Linking smallholder potato farmers to the market: Impact study of multi-stakeholder platforms in Ecuador

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Abstract

This paper analyzes the impact of participation in multi-stakeholder platforms (*Plataformas*) aimed at linking smallholder potato farmers to the market in the mountain region of Ecuador. It describes and evaluates the Plataformas' program to determine whether it has been successful in linking farmers to higher-value markets and the effects that such connections have brought, particularly with regard to farmers' welfare and to the environment. The analysis is run comparing a set of different and carefully constructed control groups to beneficiaries and using various specifications. Results are strongly consistent across the different specifications and are sound across the counterfactuals, suggesting impacts are adequately identified. Findings suggest that the program was successful in improving the welfare of beneficiaries, while potential negative environmental impacts, particularly with relation to agrobiodiversity and use of agrochemicals seem not to be a concern. Mechanisms through which impacts have been achieved are analyzed. Little spillover effects are found.

Keywords: New agricultural economy, impact evaluation, food-security, agro biodiversity.

Smallholders and the new agricultural economy

The last two decades has witnessed profound changes in farming systems and the way in which agricultural production is organized in many developing countries. While changes affect the whole chain, they are most clearly manifested in the manner in which food is being retailed. Agricultural producers now supply long and complex value chains that are marketing high-value fresh and processed products to mainly urban consumers. On the input side, farmers increasingly rely on commercialized transactions in market venues to obtain seeds, and agricultural chemicals as the demand for product quality increases. These changes, referred to as the *new agricultural economy*, have led to new organizational and institutional arrangements within the food marketing chain such as new forms of contracts, as well as the imposition of private grades and standards (Dolan and Humphrey, 2004).

The net effect of the new agricultural economy both on the welfare of poor people and on the environment is controversial. On the one hand, increased commercialization shifts farm households away from traditional self-sufficiency goals towards profit and income-oriented decision making. On the other hand, benefits to smallholders are by no means guaranteed and indeed the process may even exacerbate poverty levels through marginalization of the rural poor if they are unable to directly take advantage of new market opportunities or benefit from increased labor demand. Furthermore, the agricultural intensification that often accompanies market-oriented agriculture may lead to a focus on a few commercially-oriented varieties, to increased chemical use and to intensified land use, and thus to potentially negative environmental and health consequences.

One approach that has been used in the Andean to enhance the benefits to smallholders of linking with the new agricultural economy has been the multi-stakeholder platforms, *Plataformas de concertación* or simply *Plataformas* (Devaux et al., 2009). The *Plataformas* program in Ecuador has been implemented by the Instituto Nacional Autónomo de Investigaciones Agropecuarias (INIAP) through the FORTIPAPA (Fortalecimiento de la Investigación y Producción de Semilla de Papa) project, supported by the International Potato Center (CIP) through its Papa Andina Partnership Program, and funded by the Swiss Agency for Development and Cooperation (SDC). The *Plataformas* program brought together potato farmers and a range of suppliers of research and development services, with the purpose of linking farmers to higher-value markets. High-value market purchasers included local fast food restaurants supermarket chains and the multinational food processor Frito-Lay. By establishing direct linkages of farmer organizations to these purchasers, *Plataformas* have displaced traditional intermediaries, potentially providing the smallholders with greater opportunities to obtain benefits from the changes in agricultural marketing systems.

The objective of this paper is to describe and evaluate the *Plataformas* program in order to determine whether it has been successful in linking farmers to higher-value markets and the effects, particularly with regard to farmers' welfare and to the environment that such connections have brought.

Linking farmers to markets: the logic of *plataformas*

When smallholders have no apparent advantage in production, the challenge is to reduce the transaction costs associated with purchasing from large numbers of farmers producing small quantities to make them relatively competitive or to devise a way to directly link smallholders to high-value purchasers. This requires organizing smallholders to overcome the costs of transactions as well as providing them with the necessary information to meet market requirements. The *Plataformas* program does just this. The approach used is to provide support for smallholders from a range of institutions, through building a strong social capital. This latter functions as a connector between groups and among individuals facilitating co-operation and mutually supportive relations and, thus, as an effective means to reduce transaction costs and link associate farmers directly to high-value purchasers. The connection is reached in a manner that ensures that those buyers receive quality potatoes, of the variety they require, and in a timely fashion. The intervention operates, on the basis of a well designed program, through the whole potato supply chain in such a manner to reduce inefficiencies, overcome barriers and reduce costs in each link of the chain.

The logic of the program is to reduce transaction costs, so smallholders can be a low cost option for high-value purchasers and take advantage of the benefits of the new agricultural economy. The ultimate expected benefit of the intervention is to increase the income obtained from potato production not only through increasing productivity, but also through higher output prices and through lower transaction costs. When transactions are taken care of by the *Plataforma*, single transactions requiring that each smallholder deals directly with final clients are avoided and thus associated costs and burdens are dramatically reduced.

Setting the scene

In order to conduct a proper impact evaluation it is crucial to have a clear picture of the intervention under scrutiny, of its overall program and of the context in which it operates. To this end, prior to the beginning of the evaluation, a qualitative study was conducted to inform and guide the research. This first phase was based on interviews with key informants, focus group discussions in the regions of interest, and a value chain analysis of the Ecuadorian potato market. This section describes the Ecuadorian potato market and the key elements of the *Plataformas*.

Ecuadorian potato market. Potato is the primary staple and one of the most lucrative market crops cultivated in the highlands of Ecuador. Farmers can be differentiated by the use of technology, chemical inputs, production efficiency, types of varieties farmed, and the degree of market integration (An, 2004). Cultivation is largely undertaken by small-scale farmers. 32.2% of farmers in the country grow potatoes in areas smaller than 1 ha (OFIAGRO, 2009), and about half of all potato farmers grow potatoes in less than 2 hectares of land (Mancero, 2007). Almost all potato production is for domestic consumption, with per capita consumption of around 32 kg per year (OFIAGRO, 2009).

Over the past decade, total production has fallen from more than 450,000 metric tons to less than 320,000, while the cultivated area has shrunk from 65,000 ha to less than 50,000 (FAOSTAT, 2007). Average yields (6.8 t/ha) (INEC, 2007) are still far below the international average not only when compared to Europe (17.27 t/ha) and North America (36.79 t/ha), but also when compared to nearby countries: 12.6 t/ha in Peru and 17.3 t/ha in Colombia (FAOSTAT, 2007). From 2002 to 2006, imports of potato-based products mainly frozen French fries, have increased from 2423 t in 2002 to 7119 t in 2006 (OFIAGRO, 2009) in response to growth in demand from fast food restaurants mainly. Although this still represents less than 2% of total consumption, it shows an interesting trend.

Description of the *Plataformas*. The *Plataformas* are multi-stakeholder alliances which bring farmers together with a range of agricultural support service providers, including INIAP, local NGOs, researchers, universities, and local governments. *Plataformas* are part of a comprehensive program which involves practical intervention that pays special attention to improving the participation of low-income farmers in high-value producer chains by providing them with new technologies, promoting their organization and social capital accumulation, and involving them in a "value chain vision" of production and commercialization that directly links them with the market.

The primary objective of the *Plataformas* was to "reduce poverty and increase food security, through increasing yields and profits of potato-producing smallholders" (Pico, 2006). The *Plataformas'* program was undertaken in four provinces of the central highlands, two of which are the focus of the present study: Tungurahua and Chimborazo.

An integral component of the *Plataformas* was the training provided at the farmers' field schools (FFS) in order to build knowledge and capacity of farmers. FFS made special emphasis on production technologies and integrated pest management (IPM) techniques aimed to improve quality and quantity of production while protecting the environment and farmers' health. Farmers were taught techniques to efficiently manage soil, seed, insects, diseases and pesticides using training materials adapted to resource-poor farmers. With regard to soil management special emphasis was given to techniques to reduce soil erosion as most of the farmers are located in steeped areas. Farmers were taught the importance of renewing seed of good quality and techniques to select their own stocks, considering size, shape and health status of the tubers. Use of synthetic and organic fertilizers was also taught, including sources, methods and periods of application, and dosages. To efficiently manage potato Andean weevil (*Premonotrypes vorax*) and tuber moths (*Phthorimaea operculella*, *Symmestrischema tangolias* and *Tecia solanivora*), farmers learned the life cycle of the insects and different techniques to reduce the population and damage of the pests. Traps using low-toxicity insecticides are widely used to catch and kill Andean weevil adults. To manage late blight, farmers learned to recognize the symptoms of the disease, the life cycle of the pathogen, the use of resistant potato varieties, and the use of fungicides. Lastly, farmers were taught how to recognize the toxicity level of pesticides (by the color of the label), the main symptoms of intoxication, and how to protect the environment and themselves from risks associated with using pesticides. Hence, the training provided in the FFS with respect to the importance of preserving the environment and of protecting human health, might diminish the over usage of agrochemicals. However, pressure to reach market-required standards might operate in the opposite direction and the net effect on chemical use would need to be empirically determined.

Of particular importance among varieties used is CIP clone 388790.25 (CIP, 2009) released by INIAP in 1995 as INIAP-Fripapa (Fripapa), and which is specifically suitable for processing and frying (Pumisacho and Sherwood, 2002). INIAP produces, supplies and certifies high quality Fripapa seeds, and has promoted its use in the *Plataformas* as it is demanded and preferred by fast food restaurants. Fripapa is particularly suitable for resource scarce small producers, because it has a good degree of resistance to potato late blight and its use, therefore, reduces the need for frequent fungicide applications.

During harvest and commercialization, the *Platforms* carry out some quality control to ensure marketed potatoes meet clients' needs. They also identify potential clients who can make a commitment to make purchases as long as the produce meets their required standards. In this regard, the sales are done through pre-established verbal agreements.

Creating a counterfactual: sample selection, data collection and data description

Sample Selection. The challenge of evaluating the impact of a program, project or intervention is that it is not possible to observe what would have happened to participants in its absence. The key to identifying and measuring the impact is, thus, to have a proper counterfactual—that is, a comparison (control) group that is similar to the intervention (treatment) group with the exception that it did not receive the intervention. In the case of this study, the challenge in creating a counterfactual was complicated by the *ex post* nature of the evaluation which required creating a counterfactual after the program intervention had been implemented. This entailed ensuring that the communities selected as controls had characteristics similar to the treatment communities at the initiation of the program.

The final sample includes three sets of households: i) beneficiaries of the program, ii) non-beneficiaries in the treatment communities (referred to as non-participants), and iii) non-beneficiary households in the control communities (referred to as non-eligible). Lists of households from each of these categories were provided by *Plataforma* coordinators and community leaders. Households from the lists were randomly selected to be interviewed (157 out of 227 in Tungurahua and 167 out of 232 in Chimborazo). The final sample included 1007 households of which 683 reside in beneficiary communities (324 participants and 359 non-participants) and 325 in control communities (non-eligible).

Data collection and description. The data was collected from June to August 2007 through a household questionnaire, which was designed to conduct an impact evaluation and which included a number of questions on participation in the *Plataforma*. The questions were developed based on qualitative information collected through an earlier value chain analysis and focus group discussions.

Description of indicators and impacts. In determining the success of the *Plataforma* program, we wanted to first find out whether the intervention it supported reached its primary objective of improving the welfare of participating farmers. To do this we look at the relevant *primary indicators*. If the answer was positive, that is the intervention increased participants' welfare, the next step was to consider the *mechanisms* through which this primary objective was reached; or alternatively why the intervention might have failed to meet its objectives. Lastly, *secondary indicators* arising from *Plataforma* participation, particularly with regard to knowledge of precautionary measures in agrochemical applications and environmental impacts, are considered. These three sets of variables – primary indicators, mechanisms and secondary indicators- which measure the impacts we were interested on analyzing, are presented in Table 1 for the entire sample as well as for the three distinct groups of households we are comparing. Tests of difference (*t*-test) for the equality of mean values are reported for participants versus non-participants, participants versus non-eligible, and participants versus all non-beneficiaries.

The first set of indicators in Table 1 show that the group of beneficiaries, on average, obtained a greater amount of yields per hectare than the three possible counterfactual groups. The range in yields goes from 6.3 t/ha for non-participants to 8.4 t/ha for beneficiaries. Although the average yield for beneficiaries is substantially below the average harvest in Latin America (16 t/ha), it is consistent with the average for Ecuador (6.8 t/ha) and about 2 t above the average of the focus region (6 t/ha) (INEC; 2007).

The mechanisms through which the platform achieves these outcomes is primarily through shortening and improving the efficiency of the potato value chain to decrease transaction costs and capture a higher share of final price for producers, as well as through the application of better agricultural techniques. Two transaction cost indicators are considered here - time per transaction, and price of sale - in addition to transport cost which is closely related to the transaction. Households on average sell almost half of their potato harvest (45%) at a price of about $0.11/kg. The transport cost is about $0.01/kg and the time spent in each transaction is around 1.29 hours. *Plataforma* beneficiaries appear to sell more, receive more value for them and get a higher price per kg than non-beneficiaries.

The secondary indicators analyze the side impacts of participation in the *Plataforma*. The first, which considers both health and environmental impacts, is the use of agrochemicals. To assess the environmental impact caused by pesticides a methodology -the Environmental Impact Quotient (EIQ)- to account for the toxicity level of the active ingredients contained in each pesticide and for their quantities has been used as described by Kovach et al. (1992). The comparison of EIQ measures for fungicides (curative and preventative), insecticides and total EIQ for the three household categories show no significant differences (Table 1). This indicates that even if beneficiaries use more chemicals in terms of quantities and number of applications, their environmental impact is not different than the pesticides used by other household groups, indicating that the type of pesticides beneficiaries use are less toxic.

Another environment-related indicator is the level of agrobiodiversity maintained at the household level, i.e., how the composition and share of potato varieties changes due to market participation. The *Plataforma* program directs its attention towards commercial varieties. In particular the Fripapa variety was introduced and supplied through the intervention of the *Plataforma* because of its market acceptance and resistance to late blight. If farmers are more specialized, the number of varieties cultivated may be reduced as farmers shift to the market variety. To measure this, four indexes of diversity are used: the Count, the Margalef, the Shannon and the Berger-Parker index (Winters et al., 2006). On average they show that there is not a great diversity in the sample. Total potato planted per hectare is about 1000 kilograms, or slightly more, with a large share represented by Fripapa (29%) and by INIAP-Gabriela (30%). While there appears to be no difference in agrobiodiversity among beneficiaries and non-beneficiaries, it does seem that beneficiaries have shifted toward Fripapa and away from Gabriela.

In connection to the use of pesticides and to their toxicity level, some health related measures are considered. The percentage of households that use protective measures is in general very low: 19% uses gloves, 13% uses ponchos and 6% use masks (Table 1). Slightly higher is the percentage of farmers that use plastic protection for the shoulders (38%). The results show that on average 34% of farmers know that the red label indicates high toxicity level and 25% know that the green label indicate less toxic products. The results suggest that participating to the *plataforma* did lead to more beneficiaries using precautions and having better knowledge about the toxicity of products.

The empirical approach

The empirical problem faced in this analysis is the typical one of missing data to fill in the counterfactual. Propensity score matching (PSM) offers a potential solution to this problem if differences between the treatment and control are observable. The basic idea of PSM is to construct a control group who has similar characteristics as the treated group, through a predicted probability of group membership calculated via a logit or probit regression, and then compare the outcomes. An alternative to using PSM, particularly when control and treatment although not randomly assigned are reasonably comparable, is a weighted least squares procedure that uses weights calculated by the inverse of the propensity score (Todd et al, 2008).

We estimate the impact of the program using three approaches, i) a standard OLS (ordinary least squares) with multiple controls, ii) propensity score matching using a kernel weighting scheme and bootstrapped standard errors, and iii) an intermediate approach of weighted least squares with weights determined as previously discussed from the propensity scores. Additionally, we also reconsider the use of all non-beneficiaries as the best counterfactual and check the robustness of results using the four alternative counterfactuals: beneficiaries versus non-beneficiaries; beneficiaries versus non-participants; beneficiaries versus non-eligible households; and treatment communities (beneficiaries and non-participants) versus control communities (non-eligible households);

Impact analysis and results

Table 2 reports the results of the analysis of the least squares regression, propensity score matching and weighted least squares comparing *Plataforma* beneficiaries to non-beneficiaries. An analysis using the weighted least squares using the alternative counterfactual groups was also done (not shown) to demonstrate consistency and robustness of results. The results are remarkably consistent across specification and make sense for the different types of counterfactual indicating that the impact is well identified.

Table 2 shows that all three primary indicators of impact are positively and significantly influenced by participation in the program with the estimated differences very similar across specification. The results suggest that yields are 33.3% percent higher as a result of the platform intervention, input output ratios are about 20% higher and gross margins per hectare were four fold higher (Table 1). Overall, it appears that while beneficiary farmers paid more for some key inputs, they received the benefits of this investment through higher yields and higher prices and thus higher returns to potato production.

Moving into the secondary indicators of impact, there is some concern that linking smallholders to market may lead to higher returns but at a cost of greater environmental and health problems. The increased use of inputs suggests this might be a problem. The evidence is somewhat mixed, but does not seem to imply a widespread problem. Beneficiaries do not use significantly more fungicides, but do use significantly more insecticides and chemical fertilizers (Table 1). The evidence does not suggest, however, that they are using more toxic mixes of chemicals (see environmental impact, Table 1) and in fact suggests that they can identify toxic products better than before joining the *Plataforma* most likely due to the training they received. The increased use of insecticides and chemical fertilizers may be due to quality requirement for tubers to be a certain size and free from any damage (including insect damage). Program participants are generally more likely to use protective gear as evidenced by a greater use of a plastic poncho and mask.

A final concern relates to the influence of linking farmers to market on agricultural biodiversity. Market pressure may lead farmers to abandon traditional varieties and produce those demanded by high-value markets. The evidence does not support this hypothesis as indicated by the insignificant impact on any of the measures of agricultural biodiversity (Table 1). In fact, what appears to have happened is that farmers replaced one modern variety (Gabriela) with another variety (Fripapa), which is demanded for its frying qualities. Thus, this group of farmers is maintaining the same diversity level although changing the primary variety.

Conclusions

The results are strongly consistent across the different specifications and the different types of counterfactuals suggesting that the impact is well identified. Our findings suggest that the *Plataforma's* program successfully improved the welfare of beneficiary farmers. All impacts related to the primary objectives of the *Plataforma* (gross margins and input-output ratio) are positive and significantly influenced by participation in the program. Since similar results are obtained when using the non-participants as a control group very little or no indirect effects of the program is implied. The mechanisms through which the *Platforma* achieves this success is through shortening and improving the efficiency of the potato value chain as well as through the application of better agricultural techniques, thus decreasing transaction costs with the former, and improving yields with the latter. Results show that not only beneficiaries sell more of their harvest as compared to non-beneficiaries both in terms of percentage as well as quantity per hectare harvested, but they also sell at a price that is about 30% higher than those who were not in the program. To achieve these results, though, participant farmers have higher input costs, particularly for seeds (of which a higher percentage and quantity per hectare is bought) as well as for hired labor and fertilizers. Nevertheless, participants receive the benefits of this investment through higher yields and higher prices and thus higher returns to potato production. The existence of social capital has proved to be fundamental in implementing the program which, through its intervention, has strengthened the social tissue and has built or improved the capacity of farmers to link successfully to the market.

There is some concern about increased use of inputs. While the results are somewhat mixed with respect to the use of agrochemicals, they do not seem to suggest a substantial problem. Our findings show that participants use significantly more insecticides and chemical fertilizers. However, they are likely using less toxic products as the environmental impact is not significantly different than non-beneficiaries. These results might also be reinforced through the FFS and IPM approach used by the program, as it appears that through a better knowledge of risks and hazards associated to the use of agro-chemicals participant farmers tend to use more protective gears, although overall the percentages are remarkably small. Likewise the concern related to potential impacts on agricultural biodiversity is unfounded as seen by the insignificant effect on any of the four indexes of agricultural biodiversity considered.

Overall, participation in the *Plataforma* suggests a successful way of linking smallholder potato farmers to the global market. While primary benefits are undoubtedly obtained, concerns related to potential costs supported by the natural resource base with respect to varieties cultivated and agrochemical impact seem to be unfounded. The success of the *Plataforma* can be first explained by its patient and efficient intervention along the value chain, eliminating unnecessary transaction costs and intervening also on the input side, not only introducing and supplying market-demanded varieties but also, and above all, providing good quality seeds. Secondly, the importance of the social capital in determining participation to the *Plataforma* can explain its successful results, while suggesting the most effective way of overcoming entrance barriers. Finally, it is important to note that while the program proved very successful, it only applies to a small proportion of Ecuadorian potato producers. Thus, if any significant effects are aimed at national level, successful programs and interventions such as this need to be scaled up taking into account context specific situations and using appropriately those elements that have proven successful.

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Table 1. Program Impact Indicators at household level+ for whole sample and comparing beneficiaries to counterfactuals

Indicators and mechanisms	Whole Sample	Benef.	Non-part.	Test vs. Benef.	Non-elig.	Test vs. Benef.	All non-benef.	Test vs. Benef.
Primary indicators								
Total harvest (kg/ha)	7006	8400	6290	**	6357		6323	*
Input-output ratio (planted/harvested)	8.24	8.89	8.98		6.86	***	7.92	
Gross margins ($/ha)	112.7	259.5	63.1	**	18.4	**	40.8	***
Mechanisms								
Total potatoes sold (kg/ha)	3581	4961	2851	***	2958	**	2904	***
Total potatoes Sold (% of harvest)	0.45	0.50	0.44	*	0.42	**	0.43	*
Value of potatoes harvested ($/ha)	763	1085	590	***	621	***	606	***
Transaction costs (# observations)	475	167	158		150		308	
Transport ($/kg)	0.01	0.01	0.01		0.01		0.01	
Time of transaction (hr)	1.29	1.27	1.07		1.56		1.31	
Price of potatoes sold ($/kg)	0.11	0.14	0.11	***	0.10	***	0.10	***
Costs								
Input costs ($/ha)	651	826	527	***	603		565	
Total seeds purchased (kg/ha)	196	255	179		156	**	168	*
Total seeds purchased (%)	0.20	0.25	0.17		0.18		0.18	**
Value of seeds planted ($/ha)	181	247	155	***	144	***	149	***
Cost of seeds purchased ($/ha)	49	82	43		21	***	32	***
Cost of paid labor ($/ha)	97	147	49	***	97		73	***
Secondary Indicators								
Agrochemicals								
Preventive fung. applied (kg or l/ha)	3.15	2.79	2.69		3.98		3.33	
Curative fung. applied (kg or l/ha)	4.16	3.61	2.52	*	6.34		4.43	
Insecticides applied (kg or l/ha)	2.22	2.95	1.71	**	2.02		1.86	**
Cost of chemical fertilizer ($/ha)	124.68	153.75	121.49		99.33	***	110.44	***
Cost of organic fertilizer ($/ha)	46.04	71.74	46.06	*	20.79	***	33.45	***
Applies traps (%)	26.7	59.4	13.1	***	8.1	***	10.6	***
Total traps used (#/ha)	26.32	66.50	5.57	***	7.71	***	6.64	***
Env, impact for preventive fungicide	39.18	27.43	31.43		58.50		44.93	
Env. impact for curative fungicide	32.25	20.60	17.29		58.72		37.96	
Env. impact for insecticide	23.81	27.53	19.77		24.21		21.99	
Total environmental impact	95.24	75.56	68.50		141.43		104.88	

Indicators and mechanisms	Whole Sample	Benef.	Non-part.	Test vs. Benef.	Non-elig.	Test vs. Benef.	All non-benef.	Test vs. Benef.
Agrobiodiversity								
Number of varieties planted	1.66	1.66	1.66		1.65		1.65	
Margalef index of diversity	2.36	2.03	2.13		2.93		2.53	
Shannon index of diversity	0.36	0.37	0.35		0.36		0.35	
Berger index of diversity	1.45	1.44	1.45		1.47		1.46	
Most used var.: Fripapa (%)	29.0	53.4	15.9	***	18.2	***	17.0	***
Second most used var.: Gabriela (%)	30.1	19.6	38.4	***	32.1	***	35.2	***
Precautions with agrochemical applications								
Always use plastic protection (%)	38.2	42.9	36.5		35.3	**	35.9	*
Always use gloves (%)	19.1	24.0	15.8	**	17.6	*	16.7	**
Always use plastic poncho (%)	13.0	18.4	10.8	**	10.0	***	10.4	**
Always use mask (%)	6.4	10.1	4.1	**	5.0	**	4.5	***
Can identify most toxic products (%)	34.1	59.4	25.2	***	18.1	***	21.7	***
Can identify least toxic products (%)	24.7	43.3	18.9	***	12.2	***	15.6	***
Observations	660	217	222		221		443	

Tests are differences in means (*t*-test); * significant at the 10% level; ** 5%; *** = 1%

+ For households that have harvested.

Table 2. Comparison of beneficiaries vs. all non-participants using different methods: ordinary least squares, propensity score matching, and weighted least square

Indicators and mechanisms	Ordinary least squares Diff.		Propensity score matching Diff.		Weighted least square Diff.	
Primary indicators						
Log of total harvest (kg/ha)	0.58	***	0.58	***	0.61	***
Input-output ratio (planted/harvested)	2.21	***	2.04	***	1.69	***
Gross margins ($/ha)	204	***	232	**	194	***
Mechanisms						
Total potatoes sold (kg/ha)	1639	***	2011	***	1664	***
Total potatoes Sold (% of harvest)	0.09	***	0.08	**	0.09	***
Value of potatoes harvested ($/ha)	386	***	459	***	372	***
Transaction costs (# observations)						
Transport ($/kg)	0.002	*	0.002		0.002	*
Time of transaction (hr)	-0.015		0.013		-0.031	
Price of potatoes sold ($/kg)	0.029	***	0.031	***	0.030	***
Costs						
Input costs ($/ha)	182		227	**	178	**
Total seeds purchased (%)	0.06	*	0.05		0.05	
Value of seeds planted ($/ha)	91.9	***	94.8	***	83.9	***
Cost of seeds purchased ($/ha)	47.7	***	47.6	**	33.0	**
Cost of paid labor ($/ha)	46.8	**	85.2	***	32.5	*
Secondary Indicators						
Agrochemicals						
Preventive fung. applied (kg or l/ha)	-0.32		-0.26		-0.235	
Curative fung. applied (kg or l/ha)	0.48		0.40		-0.32	
Insecticides applied (kg or l/ha)	1.07	*	0.96		1.13	**
Cost of chemical fertilizer ($/ha)	42.7	**	48.2	**	37.8	**
Cost of organic fertilizer ($/ha)	17.8		24.0	*	16.1	
Applies traps (%)	0.50	***	0.47	***	0.52	***
Total traps used (#/ha)	55.9	***	55.5	***	57.8	***
Env, impact for preventive fungicide	-16.45		-17.27		-11.34	
Env. impact for curative fungicide	-4.77		-2.34		-12.69	
Env. impact for insecticide	5.28		4.41		7.78	
Total environmental impact	-15.94		-15.21		-16.26	
Agrobiodiversity						
Number of varieties planted	-0.01		0.01		-0.02	
Margalef index of diversity	-0.53		-0.64		-0.56	
Shannon index of diversity	0.01		0.02		0.01	
Berger index of diversity	-0.02		-0.03		-0.03	
Most used var.: Fripapa (%)	0.36	***	0.36	***	0.36	***
Second most used var.: Gabriela (%)	-0.15	***	-0.14	***	-0.150	***
Precautions with agrochemical applications						
Always use plastic protection (%)	0.08	*	0.07		0.06	**
Always use gloves (%)	0.05		0.04		0.03	*
Always use plastic poncho (%)	0.06	**	0.08	***	0.07	***
Always use mask (%)	0.04	*	0.06	***	0.04	***

Indicators and mechanisms	Ordinary least squares Diff.		Propensity score matching Diff.		Weighted least square Diff.	
Can identify most toxic products (%)	0.36	***	0.36	***	0.35	**
Can identify least toxic products (%)	0.26	***	0.26	***	0.25	*
Observations	660		660		660	

Tests are differences in means (*t*-test); * significant at the 10% level; ** 5%; *** = 1%