms (<1 ha)		Medium farms (1–5 ha)		Large farms (>5 ha)	
	Diff.	P>|*t*|	Diff.	P>|*t*|	Diff.	P>|*t*|
Primary indicators						
Log of total harvest (kg/ha)	0.45	.004***	0.67	.005***	0.06	.799
Gross margins (US$/ha)	–23.16	.844	318.68	.004***	111.81	.068*
Mechanisms						
Total potatoes sold (share of harvest) (%)	13	.001***	4	.353	1	.912
Value of potatoes harvested ($/ha)	375.79	.012**	442.69	.009***	43.34	.646
Price of potatoes sold ($/kg)	0.03	.000***	0.03	.000***	–0.02	.119
Time of transaction (hours)	–0.40	.010***	0.19	.559	0.16	.694
Input costs ($/ha)	398.95	.002***	124.01	.299	–68.48	.202
Cost of paid labor ($/ha)	100.05	.042**	16.18	.608	–52.33	.005***
Cost of seeds purchased ($/ha)	78.42	.097*	49.93	.012***	–6.67	.636
Value of seeds planted ($/ha)	137.63	.017**	92.34	.000***	–7.88	.663
Secondary indicators						
Preventive fungicide applied (kg or l/ha)	–0.20	.827	0.19	.745	–0.52	.574
Curative fungicide applied (kg or l/ha)	–1.23	.630	0.25	.689	–0.71	.220
Insecticides applied (kg or l/ha)	3.31	.032**	0.23	.546	–0.13	.423
Cost of chemical fertilizer ($/ha)	83.33	.027**	22.99	.123	–1.42	.930
Cost of organic fertilizer ($/ha)	–2.41	.907	43.63	.005***	11.46	.011**
Applies traps (share)	0.55	.000***	0.49	.000***	0.32	.007***
Total environmental impact quotient (TEI/ha)	–11.93	.733	–8.69	.745	–18.10	.538
Can identify most toxic products (label color) (%)	35	.000***	41	.000***	20	.124
Always uses plastic poncho (%)	3	.613	7	.136	11	.050**
Always uses mask (%)	0	.888	2	.669	14	.120
Berger index of diversity	0.14	.108 s	–0.05	.422	–0.11	.478
Most used variety—Fripapa (%)	34	.000***	41	.000***	11	.262
Observations	302		263		88	

Source: Authors' calculation using survey data.

Note: Probability * ≤.1, ** <.05, *** <.01.

particularly for significantly smaller labor costs. Larger farmers are also not increasing other costs compared to those with smaller landholdings. This may be due to the fact larger farmers are already relatively efficient and do not get the level gains that medium farmers experience. In sum, while for larger farmers, economies of scale are sufficient to outweigh the costs and guarantee higher gross margins, in the case of smallholders an intensification of technology adoption combined with a reduction of direct and transaction costs would be needed to guarantee that higher productivity translates into higher gross margins.

Conclusion

In this chapter, the challenges of linking smallholder potato farmers to high-value markets are examined by looking at the experience of the multistakeholder *Plataformas* program in the provinces of Chimborazo and Tungurahua in the Ecuadorian Sierra. An empirical analysis has been conducted to assess whether the program has been successful in increasing yields and profits of potato-producing smallholders while protecting farmers' health and the environment. Mechanisms by which these objectives have been achieved were also analyzed.

To ensure a proper and sound empirical analysis, the data were collected in a way that made it possible to create a reasonable counterfactual for comparing *Plataformas* participants. Additionally, multiple econometric methods were employed to ensure results were not driven by a specific methodology. Spillover effects are also considered using different counterfactual groupings. The results are strongly consistent across the different specifications and the use of different types of counterfactuals, suggesting that the success of the *Plataformas* is well identified. Our findings show that the *Plataformas* program successfully improved the welfare of beneficiary farmers and that the benefits were limited to farmers who directly participated since there appear to be few spillover effects on nonparticipants.

Both primary indicators, namely yields and gross margins, are positive and significant for beneficiaries, with estimated differences very similar across specifications. The mechanisms through which the *Plataformas* achieve these primary benefits are through selling higher percentages and amounts of potato harvest than nonbeneficiaries in addition to selling at a 30 percent higher price. Although participant farmers incur higher input costs, particularly for seeds but also for hired labor and fertilizers, benefits are enough to outweigh these added costs. Clear benefits are achieved by medium-sized farms while large farms achieve benefits mainly due to economies of scale. On the other hand, smallholders need to intensify technology and reduce direct as well as transaction costs to be able to achieve higher returns. The regional analysis has shown that farmers in Chimborazo, which are on average poorer than farmers in Tungurahua, have achieved higher and better results through participating in the *Plataformas*.

Results for secondary indicators are somewhat mixed. With respect to the use of agrochemicals, beneficiaries do use slightly more insecticides and chemical fertilizers, but most of the other indicators are not significantly different. Products utilized are likely to be less toxic given the TEI is not significantly different from nonbeneficiaries and in general has a negative sign. The *Plataformas* is clearly having an impact on the utilization of traps and in diffusing knowledge: a significantly higher percentage of participant farmers apply traps while a significantly higher percentage of farmers are able to recognize the toxicity of agrochemicals. This latter translates into a higher utilization of protective gears although percentages are generally relatively low.

Concerns related to potentially negative impacts on agricultural biodiversity are unfounded since results suggest that participants and nonbeneficiaries maintain the same level of diversity. Given that most of the varieties cultivated are modern, it appears that genetic erosion, if any, happened in the past due to a combination of natural causes (El Niño), agro-industrialization and farmers' preferences in response to changing market opportunities.

Overall, participation in the *Plataformas* suggests a successful way of linking smallholder potato farmers to the markets. The success of the *Plataformas* can be first explained by its intervention along the value chain. On the output side, this led to reduced transaction costs that resulted from circumventing intermediaries and making sure farmers obtain a greater share of the returns from their production. Value-chain interventions on the input side led to the introduction and supplying of market-demanded varieties, provided high-quality seeds, and taught efficient farming techniques. Secondly, the success of the *Plataformas* highlights the importance of social capital in identifying and organizing beneficiaries in a manner that effectively overcomes entrance barriers.

While this chapter has, overall, found important positive and significant impacts of the *Plataformas* on the welfare of farmers and no negative effects on farmers' health and the environment, there still remains a question of cost-effectiveness and the potential effect on efficiency. For example, Thiele et al. (2011) note one question that has not so far been addressed because of data limitations: whether there is sufficient value-added in the new market opportunities to cover the costs of the *Plataformas* and still provide farmers with a sufficient income increment to justify program participation. The authors also observe that while the program received substantial subsidies through project funding, this was probably a reasonable investment given the positive results. In the long run and for scaling up the program, however, other funding mechanisms would need to be explored to achieve financial sustainability (Chapter 8). Although we recognize the importance of assessing costs and shedding light on the sustainability of the *Plataformas*, it is not possible with the current available data. The total investments in the program have not been sufficiently identified since they came from multiple sources. Further, sustainability would need to be assessed with a new round of data collection that would examine how the program is currently operating now that much of the external support has been withdrawn. New initiatives are under way to gather the necessary information to arrive at a more accurate answer to these important questions, presenting a clear direction for future research.

Appendix

TABLE 12A.1 Punctual test of means comparing beneficiaries to all nonbeneficiaries

Variable	Mean treated	Mean control	% reduction |bias|	P>|*t*|
Land owned (ha)	2.55	2.41	–230.7	.622
Owned plots (no.)	3.25	3.11	68.2	.617
Black soil (%)	0.77	0.78	60.3	.884
Flat land (%)	0.38	0.36	48.6	.857
Irrigated land (%)	0.54	0.52	49.1	.659
Family size	4.79	4.82	75	.930
Average education of HH head	5.24	4.96	32.3	.462
Indigenous HH head	0.58	0.61	43.6	.532
Female HH head	0.12	0.11	–155.5	.913
Age of HH head	42.20	42.38	–22.7	.953
Dependency share	0.29	0.29	64	.958
Livestock	0.06	0.05	–113.1	.893
Agricultural assets	0.13	0.00	33.6	.788
Durable assets	0.04	0.01	30.5	.870
House	0.84	0.86	27.8	.570
Concrete/brick house	0.83	0.85	73.6	.732
Access to water system	0.92	0.93	70.1	.759
Access to sewage system	0.06	0.06	72.5	.954
Cook with electricity/gas	0.57	0.55	60.5	.751
Distance to closest city (km)	27.13	26.14	70.4	.362
Altitude (m a.s.l.)	3,447.50	3,446.00	90.4	.918
Chimborazo	0.50	0.50	–20.8	.849
Agricultural association (>1 year)	0.34	0.33	98.7	.943
External nonagricultural association	0.17	0.17	–221.9	.930
External agricultural association	0.07	0.06	3	.763
Nonagricultural association in community	0.82	0.85	–93.5	.595

Source: Authors' calculation using survey data.

Note: HH = household.

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