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Evidence from Bolivia

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Direct and Spillover Effects of an Agricultural Technology Adoption Program: Evidence from Bolivia

Lina Salazar **Sebastián Bernal** **Luis Enrique Miranda**

Abstract

This study employs an experimental approach to estimate both the direct and indirect effects (i.e. spillovers) of an agricultural technology adoption program on small landholder farmers in Bolivia. Specifically, the evaluation focuses on the second phase of the "Creación de Iniciativas Agroalimentarias Rurales" (CRIAR) program, which aimed to increase agricultural productivity, income, and food security among smallholder farmers through technology adoption. Implementing a two-stage randomized experiment, the study uses instrumental variable (IV) analysis to measure the local average treatment effect (LATE) of the program. The survey sample includes 1,684 farmers, consisting of direct beneficiaries, contaminated control households, and pure control households. Findings reveal statistically significant direct effects on household income, total production value, sales, technology adoption, and crop diversification. The results also suggest that most of the direct effects intensify over time. Furthermore, the analysis confirms the presence of spillover effects, supporting the hypothesis that farmers residing near program beneficiaries receive indirect benefits.

Keywords:

Agricultural Technology, Technology Adoption, Agricultural Productivity, Food Security, Smallholder farmers, Bolivia

JEL Codes:

O13, 033, Q12, Q16, Q18,

1. Introduction

Agriculture in Latin America and the Caribbean (LAC) plays a vital role as a source of income, exports, and ecosystem services. Hence, promoting a productive, sustainable, and resilient agricultural sector is essential for reducing poverty, improving rural livelihoods, and strengthening food security. Agriculture accounts for approximately 6.5% of LAC's Gross Domestic Product (GDP), significantly higher than the global average of 4.1% (WDI, 2023). While the region is widely recognized for its contribution to the global supply of food, the contribution of the agricultural sector to the economy varies greatly across countries and subregions. For example, agriculture comprises 15.3% of GDP in Nicaragua and 13.5% in Bolivia, compared to just 3.5% in Chile and 3.8% in Mexico (WDI, 2023).

Despite these differences, agricultural sectors across LAC countries face a common set of unprecedented challenges: producing enough nutritious food for a growing population, supporting prosperous livelihoods, reducing greenhouse gas emissions and pollution, and protecting natural resources, all in the face of climate variability and increasing frequency of natural disasters (De Salvo et al., 2025). Furthermore, agriculture in LAC is widely affected by the effects of climate change. Rising temperatures, desertification, land degradation, salinization, changes in precipitation patterns, and biodiversity loss are some of the most common consequences of this phenomena in the region (FAO, 2015; UNFCCC, 2020). Most of these events directly affect agricultural activities, particularly smallholder farmers who can't incorporate adequate adaptation strategies due to lack of both financial resources and access to information.

Several studies predict an overall negative impact of climate change on crop yields (Nelson et al., 2014; Rosenzweig et al., 2014; IPCC, 2014; Porter et al., 2014; FAO, 2015; Müller & Elliott, 2015; Thomas & Rosegrant, 2015; IPCC, 2022; IPCC, 2023). In fact, recent estimates suggest that anthropogenic climate change (ACC) has contributed to a slowdown in agricultural productivity growth, especially in warmer regions (Ortiz-Bobea et al., 2021). Specifically, the cumulative impact of ACC over the 1961–2020 period is estimated to have reduced agricultural productivity by 25.9% in LAC (Ortiz-Bobea et al., 2021). Decreases in food availability are likely to exert upward pressure on food prices and reduce real incomes of rural households (GCA, 2019). Salazar, Gonzalez-Flores and Alvarez (2024) suggest that climate vulnerability in LAC countries is associated with an increased prevalence of undernourishment and food insecurity in all its dimensions (i.e. availability, access, utilization and stability). The authors find that one point increase in climate change vulnerability (measured with the ND-GAIN), is associated with a 4.1 percentage points (pp) reduction of food production. Furthermore, a 20% increase in food prices could increase poverty by 2.6 pp on average, leading 63.5 million people transitioning to poverty. Rural areas would be the most affected, with a 3.9 pp increase in poverty rates compared to a 2.3 pp increase in urban areas (Salazar, Gonzalez-Flores and Alvarez, 2024).

Smallholder farmers, who make up approximately 80% of agricultural producers in LAC (Lowder et al., 2021), are particularly vulnerable to the impacts of climate change due to their heavy reliance on agriculture for their livelihoods. The risks of farming are further exacerbated when climate-related challenges intersect financial constraints, limited access to information, and market failures, as these factors hinder the farmers' ability to adapt production systems effectively. Strengthening the climate resilience of smallholder farmers through the adoption of climate-smart technologies and practices[1] is therefore essential. However, climate finance in LAC has largely fallen short of meeting these specific needs. Most climate funds continue to be directed toward mitigation rather than adaptation, and their distribution is highly uneven across countries. For instance, multilateral climate finance allocated to mitigation activities amounts to USD 3.6 billion, more than four times the funding allocated to adaptation (USD 0.8 billion) (Watson et al., 2024). Moreover, nearly half of this funding is concentrated in just four countries: Brazil, Mexico, Costa Rica, and Colombia (Watson et al., 2024).

In this context, it becomes essential to identify effective mechanisms to promote the adoption of that climate-smart technologies to increase resilience of small landholder farmers. This study assesses the impact of the second phase of the "Creación de Iniciativas Agroalimentarias Rurales" (CRIAR) program that aimed to increase climate resilience of smallholders in Bolivia by improving productivity, income and food security through technology adoption and technical assistance. The technologies offered included irrigation systems, mills, silos, and equipment for small livestock production. While irrigation systems aimed to reduce risk to droughts and changes in rain patterns, post-harvest and small livestock equipment was offered to promote income and agricultural diversification as an adaptation strategy. The program was randomly assigned at the municipality and community levels establishing a proper counterfactual to measure causal effects on program beneficiaries and spillovers effects on non-beneficiaries located near beneficiary farmers.

Recent research studies confirm a positive link between agricultural technology adoption programs (ATAPs), household income and crop productivity[2] (Nakano et al., 2018; Wordofa et al., 2021; Wu, 2022; Bambio et al., 2022; Baiyegunhi et al., 2022). Mulugeta and Heshmati (2023) conduct a meta-analysis of programs that aim to promote the adoption of agricultural technologies in African countries, finding positive outcomes in terms of increased income and food security. Similarly, a systematic literature review by Abdul-Majid et al. (2024) reveals that most academic evidence of ATAPs shows positive effects in terms of productivity and household income. Although fewer analyses have been conducted in LAC, studies in

[1] Some management strategies are: i) diversifying income through different types of production, ii) reducing soil erosion; iii) changing crop mixes and planting dates; and iv) improving trade between producers, allowing the transport of food from regions with production surpluses to regions with food deficits (FAO, 2015, 2021).

[2] Academic literature provides ample empirical evidence on how interventions, that promote climate resilience through technology and management strategies, impact farmers' incomes, crop yields, and food security. However, most of these studies focus on African and Asian countries (Abid et al., 2016; Ojo and Baiyegunhi, 2020; Khan et al., 2021; Zakari et al., 2022; Duc et al., 2023; Tilahun et al., 2023).

Bolivia (Salazar et al., 2016), the Dominican Republic (González et al., 2009; Aramburu et al., 2019; Salazar et al., 2021) and Argentina (Rossi, 2013) report positive effects on outcomes such as household income, productivity, and food security. In Bolivia, the impact evaluation of the first phase of the CRIAR program employed an instrumental variables model, finding positive and significant effects in agricultural sales, household income, agricultural productivity and food security (Salazar et al., 2016).

A key reason for financing ATAPs lies in their potential to create spillover effects through informal peer-to-peer learning. In other words, these interventions aim to increase the technology adoption rate among non-treated farmers as a result of the effectiveness demonstrated by other farmer peers. Empirical evidence has shown that ATAPs have potential to generate spillover effects by fostering technology adoption (Foster & Rosenzweig, 1995; Holloway et al., 2002; Bandiera & Rasul, 2006; Maertens, 2010; Gao et al., 2020; Varshney et al., 2022; Vaiknoras & Larochelle, 2023; Yanbing, Möhring & Finger, 2023), as well as by enhancing variables such as production, crop yields, sales, and food security (Bonan & Pagani, 2017; Gautam et al., 2020; Carter, Rachid & Dean, 2021; Gatto et al., 2023; Kijima, Y., 2023).

However, spillover effects associated with ATAPs in LAC countries have not been extensively explored in the literature. Only a limited number of studies have focused on identifying and measuring indirect effects, yielding mixed results. On one hand, Bravo-Ureta et al. (2011) found no significant spillover effects from sustainable agricultural production investments in Honduras. On the other hand, Salazar et al. (2021) identified positive and statistically significant spillover effects on productivity from a program that promoted modern irrigation systems in the Dominican Republic. Similarly, Rocha, Gonçalves, and Almeida (2019) documented technological spillovers in Brazilian municipalities, where technology adoption negatively impacted cropland use. Additionally, in the Dominican Republic, Aramburu et al. (2019) found that social proximity to ATAP beneficiaries reduced the probability of technology adoption, while Wollni & Andersson (2014) observed positive knowledge spillovers that encourage organic agriculture adoption in Honduras.

Considering these gaps in the literature, this paper aims to analyze the effectiveness of a technology transfer program among smallholder farmers in Bolivia by measuring direct and spillover effects, leveraging on an innovative experimental approach and thereby complementing previous findings with a more robust methodological approach. The remainder of this paper is structured as follows: Section 2 describes the program. Section 3 presents the identification strategy followed by the descriptive statistics presented in Section 4. Sections 5 and 6 present the econometric methodology and the main results, respectively. Finally, Section 7 concludes.

2. The CRIAR program

The agricultural sector is central in Bolivia's economy. According to the National Statistics Institute (INE, 2022; INE, 2023a; INE, 2023b), the sector accounts for 14% of the country's

GDP. In 2022, the growth of the agricultural sector was above the GDP growth, registering an annual variation of 3.8%, above the overall economy's annual variation of 3.6%. In terms of employment, 25% of the workforce is engaged in agricultural activities, rising to 67% in rural areas. Regarding poverty, Bolivia has a poverty rate of 38%, with 51% of individuals residing in rural areas falling below the poverty line (equivalent to 1.8 million people). In terms of agricultural production, Bolivia has achieved an eightfold increase over the last sixty years, with an average annual growth rate of 3.6% (Salazar, Tadeo & Alvarez, 2024). However, agricultural productivity growth has slowed since the 1980s. Specifically, while the average annual growth rate of Total Factor Productivity (TFP) was about 3.4% during the 1960s and 1970s, it fell to a range between 1.3% and 1.8% in the decades from the 1980s to the 2010s (Salazar, Tadeo & Alvarez, 2024).

Bolivia is highly susceptible to the effects of climate change, ranking fourth in climate vulnerability according to the ND-GAIN index in the LAC countries, only behind Haiti, Honduras and Guyana (Salazar, Gonzalez-Flores, and Alvarez, 2024). Bolivia is also highly vulnerable in terms of food insecurity. The country is a net food importer and has seen a rise in chronic food insecurity, as measured by the prevalence of undernourishment, since 2019. In fact, while 14.5% of the population experienced undernourishment in 2019, this figure rose to approximately 23% by 2022, significantly higher than LAC's average (6.6%) (FAOSTAT, 2022). Given the substantial role of the agricultural sector in the country's socioeconomic indicators, and its vulnerability to climate change and food insecurity, it is key for Bolivia to implement and assess interventions that strengthen smallholder farmers resilience to climate change, such as agricultural technology transfer programs.

The CRIAR program, implemented by the Ministry of Rural Development and Land (MDRyT), consisted of two phases that provided financial and technical support to Bolivian smallholders. The first phase concluded in 2012, while the second phase initiated in 2016 and concluded in 2022. This paper evaluates the effects related to the second phase of the program (i.e. CRIAR II) which achieved nationwide coverage, spanning all departments of Bolivia, encompassing 100 municipalities, and reaching 2,581 communities. Overall, CRIAR II benefited a total of 48,753 farmers nationwide.

Similar to the first phase, CRIAR II provided financial support consisting of a non-reimbursable voucher with a fixed value of up to US$1,200 per household. This voucher partially covered the cost of an agricultural technology selected by the producer (up to US$1,000) and technical assistance (US$200). The voucher financed 90% of the technology while the remaining 10% was assumed by the beneficiaries. The array of technologies offered included irrigation systems, mills, greenhouses, electric fences, and livestock technologies. The most demanded technologies included irrigation systems (41%), weeders (19%), rototillers (15%) and mills (12%). CRIAR II aimed to solve market failures that limit the adoption of agricultural technologies by fostering private competition and farmers' empowerment. For this, the program implemented "technology fairs", a physical space where farmers selected the technology of their choice among several private providers. Thus, creating the incentives for competition among suppliers. The "technology fairs" also sought to meet demand and supply in a physical location, in remote rural areas where technology providers are not usually available. The "technology fairs" were implemented in schools, sport centers, community centers, among others, and served as platforms where producers received the information to select the most adequate agricultural technology. In the fairs, producers claimed their vouchers and purchased the technology of their choice. Next, producers received the technology along with personalized technical assistance provided in the field. Technical assistance sought to provide guidance on the proper maintenance of the acquired technology, and training to improve their productive potential and associative capacity.

To select beneficiary producers, the program's executing unit defined a set of 190 eligible municipalities based on the following criteria: (i) vulnerability to food insecurity; (ii) agricultural vocation as defined by the current Classification of Major Land Use Capacity Methodology (CUMAT); (iii) not located in an environmental protected area; and (iv) not being a beneficiary municipality of the first phase (CRIAR I). Among the 190 eligible municipalities, 35 municipalities were prioritized and included directly in the program because of their high poverty rates. Of the remaining municipalities (155), 65 were randomly selected to receive the program. Next, within the selected municipalities, the program randomly selected 2,581 communities. For producers in these communities, the program's selection criteria included: (i) being a smallholder producer with less than 35 hectares (ha) of land[3]; (ii) having a valid identification card; (iii) working in agriculture as their principal economic activity; and (iv) having certification of land tenure/use rights.

3. Identification strategy

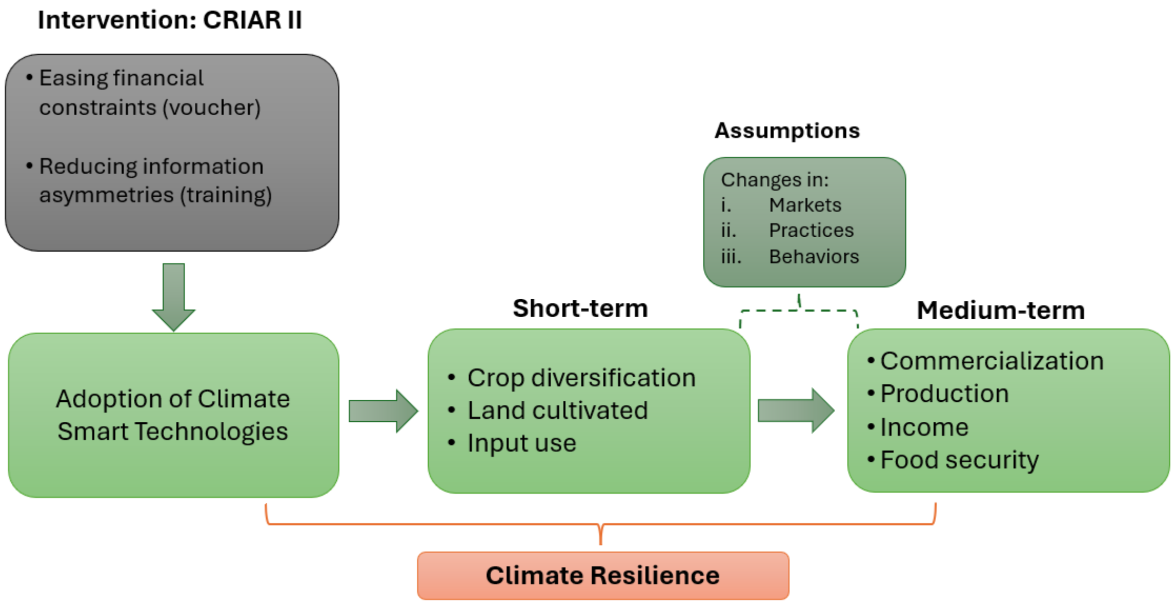
CRIAR II aims at improving productivity, income and food security of small landholders by incentivizing the adoption of climate-smart agricultural technologies. To assess the program's impact, we measure the effects of technology adoption resulting from program participation on both short-term and medium-term outcomes. Short-term outcomes refer to on-farm variables that are more likely to change within one or two agricultural cycles after adopting the technology. These outcomes require less complex processes and could occur in a relative short period, for instance: (i) number of crops for which some type of technology was used during the planting or harvesting processes; (ii) land allocated to traditional crops; (iii) input costs; (iv) number of cultivated hectares; and (v) crop diversification[4]. On the other hand, medium-term outcomes need more complex processes to take place (ex. finding new markets, learning new cropping techniques, using different machinery, etc.). Therefore, it is expected that a longer period is necessary to present measurable effects. These include variables such

[3] The Ministry of Rural Development and Land of Bolivia defines a smallholder as any farmer who works 35 ha of land or less.

[4] Among the variables related to crop diversification, the study considers: i) the crop count per household; ii) the Shannon index, which captures evenness and proportional abundance, calculated as $Shannon = -\sum \alpha_i \, Ln(\alpha_i)$, where α_i represents the ratio between the hectares planted with crop i and the total hectares planted by the household ; and iii) the Simpson index, which measures proportional abundance and is computed as $Simpson = 1 - \sum \alpha_i^2$. Both indices have a lower limit of 0, indicating low crop diversity when the household cultivates only one crop (Salazar & Winters, 2012).

as: (i) commercialization; (ii) household income; (iii) production; (iv) food security; and (v) agricultural sales. The intervention's theory of change suggests that by addressing limitations related to financial constraints and information asymmetries, the program could guide farmers toward more diversified and higher-value production systems, leading to increased income, productivity, and food security, and ultimately improving climate change resilience (See Figure 1).

Figure 1. Theory of change



This impact evaluation aims to quantify the direct effects on program beneficiaries as well as potential spillover effects on non-beneficiary farmers who might be indirectly affected by the program. Spillovers are hypothesized to occur through demonstrative peer effects due to geographical proximity to treated farmers. Potential spillover effects include general equilibrium effects (Taylor, 2012) and behavioral effects (Avitabile & Di Maro, 2007; Angelucci & De Giorgi, 2009; Angelucci & Di Maro, 2010). In this context, behavioral effects could arise if the influence of treated farmers leads non-beneficiaries to adopt similar technologies or management practices. Additionally, general or local equilibrium effects could result if increased incomes lead to higher local demand, or if increased production boosts food availability, thereby reducing food prices.

To assess the direct effects of the program, it is necessary to identify a group of non-beneficiary producers who are neither directly nor indirectly exposed to the program (i.e., a pure control group). Given that geographical proximity may increase the likelihood of program exposure among non-beneficiary farmers, the pure control group consists of comparable farmers in non-selected municipalities. Thus, the direct effects of the program are determined by comparing the outcomes of treated farmers with those of the pure control group. Spillover effects, on the other hand, are estimated by comparing the outcomes of the pure control group with those of non-beneficiaries located in close geographical proximity to the treatment group (i.e. the contaminated control). The contaminated control group includes non-treated farmers residing in selected municipalities but located in non-selected communities.

In sum, the program was implemented using a two-stage randomization process: first at the municipality level, and then at the community level. This approach creates three groups of producers (Figure 2):

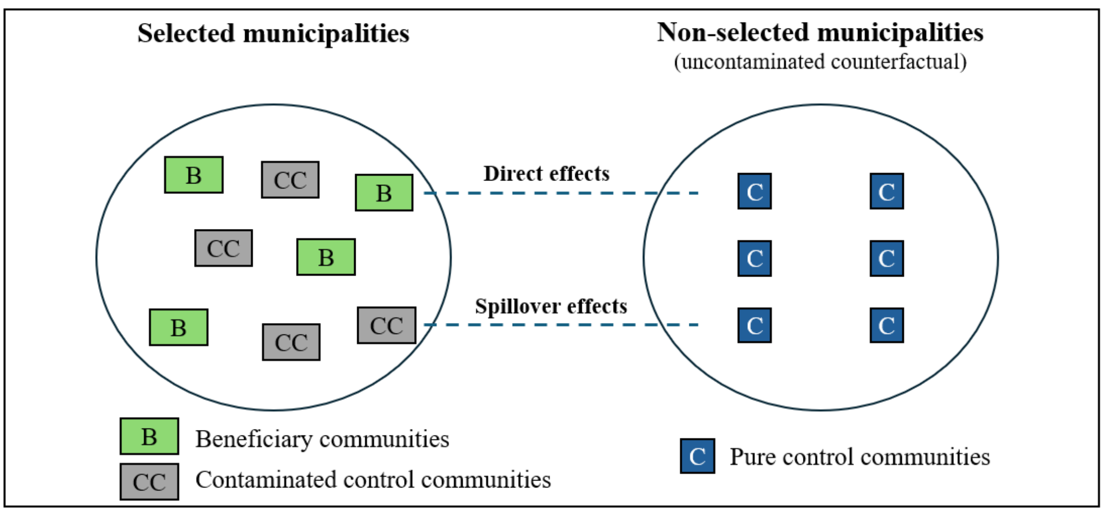
A) Beneficiaries: Farmers located in randomly selected municipalities and communities.

B) Contaminated controls: untreated farmers in selected municipalities but residing in non-selected communities.

C) Pure controls: untreated farmers in non-selected municipalities.

Thus, the direct effect of CRIAR II is measured by the difference between beneficiaries (Group A) and pure controls (Group C), while spillover effects are derived from the difference between contaminated controls (Group B) and pure controls (Group C).

Figure 2. Direct and spillovers effects

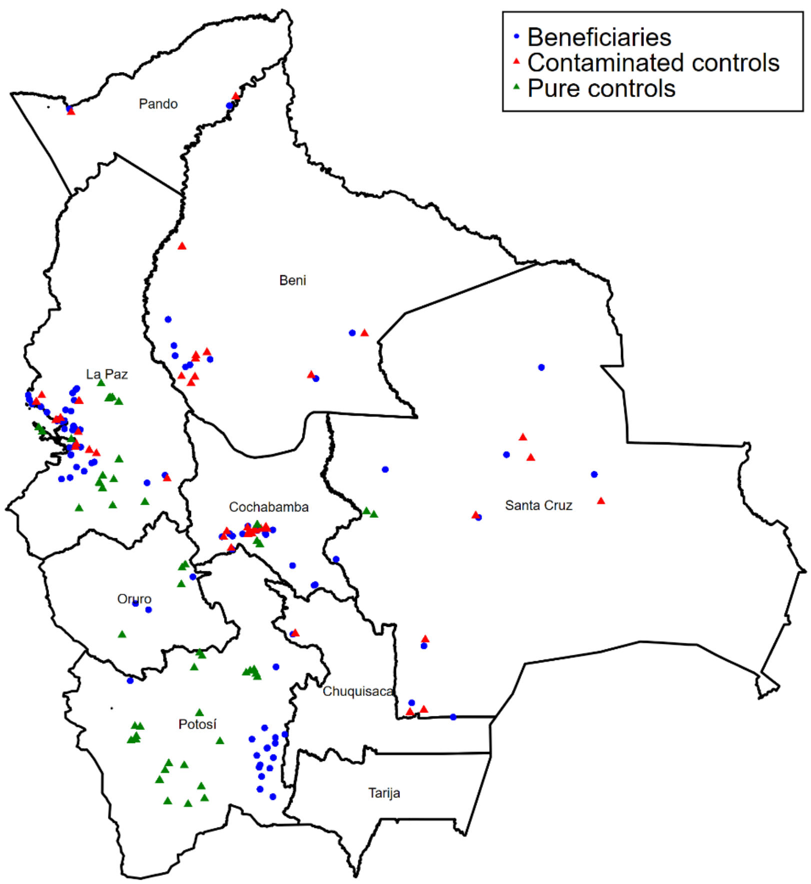


This two-stage randomization assures that farmers in the treatment and control groups have, on average, similar observable and unobservable characteristics. As such, if successful, a randomized control trial allows to capture direct causal impacts through simple comparison between treatment and control groups under the assumption of full compliance. However, in this context, some beneficiary farmers did not adopt the agricultural technologies offered by CRIAR II while some non-beneficiary adopted these technologies. To address the issue of non-compliance, this analysis applies an Instrumental Variables (IV) methodology. This method captures the local average treatment effect (LATE), which is the effect of the program on farmers who (not) adopted the technology due to (not) being selected in the program. The issue of noncompliance does not affect control farmers and therefore, spillover effects are estimated using an Ordinary Least Square (OLS) estimation.

4. Data and descriptive statistics

This section assesses the comparability between treated and control producers by examining observable characteristics. The data for this analysis was collected in November and December 2022[5], after the program finalized its implementation. Baseline data was not collected, limiting the comparability assessment. The information collected was comprised of an agricultural household survey administered to 1,841 producers in 183 communities, located across 67 municipalities[6]. The eligible universe included communities located in the 155 municipalities that fulfilled the program's criteria and participated in the randomization process (the 35 prioritized municipalities were excluded from the evaluation). From the sample, 157 producers[7] without agricultural activity and/or incomplete information were excluded. The final sample for the study consists of 1,684 agricultural producers, 879 treated, 395 contaminated controls, and 410 pure control farmers (**Figure 3**).

Figure 3. Smallholder farmers sample



[5] The data was collected by Ipsos CIESMORI.

[6] The sample size was designed considering representativeness criteria of direct beneficiaries and contaminated and pure control groups.

[7] 42 beneficiaries, 29 contaminated controls, and 86 pure controls.

The questionnaire comprised eight modules requesting socio-demographic information about the household members, employment-related variables, and inquiries pertaining to gender roles. Also, the questionnaire included detailed information on prices, production and costs associated to crops, livestock, and transformation activities. The information collected covered the agricultural cycle from July 2021 to June 2022. Due to logistical problems, the survey did not include questions concerning food security. To address this limitation, telephone surveys were conducted in 2024 to 720 households (a subsample from the 1,684 households interviewed in 2022), the questions related to the household food insecurity experience referred to the period of 2023. The subsample comprises 371 beneficiaries, 137 contaminated controls, and 212 pure controls. The descriptive statistics for this subsample are provided in appendix A.

To establish the comparability between treated and control groups and thus, the validity of the randomization process, the difference in means between treated and control groups for exogenous variables (i.e. not affected by the program) is presented in **Table 1**. These variables capture aspects related to the demographic composition of the household as well as education, sex, age, language, among other aspects related to the heads of the household. On average, the households in the sample are composed of four members, of which 38% are dependents (under 15 years or over 65 years old), and 9% of households belong to a cooperative or an agricultural association. As for the heads of the household, 80% are men, 7% are single, 68% are considered indigenous or native, and they are 54 years old, on average. Regarding the language spoken, 22% of household heads speak Spanish. In terms of the educational level, 8% of the household heads have not received formal education, 59% have primary education, 26% have secondary education, and 6% have advanced education.

Table 1. Descriptive statistics – Household and head of household characteristics

Variables (units)	Total	Treated	Controls		Diff. in means	
			Contaminated	Pure	(ii)- (iv)	(iii-iv)
	(i)	(ii)	(iii)	(iv)	(v)	(vi)
H size (# members)	3.81	3.86	4.11	3.41	0.45**	0.69***
H dependency ratio (%)	0.38	0.37	0.38	0.38	0.00	0.00
H belongs to agric. cooperative (0, 1)	0.09	0.11	0.06	0.09	0.02	-0.03
Male HH (0,1)	0.80	0.80	0.82	0.77	0.04	0.05*
Single HH (0,1)	0.07	0.07	0.06	0.09	-0.02	-0.03*
Indigenous or native HH (0, 1)	0.68	0.71	0.63	0.69	0.02	-0.06
Age HH (years)	53.96	55.00	50.71	54.86	0.14	-4.15***
Speak Spanish HH (0,1)	0.22	0.22	0.16	0.28	-0.06	-0.12**
Literate HH (0,1)	0.90	0.90	0.89	0.94	-0.04**	-0.05**
No education HH (0,1)	0.08	0.08	0.09	0.07	0.02	0.02
With elementary education HH (0,1)	0.59	0.61	0.57	0.58	0.04	-0.01

With secondary education HH (0,1)	0.26	0.24	0.28	0.29	-0.05	0.00
With higher education HH (0,1)	0.06	0.05	0.05	0.07	-0.02	-0.02

P-values are obtained controlling for clusters at the community level. *Difference in means is significant at the 10% level. **Difference in means is significant at the 5%. ***Difference in means is significant at the 1%.

Column (v) presents the difference in means for treated and pure controls, significant differences at a 95% confidence level are found only for household size and literacy, but the differences are rather small (0.5 and -0.04, respectively). A similar pattern is observed between contaminated controls and pure controls (column (vi)), although differences are also seen in age and head of household's language (Spanish). The descriptive statistics confirm that treatment and control groups have similar observable characteristics, confirming the comparability between both groups. Yet, differences between groups are addressed by including control variables in the econometric estimations.

Table *2* presents variables related to agricultural production and food insecurity. Given the nature of the program and the timing of the data collection (up to four years after the beneficiary households obtained the technology[8]), it is expected to find statistically significant differences that could be attributed to the program. In terms of agricultural production, households cultivate about three crops and allocate about 1 hectare of land for agricultural activities. On average, farmers have modern irrigation in 12% of their agricultural land and allocate 68% of this area for the cultivation of traditional crops[9]. Overall, the average annual value of production per farmer is US$1,432 and US$4,303 value per hectare. About 63% of the households are engaged in commercialization activities, selling 28% of their crop production and obtaining an average value of US$485 from agricultural sales. In terms of income, households earn about US$1,195. From the production obtained, approximately 28% of the production is used for home consumption. Significant differences between treatment and pure control groups are observed for most variables, where beneficiaries present superior outcomes.

Regarding livestock activities, 79% of households have livestock production and own about 4 livestock units (TLU)[10]. Also, 51% of the household participate in commercialization activities, allocating about 11% of their livestock production to market sales and earning about US$444 from commercialization activities. Income from livestock activities represents about US$584. Again, for most of these variables, positive and significant differences are found between treatment and pure control with superior outcomes for beneficiary households. Additionally, the survey collected information about transformed products. Approximately, 35% of households produce transformed agricultural products such as

[8] Of the 879 beneficiaries interviewed, 6% received the technology in 2017, 33% in 2018, 30% in 2019, 1% in 2020 and 29% in 2021.

[9] Traditional crops are rice, barley, corn, quinoa, wheat, oca, potato and cassava.

[10] The coefficients published by the Food and Agriculture Organization of the United Nations (FAO) for the South American continent were used to construct the tropical livestock unit index. Information available at https://www.fao.org/3/i2294e/i2294e00.pdf.

cheese, honey, marmalade, ground corn, etc., and 19% sell some of this production in the market. On average, farmers earn about US$144 from this activity. In general, concerning agricultural production, the average household has annual expenditures in the order of $395 USD[11] with an average annual income of US$1,620[12]. Also, significant differences between groups are observed.

To measure food insecurity, this study employs the Food Insecurity Experience Scale (FIES) survey module, which assesses individuals' or households' food insecurity status based on experiences related to food access (FAO, 2016). A food insecurity index is constructed from responses to eight binary (yes/no) questions, following the classification criteria established by the Latin American and Caribbean Food Security Scale (ELCSA, by its Spanish acronym). According to this scale, households with four or more affirmative responses are categorized as experiencing moderate or severe food insecurity (FAO, 2012)[13]. Results indicate that, on average, 67% of households fall into this category, with a higher prevalence among beneficiaries and contaminated controls. The differences between groups are statistically significant.

Table 2. Household production, income and food insecurity

Variables (units)	Total	Treated	Controls: Contaminated	Controls: Pure	Diff. in means: (ii)- (iv)	Diff. in means: (iii-iv)
	(i)	(ii)	(iii)	(iv)	(v)	(vi)
Agricultural production						
Number of crops (#)	2.90	3.25	2.65	2.39	0.86***	0.27
Number of workers (#)	3.74	3.99	3.91	3.04	0.95***	0.87***
Prop. of crops that use some type of technology (%)	0.31	0.51	0.12	0.06	0.45***	0.06***
Hectares worked (Has)	1.22	1.32	1.33	0.91	0.42*	0.42*
Prop. of land with modern irrigation (%)	0.12	0.19	0.06	0.04	0.15***	0.02
Prop. of land with traditional crops (%)	0.68	0.65	0.69	0.75	-0.10**	-0.06
Value of production (USD)	1,432	1,728	1,711	528	1,200***	1,183***
Value of production (USD/HA)	4,303	4,122	4,109	4,879	-757	-770

[11] The following input costs were included: seeds, compost, fertilizers, pesticides, animal feed and veterinary inputs.
[12] Household income includes earnings from commercialization and value of non-commercialized agricultural products. Total income refers to the sum of all revenues from crop, livestock, and processed products. Total income variables were adjusted for extreme outliers. Observations with values above (below) the third (first) quartile by a distance greater than 3 times the interquartile range were imputed with the maximum (minimum) value that was not considered an outlier.
[13] FIES offers a specific methodology for the treatment of the food insecurity responses. However, it was chosen to use the ELCSA's categories, given that the eight FIES's questions come directly from the eight ELCSA's questions referring to adults (FAO, 2016). Furthermore, FAO recognizes rankings based on the raw score (number of affirmative responses) as methodologies for assessing food insecurity status (FAO, 2018). The main drawback of using the raw score is that it generates a ranking not comparable across countries or over time, an aspect that is not relevant for the aim of this paper.

Household commercialize agricultural production (0,1)	0.63	0.66	0.71	0.51	0.15***	0.20***
Prop. of production sold (%)	0.28	0.29	0.32	0.22	0.07*	0.10**
Value of sales (USD)	485	605	506	208	397**	298***
Prop. home-consumption (%)	0.28	0.28	0.25	0.32	-0.04*	-0.07**
Annual income (USD)	1,195	1,472	1,241	559	913***	681***
Livestock production						
H has livestock production (0,1)	0.79	0.85	0.81	0.66	0.19***	0.15***
TLU (units)	4.17	5.08	2.83	3.53	1.55*	-0.69
Commercialize livestock (0, 1)	0.51	0.57	0.56	0.34	0.23***	0.22***
Prop. of production sold (%)	0.11	0.12	0.14	0.07	0.04***	0.07***
Value of sales (USD)	444	495	533	251	244***	282**
Annual income (USD)	584	640	649	401	239**	248
Transformed products						
H produce transformed products (0,1)	0.35	0.40	0.28	0.31	0.09*	-0.03
H sells (0, 1)	0.19	0.25	0.15	0.08	0.17***	0.07**
Prop. of production sold (%)	0.28	0.29	0.32	0.22	0.07*	0.10**
Value of sales (USD)	144	206	107	46	161**	61
Annual income (USD)	186	268	130	65	203***	65
Production costs, total annual incomes and food insecurity						
Total household income (USD)	1,620	1,915	1,613	994	921***	618***
Total costs of agricultural and livestock production (USD)	395	462	398	246	215**	152*
Total net household income (USD)	1,231	1,463	1,232	736	727***	496***
Food insecurity - FAO index (0,1)	0.67	0.70	0.72	0.59	0.10**	0.13**

P-values are obtained controlling for clusters at the community level. *Difference in means is significant at the 10% level. **Difference in means is significant at the 5%. ***Difference in means is significant at the 1%.

5. Econometric approach

5.1 Direct effects (beneficiaries vs pure controls):

The econometric method used in this analysis is the Instrumental Variables (IV) approach, which compares treatment and pure control groups. This method addresses the issue of imperfect compliance, where some beneficiary farmers did not adopt the technology, while some non-beneficiaries did. Implementing IV requires identifying an instrument (Z) that influences/affects program participation, while remaining exogenous with the outcome of interest (ex. production, income, sales) (Stock & Watson, 2007). In other words, the instrument must comply with the conditions of exogeneity and relevance. In this case, the instrument is the randomization that determined program entry and therefore, exogenous to the outcomes of interest. On the other hand, the instrument is relevant as it encourages adoption through a random incentive (i.e. voucher and technical assistance) that partially covered the financial and informational costs of implementing the technology. This condition of relevance is assessed by the results obtained through the first stage. The instrument Z is a dummy variable that takes the value of 1 for farmers in selected communities and 0 otherwise.

The first stage estimates the adoption of the agricultural technology as a function of the instrument Z and other exogenous variables. A technology is considered to be adopted if applied in the last agricultural cycle. In the case of a binary endogenous regressor (technology adoption), a linear probability model is appropriate in the first stage as the aim of the analysis is to estimate causal effects rather than structural coefficients (Angrist, 2001). The first stage is estimated as follows:

$$Prob(tech.adopt_i|X_i) = \beta_0 + \beta_1 Z_i + \beta_2 \sum HH_i + \beta_3 \sum H_i + \beta_4 \sum G_i + \varepsilon_i$$

Where:

- Z_i is the instrument, taking the value of 1 if the household i is in a selected community and 0 otherwise.

- HH_i is a vector of variables capturing demographic information about the head of household i, including age, sex, language, ethnicity, literacy, marital status, and educational level (primary, secondary, or advanced).

- H_i is a vector of variables capturing demographic and socioeconomic information about the household, including the number of household members, dependency ratio, and participation in an agricultural association.

- G_i is a vector of variables capturing geographic information, including department-level fixed effects and altitude of the community.

- β_0, β_1, β_2, β_3 y β_4 are the coefficients to be estimated; and

- ε_i is the error term.

The second stage uses the predicted values of the adoption variable estimated in the first stage to measure the impact of technology adoption on the indicator of interest as follows:

$$Y_i = \alpha_0 + \alpha_1 \widehat{tech.adopt}_i + \alpha_2 \sum HH_i + \alpha_3 \sum H_i + \alpha_4 \sum G_i + \mu_i$$

Where:

- Y_i represents the variables of interest for household i (i.e. value of production, household income, food insecurity and others).

- $\widehat{tech.adopt}_i$ is the predicted variable for technology adoption in the first stage.

- HH_i, H_i and G_i are previously defined.

- α_0, α_1, α_2, α_3 y α_4 are the coefficients to be estimated; and

- μ_i is the error term.

This approach estimates the program's direct impact while addressing non-compliance. However, the limitation of this methodology is that it estimates the average impact for producers whose adoption decision was influenced by the program assignment —those who adopted the technology because they were assigned to the program. This is known as the local average treatment effect (LATE) (Angrist, 2001).

5.2 Spillover effects (contaminated controls vs pure controls):

The spillover effect is estimated with an OLS regression by comparing pure controls (i.e. control farmers in non-selected municipalities) and contaminated controls (i.e. control farmers in selected municipalities). Various exogenous regressors are included in the estimation to control for differences that may persist after the randomization. The estimated equation is as follows:

$$Y_i = \rho_0 + \rho_1 CC + \rho_2 \sum HH_i + \rho_3 \sum H_i + \rho_4 \sum G_i + \omega_i$$

where:

- CC_i is a dummy equal to 1 if the household i is located in a selected municipality but in a non-selected community and 0 otherwise. For robustness, an additional regression is estimated with a continuous variable that measures the distance between the control farmers' community and the nearest treated community[14].

- HH_i, H_i and G_i are previously defined.

- ρ_0, ρ_1, ρ_2, ρ_3 y ρ_4 are the coefficients to be estimated; and

- ω_i is the error term.

The hypothesis to be tested is that spillover effects are likely to occur when control farmers are near treated farmers.

To corroborate the robustness of the identification strategy, placebo tests are performed on exogenous variables that should not be affected by the treatment.

6. Empirical results

The results of the first stage are presented in **Table 3.** These findings confirm that program participation has a positive and statistically significant effect on technology adoption. Specifically, being selected as beneficiary increased farmers' probability of adoption by 64 pp. This finding confirms that CRIAR II successfully incentivized the adoption of climate-

[14] This model was also estimated with a squared distance variable. The inclusion was not significant, so it was decided not to include it in the final specification.

smart agricultural technologies. Moreover, indigenous producers and geographical dummies affected the probability of adopting a new agricultural technology. The F-test confirms that control variables are jointly significant in explaining the dependent variable and that the instrument is relevant on explaining the adoption decision.

Table 3. First stage – Technology adoption

	Variables (Unit)	Coefficient	Robust SE
Head of household Characteristics	Male (0,1)	0.040	0.029
	Age (years)	-0.001	0.001
	Speak Spanish (0,1)	0.006	0.030
	Indigenous (0,1)	0.045*	0.026
	Single (0,1)	0.002	0.041
	Literate (0,1)	-0.025	0.060
	Elementary education (0,1)	0.044	0.064
	Secondary education (0,1)	0.054	0.067
	Higher education (0,1)	0.094	0.084
Household Characteristics	Size (# members)	-0.005	0.007
	Dependence ratio (%)	-0.018	0.039
	H belongs to an agric. coop. (0, 1)	0.067	0.049
Geographic Location	La Paz (0,1)	0.228***	0.041
	Cochabamba (0,1)	0.173***	0.063
	Oruro (0,1)	0.111	0.105
	Potosi (0,1)	0.307***	0.040
	Santa Cruz (0,1)	-0.007	0.123
	Beni (0,1)	0.247*	0.134
	Pando (0,1)	0.224	0.163
	Altitude	0.000	0.000
	Altitude^2	0.000	0.000
Instrument	**Beneficiary (0,1)**	**0.637*** **	**0.034**
	Constant	-0.170	0.157
	Observations	1,289	
	R-squared	0.3521	

F stat	[0.0000]

Notes: These results correspond to the OLS estimation for the first stage using a linear probability model. For the geographical dummies, Chuquisaca is the reference category. Robust standard errors clustered at the community level are in parentheses. P values for the test statistics are in brackets. * Significant at 10% level. ** Significant at 5% level. *** Significant at 1% level.

Table 4 and **5** present the second-stage results for short-term and medium-term outcomes, respectively. Regarding short-term outcomes, the results confirm that technology adoption has a positive and significant effect on the number of crops where improved technologies are incorporated (2.6), the cost of inputs (90%), the number of cultivated hectares (+0.5), and the value of annual agricultural sales (+623 USD). Also, technology adoption creates incentives to increase crop diversification, captured by the number of cultivated crops (+1.6), and the Shannon index (+34 pp). Conversely, a negative and significant impact is found on the proportion of hectares used for traditional crops (-11 pp), corresponding to a reduction of 0.15 hectares. These results indicate that adopters are more actively engaged in market activities, as evidenced by the higher revenues from agricultural sales, and greater on-farm diversification with a shift toward high-value crops.

In relation to medium term outcomes, adopting a new technology is associated with increased total income (170%) and net income (18%)[15]. This represents an increase of US$1,691 in total income and US$863 in net income with respect to the control group (US$994 and US$4,816[16], respectively). Similarly, technology adoption increased total value of agricultural production by 181%. This represents an increase of US$946 compared to pure controls (US$523).[17] In terms of land productivity, measured as the value of agricultural production per hectare, no significant impact is observed despite the positive sign of the coefficient. In sum, the estimations suggest that program participation led farmers to develop more extensive and diversified agricultural systems while strengthening market linkages, resulting in higher value of production and income.

In terms of food insecurity, no statistically significant impact is observed. This may be due to the smaller size of the subsample surveyed to measure this variable. While the statistical analysis indicates that the treated and control groups remain comparable for this subsample (see Appendix A), the effective sample size is too small to be considered representative. Therefore, given this limitation, the effects of the program on food insecurity should be interpreted with caution.

[15] Comparable outcomes were observed on per capita income and per capita production value.

[16] To calculate the logarithm function, the data distribution was adjusted to ensure that the minimum net income value was set to 1. To maintain consistency, the same magnitude was uniformly added to all other observations of the net income variable.

[17] Coefficients indicate important changes in income and production value variables, mainly due to the low initial levels observed in the control group from non-selected municipalities, where any impact causes a significant variation. Similar studies found statistically significant coefficients with magnitudes of 360% for sales income (Salazar et al., 2016) and 627% for household income (Aramburu et al., 2019).

For robustness, placebo tests are estimated on education, dependency ratio and marital status (see Appendix C). The findings confirm non-significant effects (at the 95% confidence level) of the program, concluding that effects are not found because of a correlation between the error term of the outcome equations and the instrument (Attanasio & Vera-Hernández, 2004)[18].

[18] A similar exercise is performed for spillover effects (see Appendix C).

Table 4. Results of the second stage: Short-term outcomes

Variables (unit)	Number of crops that use some type of technology	Prop. of land with traditional crops (%)	Input costs (log)	Cultivated Ha. (#)	Number of crops (#)	Shannon index[a]
Direct effect:						
Technology adoption (0,1)	2.558***	-0.113*	0.643**	0.536*	1.581***	0.337***
	(0.209)	(0.0639)	(0.321)	(0.298)	(0.326)	(0.0963)
Head of household:						
Male (0,1)	0.127	0.0278	0.0261	0.0958	0.254*	0.0439
	(0.0913)	(0.0250)	(0.145)	(0.158)	(0.130)	(0.0408)
Age (years)	-0.000573	-0.000176	0.00127	0.00288	0.00493	0.00125
	(0.00308)	(0.000732)	(0.00469)	(0.00453)	(0.00454)	(0.00129)
Speak Spanish (0,1)	-0.213	0.0196	-0.0948	-0.183	-0.351*	-0.0216
	(0.147)	(0.0283)	(0.149)	(0.193)	(0.198)	(0.0455)
Indigenous (0,1)	0.211***	0.0153	-0.0476	-0.0143	0.211*	0.0480
	(0.0812)	(0.0195)	(0.117)	(0.101)	(0.127)	(0.0373)
Single (0,1)	0.0309	-0.0350	-0.552**	0.0282	0.215	0.0149
	(0.149)	(0.0354)	(0.220)	(0.211)	(0.219)	(0.0543)
Literate (0,1)	-0.201	0.0144	0.572**	0.0471	-0.0427	-0.0217
	(0.180)	(0.0463)	(0.274)	(0.284)	(0.233)	(0.0701)
Elementary education (0,1)	0.327*	-0.00307	-0.0198	0.251	0.126	-0.0401
	(0.168)	(0.0451)	(0.306)	(0.320)	(0.231)	(0.0746)
Secondary education (0,1)	0.252	-0.0489	-0.0116	0.283	-0.196	-0.0685
	(0.178)	(0.0529)	(0.345)	(0.330)	(0.252)	(0.0814)
Higher education (0,1)	0.0196	-0.0185	0.113	0.403	-0.390	-0.110
	(0.224)	(0.0587)	(0.388)	(0.378)	(0.292)	(0.0923)
Household:						
Size (# members)	0.0187	-0.00536	0.0457	0.0185	0.0790***	0.0196**
	(0.0231)	(0.00442)	(0.0309)	(0.0266)	(0.0294)	(0.00865)
Dependence ratio (%)	-0.166	0.0563**	-0.282*	-0.00703	-0.0341	-0.0721

	(0.115)	(0.0247)	(0.152)	(0.142)	(0.189)	(0.0440)
H belongs to an agric. coop. (0, 1)	-0.0505	0.00722	0.629***	0.451**	0.0402	0.00928
	(0.152)	(0.0279)	(0.195)	(0.184)	(0.184)	(0.0487)
Geographic:						
Geographic Dummies	Yes	Yes	Yes	Yes	Yes	Yes
Altitude	0.000777***	0.000125	0.000677	-0.00166**	0.000662	0.000177
	(0.000289)	(0.000172)	(0.000754)	(0.000845)	(0.000543)	(0.000158)
Altitude^2	-2.00e-07***	5.02e-09	-1.15e-07	3.21e-07**	-1.91e-07*	-3.99e-08
	(5.93e-08)	(3.07e-08)	(1.33e-07)	(1.54e-07)	(1.06e-07)	(2.98e-08)
Constant	-0.613	0.171	3.984***	1.468	1.203	0.417*
	(0.428)	(0.241)	(1.067)	(1.230)	(0.740)	(0.223)
Observations	1,289	1,289	1,289	1,289	1,289	1,289
R-squared	0.437	0.181	0.136	0.184	0.147	0.062

Notes: All models are estimated by 2SLS. Robust standard errors clustered at the community level are in parentheses. Income, cost, and production value variables were adjusted for extreme outliers. Annex B presents the results of the full regressions. * Significant at 10% level. ** Significant at 5% level. *** Significant at 1% level. [a] Similar results were found with the Simpson index.

Table 5. Results of the second stage – Medium-term outcomes

Variables (unit)	Total income (log)	Net income (log)	Value of agricultural production (log)	Value of agricultural production per HA (log)	Household sells agricultural production (1=yes)[a]	Prop. of agricultural production sold (%)	Value of sales (USD)	Food insecurity (1= Insecurity)[a]
Direct effect:								
Technology adoption (0,1)	0.994***	0.165***	1.033***	0.301	0.113	-0.00983	623.3***	-0.0166
	(0.260)	(0.0498)	(0.283)	(0.384)	(0.0898)	(0.0620)	(158.3)	(0.0610)
Head of household:								
Male (0,1)	0.344***	0.0466	0.424***	0.0565	0.0624*	0.0201	58.49	-0.00854
	(0.109)	(0.0306)	(0.115)	(0.132)	(0.0352)	(0.0259)	(79.70)	(0.0551)
Age (years)	0.00353	0.000399	-0.000892	-0.00249	-0.000974	-0.00172**	-0.167	0.00203
	(0.00355)	(0.000727)	(0.00417)	(0.00465)	(0.00109)	(0.000818)	(2.882)	(0.00139)
Speak Spanish (0,1)	0.0201	-0.0137	-0.100	-0.0452	0.00715	-0.0224	73.59	-0.0554

	(0.135)	(0.0386)	(0.130)	(0.154)	(0.0380)	(0.0292)	(110.9)	(0.0549)
Indigenous (0,1)	0.268***	0.0859**	0.149	0.0853	0.0686**	0.0130	100.4*	0.0635
	(0.0904)	(0.0393)	(0.0991)	(0.112)	(0.0298)	(0.0184)	(60.97)	(0.0447)
Single (0,1)	-0.138	0.0306	0.0303	-0.0396	0.0810*	-0.0168	-163.2	0.0118
	(0.150)	(0.0392)	(0.165)	(0.183)	(0.0466)	(0.0307)	(104.6)	(0.0810)
Literate (0,1)	0.351*	0.0353	0.319	0.480	0.0439	0.0199	132.2	-0.0939
	(0.204)	(0.0354)	(0.243)	(0.296)	(0.0667)	(0.0400)	(131.5)	(0.167)
Elementary education (0,1)	-0.0193	0.00248	-0.0953	-0.512**	0.00498	0.00215	154.9	0.0726
	(0.203)	(0.0351)	(0.225)	(0.246)	(0.0690)	(0.0414)	(135.9)	(0.174)
Secondary education (0,1)	-0.0798	-0.0712	-0.166	-0.721***	-0.0316	-0.0148	115.4	0.0565
	(0.215)	(0.0754)	(0.231)	(0.264)	(0.0760)	(0.0465)	(146.5)	(0.174)
Higher education (0,1)	-0.0814	0.0219	-0.223	-1.067***	-0.0930	-0.0773	263.1	-0.00362
	(0.255)	(0.0541)	(0.308)	(0.356)	(0.0893)	(0.0502)	(194.8)	(0.207)
Household:								
Size (# members)	0.0715***	0.0189***	0.0455*	0.0346	0.0147**	-0.00118	33.15*	0.0201**
	(0.0202)	(0.00585)	(0.0247)	(0.0301)	(0.00717)	(0.00457)	(17.64)	(0.0101)
Dependence ratio (%)	-0.311***	-0.00280	-0.201	-0.101	0.0206	-0.0104	-95.67	0.0528
	(0.112)	(0.0364)	(0.136)	(0.168)	(0.0452)	(0.0271)	(90.76)	(0.0629)
H belongs to an agric. coop.	0.833***	0.192***	0.576***	0.109	0.0504	0.0221	792.0***	0.0332
(0, 1)	(0.138)	(0.0433)	(0.145)	(0.150)	(0.0590)	(0.0348)	(145.8)	(0.0583)
Geographic:								
Geographic Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Altitude	6.32e-05	-0.000160	0.000309	9.19e-05	-6.62e-06	3.38e-05	-0.102	0.000232*
	(0.000515)	(0.000103)	(0.000562)	(0.000711)	(0.000185)	(0.000181)	(0.362)	(0.000121)
Altitude^2	1.19e-09	3.40e-08*	-4.95e-08	-2.17e-08	-3.10e-08	-3.20e-08	6.81e-06	-3.96e-08*
	(1.01e-07)	(2.04e-08)	(1.05e-07)	(1.31e-07)	(3.49e-08)	(3.31e-08)	(6.72e-05)	(2.12e-08)
Constant	5.356***	8.302***	4.824***	8.141***	0.906***	0.733***	570.6	-0.0212
	(0.642)	(0.126)	(0.741)	(0.929)	(0.250)	(0.236)	(515.1)	(0.241)
Observations	1,289	1,289	1,289	1,289	1,289	1,289	1,289	583
R-squared	0.136	0.065	0.088	0.099	0.168	0.211	0.167	0.082

Notes: All models are estimated by 2SLS. Robust standard errors clustered at the community level are in parentheses. Income, cost, and production value variables were adjusted for extreme outliers. Annex B presents the results of the full regressions. * Significant at 10% level. ** Significant at 5% level. *** Significant at 1% level. [a] As a robustness analysis, biprobit models were estimated, yielding results consistent with those in this table. Additional results are available upon request.

Previous results confirm the positive impact of program participation on technology adoption. Moreover, being exposed to the program for a longer period may lead to more effective use of the technologies and improved outcomes, thereby strengthening the effects over time. To assess this, we assess the performance of the outcome variables for each additional year of program participation. For this purpose, an intensity analysis of the intention to treat is employed (Angrist, 2006), examining the effect of an additional year during which the household has been selected as a beneficiary, regardless of its technology adoption status. Since the number of years as CRIAR II beneficiaries depends on a random assignment (being a beneficiary or not) and on logistic factors that determined the year of program participation, it is likely that the regressor variable is an exogenous factor. Therefore, an OLS regression is applied to estimate the effects over time.

The results presented in **Table 6** and **7** suggest that the effects on most of the short-term and medium-term variables intensify overtime. Specifically, an additional year in the program is associated with an increase in the number of crops where improved technologies are incorporated (+0.4), the number of crops (+0.2), the Shannon diversification index (+6 pp), total income (+10%), net income (+2%), and agricultural production value (+10%). Additionally, a negative and significant effect is found on the proportion of hectares used for traditional crops (-2 pp). Although the coefficients for input costs, the number of cultivated hectares, land productivity and commercialization variables exhibit the expected sign, these are not statistically significant.

Table 6. Time effects on short term variables

Variables (unit)	Number of crops that use some type of technology	Prop. of land with traditional crops (%)	Input costs (log)	Cultivated Ha. (#)	Number of crops (#)	Shannon index[a]
Direct effect:						
Years as beneficiary	0.368***	-0.0224**	0.0428	0.0215	0.224***	0.0602***
	(0.0430)	(0.0106)	(0.0587)	(0.0404)	(0.0464)	(0.0142)
Head of household:						
Male (0,1)	0.186*	0.0267	0.0529	0.122	0.292**	0.0489
	(0.109)	(0.0245)	(0.149)	(0.155)	(0.127)	(0.0383)
Age (years)	-0.00336	-4.41e-05	0.000648	0.00238	0.00321	0.000867
	(0.00377)	(0.000751)	(0.00483)	(0.00477)	(0.00442)	(0.00124)
Speak Spanish (0,1)	-0.145	0.0165	-0.0784	-0.169	-0.309	-0.0126
	(0.165)	(0.0289)	(0.146)	(0.190)	(0.199)	(0.0466)
Indigenous (0,1)	0.355***	0.00872	-0.0128	0.0143	0.300**	0.0674*
	(0.0979)	(0.0189)	(0.117)	(0.101)	(0.118)	(0.0342)
Single (0,1)	-0.0482	-0.0298	-0.558**	0.0270	0.167	0.00120
	(0.189)	(0.0357)	(0.225)	(0.212)	(0.229)	(0.0548)
Literate (0,1)	-0.253	0.0142	0.538*	0.0131	-0.0763	-0.0236
	(0.211)	(0.0456)	(0.277)	(0.294)	(0.221)	(0.0685)
Elementary education (0,1)	0.498**	-0.0109	0.0208	0.285	0.232	-0.0170
	(0.206)	(0.0442)	(0.309)	(0.334)	(0.217)	(0.0721)
Secondary education (0,1)	0.490**	-0.0612	0.0330	0.316	-0.0507	-0.0337
	(0.228)	(0.0519)	(0.348)	(0.342)	(0.240)	(0.0798)
Higher education (0,1)	0.321	-0.0335	0.175	0.451	-0.205	-0.0676
	(0.252)	(0.0602)	(0.395)	(0.390)	(0.282)	(0.0938)
Household:						
Size (# members)	0.0250	-0.00547	0.0487	0.0214	0.0831***	0.0201**
	(0.0293)	(0.00444)	(0.0327)	(0.0274)	(0.0293)	(0.00833)
Dependence ratio (%)	-0.283**	0.0614**	-0.311**	-0.0312	-0.106	-0.0876**

	(0.133)	(0.0250)	(0.153)	(0.136)	(0.178)	(0.0417)
H belongs to an agric. coop. (0, 1)	0.287	-0.00975	0.697***	0.503***	0.248	0.0577
	(0.181)	(0.0292)	(0.200)	(0.182)	(0.186)	(0.0487)
Geographic:						
Geographic Dummies	Yes	Yes	Yes	Yes	Yes	Yes
Altitude	0.00157***	0.000115	0.00108	-0.00126	0.00117**	0.000232*
	(0.000471)	(0.000173)	(0.000764)	(0.000774)	(0.000467)	(0.000137)
Altitude^2	-3.62e-07***	7.41e-09	-1.94e-07	2.44e-07*	-2.94e-07***	-5.22e-08**
	(9.67e-08)	(3.06e-08)	(1.33e-07)	(1.37e-07)	(9.37e-08)	(2.49e-08)
Constant	-1.854**	0.217	3.600***	1.127	0.430	0.270
	(0.722)	(0.243)	(1.084)	(1.175)	(0.713)	(0.216)
Observations	1,289	1,289	1,289	1,289	1,289	1,289
R-squared	0.227	0.174	0.122	0.198	0.165	0.103

Notes: All models are estimated by OLS. Robust standard errors clustered at the community level are in parentheses. Income, cost, and production value variables were adjusted for extreme outliers. Annex B presents the results of the full regressions. * Significant at 10% level. ** Significant at 5% level. *** Significant at 1% level. [a] Similar results were found with the Simpson index.

Table 7. Time effects on medium term variables

Variables (unit)	Total income (log)	Net income (log)	Value of agricultural production (log)	Value of agricultural production per HA (log)	Household sells agricultural production (1=yes)[a]	Prop. of agricultural production sold (%)	Value of sales (USD)	Food insecurity (1= Insecurity)[a]
Direct effect:								
Years as beneficiary	0.0965**	0.0225**	0.0961**	0.0300	0.0139	-0.00423	39.59	0.00411
	(0.0409)	(0.00972)	(0.0458)	(0.0542)	(0.0156)	(0.0102)	(25.16)	(0.0119)
Head of household:								
Male (0,1)	0.378***	0.0507	0.460***	0.0666	0.0656*	0.0205	84.88	-0.00945
	(0.112)	(0.0326)	(0.120)	(0.137)	(0.0360)	(0.0259)	(82.39)	(0.0568)
Age (years)	0.00252	0.000222	-0.00193	-0.00280	-0.00109	-0.00170**	-0.769	0.00201

	(0.00362)	(0.000774)	(0.00434)	(0.00477)	(0.00112)	(0.000817)	(3.134)	(0.00143)
Speak Spanish (0,1)	0.0459	-0.00937	-0.0734	-0.0374	0.0101	-0.0227	89.48	-0.0555
	(0.127)	(0.0381)	(0.126)	(0.158)	(0.0388)	(0.0294)	(109.4)	(0.0562)
Indigenous (0,1)	0.322***	0.0952**	0.206**	0.102	0.0749**	0.0124	134.1**	0.0632
	(0.0875)	(0.0391)	(0.0941)	(0.107)	(0.0291)	(0.0185)	(60.94)	(0.0450)
Single (0,1)	-0.156	0.0259	0.0129	-0.0452	0.0782	-0.0157	-168.6	0.0117
	(0.150)	(0.0385)	(0.163)	(0.184)	(0.0478)	(0.0315)	(103.4)	(0.0825)
Literate (0,1)	0.312	0.0314	0.276	0.468	0.0407	0.0189	98.77	-0.0946
	(0.212)	(0.0365)	(0.246)	(0.303)	(0.0685)	(0.0402)	(128.0)	(0.172)
Elementary education (0,1)	0.0449	0.0134	-0.0287	-0.492**	0.0124	0.00135	194.2	0.0729
	(0.199)	(0.0342)	(0.216)	(0.243)	(0.0703)	(0.0417)	(134.2)	(0.180)
Secondary education (0,1)	-0.00175	-0.0562	-0.0857	-0.697***	-0.0219	-0.0166	158.0	0.0577
	(0.208)	(0.0734)	(0.224)	(0.264)	(0.0775)	(0.0473)	(142.5)	(0.180)
Higher education (0,1)	0.0230	0.0409	-0.116	-1.035***	-0.0803	-0.0792	322.9*	-0.00210
	(0.248)	(0.0528)	(0.291)	(0.350)	(0.0919)	(0.0511)	(191.1)	(0.213)
Household:								
Size (# members)	0.0753***	0.0193***	0.0495*	0.0357	0.0151**	-0.00112	36.10*	0.0194*
	(0.0221)	(0.00605)	(0.0265)	(0.0305)	(0.00742)	(0.00462)	(19.17)	(0.0101)
Dependence ratio (%)	-0.356***	-0.0103	-0.248*	-0.115	0.0155	-0.00995	-123.9	0.0539
	(0.111)	(0.0369)	(0.134)	(0.171)	(0.0467)	(0.0274)	(90.55)	(0.0649)
H belongs to an agric. coop.	0.948***	0.213***	0.695***	0.144	0.0645	0.0198	857.4***	0.0344
(0, 1)	(0.141)	(0.0465)	(0.131)	(0.150)	(0.0579)	(0.0332)	(152.5)	(0.0607)
Geographic:								
Geographic Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Altitude	0.000562	-0.000104	0.000845	0.000240	3.80e-05	4.24e-05	0.297	0.000196
	(0.000460)	(0.000102)	(0.000563)	(0.000678)	(0.000179)	(0.000170)	(0.348)	(0.000119)
Altitude^2	-9.76e-08	2.27e-08	-1.55e-07	-5.10e-08	-4.00e-08	-3.36e-08	-7.13e-05	-3.28e-08
	(8.63e-08)	(1.98e-08)	(1.02e-07)	(1.25e-07)	(3.35e-08)	(3.09e-08)	(6.30e-05)	(2.08e-08)
Constant	4.806***	8.220***	4.246***	7.976***	0.848***	0.733***	195.3	0.00695
	(0.648)	(0.115)	(0.792)	(0.878)	(0.250)	(0.222)	(530.8)	(0.237)
Observations	1,289	1,289	1,289	1,289	1,289	1,289	1,289	583
R-squared	0.155	0.073	0.113	0.099	0.154	0.215	0.170	0.081

Notes: All models are estimated by OLS. Robust standard errors clustered at the community level are in parentheses. Income, cost, and production value variables were adjusted for extreme outliers. Annex B presents the results of the full regressions. * Significant at 10% level. ** Significant at 5% level. *** Significant at 1% level. [a] As a robustness analysis, probit models were estimated, yielding results consistent with those in this table. Additional results are available upon request.

Table 8 and **9** present the estimations of the program's indirect effects by comparing farmers in the contaminated control group (i.e. non beneficiaries residing in selected municipalities) and the pure control group (i.e. non beneficiaries residing in non-selected municipalities). As mentioned, the rationale for measuring indirect or spillover effects among non-beneficiary farmers in selected municipalities is based on the hypotheses of "peer-to-peer learning" or imitation behavior. Hence, if technology adoption is perceived as effective, it is expected that non-beneficiary farmers would imitate the behavior of nearby beneficiary farmers by adopting similar technologies.

Regarding short-term outcomes, the findings indicate that contaminated controls increased the number of crops with improved technologies (+0.2) and the probability of adopting a new agricultural technology (+14 pp), compared to the pure controls. However, the coefficients for crop diversification, input costs and cultivated hectares are not statistically significant. This suggests that farmers located in the selected municipalities are more likely to adopt technologies even if not treated, indicating the presence of spillovers. To corroborate this hypothesis, we also estimate the effects of the distance to the nearest beneficiary community[19]. The results confirm that distance to a beneficiary community reduces the probability of adoption and crop diversification. Thus, farmers located closer to beneficiary communities are more likely to adopt a new technology and to increase crop diversification. These results suggest that proximity between treated and untreated communities may have fostered behavioral effects.

In relation to medium term outcomes, contaminated controls increased total income by 53%, net income by 6%, and total production value by 89%. This represents an increase of US$528 in total income, US$283 in net income and US$466 in total value of production, with respect to pure controls. Also, there is some evidence that contaminated controls increased the value of production per hectare by 60%, although the variable is significant at 10%. However, despite the positive sign of the coefficients, there is no significant impact on commercialization variables or food insecurity. Next, using the distance to the closest treated community to estimate the spillover effects presents consistent results but only significant for the value of production per hectare. On the other hand, a negative association is found (significant at 10%) between the distance and the likelihood of a household experiencing moderate or severe food insecurity, which is counterintuitive as it would be expected that residing closer to a beneficiary would reduce food insecurity through the spillover effects on productivity and/or income.

[19] The distance between communities belonging to the control group in selected (not selected) municipalities and the nearest treated community registers an average value of 15.36 km (62.88 km), a median of 7.83 km (50.81 km), a minimum of 0.50 km (9.37 km) and a maximum of 124.83 km (158.83 km).

Table 8. Short term indirect impacts

Variables (unit)	Number of crops that use some type of technology		Technology adoption (1=yes)[a]		Prop. of land with traditional crops (%)		Input costs (log)		Cultivated Ha. (#)		Number of crops (#)		Shannon index[b]	
	Dummy	Km	Dummy	Km	Dummy	Km	Dummy	Km	Dummy	Km	Dummy	Km	Dummy	Km
Indirect effect:	0.224***	-0.00477***	0.142***	-0.00209***	0.00711	0.000291	-0.201	-0.00364	0.121	0.00316	0.183	-0.00599**	0.0472	-0.00181**
	(0.0840)	(0.00112)	(0.0443)	(0.000501)	(0.0526)	(0.000682)	(0.277)	(0.00345)	(0.155)	(0.00315)	(0.184)	(0.00242)	(0.0691)	(0.000822)
Head of household:														
Male (0,1)	0.0654	0.0637	0.0264	0.0266	0.0441	0.0447	-0.311	-0.321*	-0.0186	-0.0110	0.105	0.101	0.0574	0.0559
	(0.0661)	(0.0662)	(0.0304)	(0.0313)	(0.0286)	(0.0288)	(0.196)	(0.191)	(0.135)	(0.135)	(0.136)	(0.136)	(0.0447)	(0.0448)
Age (years)	0.00229	0.00126	-0.000703	-0.00122	-0.00200**	-0.00197**	0.00987	0.00967	0.000889	0.00115	0.0172***	0.0160***	0.00577***	0.00544***
	(0.00182)	(0.00186)	(0.00101)	(0.00101)	(0.000990)	(0.000962)	(0.00638)	(0.00635)	(0.00447)	(0.00458)	(0.00446)	(0.00437)	(0.00138)	(0.00136)
Speak Spanish (0,1)	-0.0974*	-0.0834*	-0.0167	-0.0186	-0.00323	-0.00792	0.133	0.212	0.0993	0.0403	-0.309*	-0.273	-0.119**	-0.107**
	(0.0506)	(0.0455)	(0.0357)	(0.0322)	(0.0405)	(0.0417)	(0.227)	(0.221)	(0.253)	(0.260)	(0.176)	(0.179)	(0.0536)	(0.0536)
Indigenous (0,1)	-0.00999	-0.0262	0.00625	-0.00173	0.0295	0.0301	0.178	0.173	-0.0288	-0.0234	0.0772	0.0588	0.0374	0.0320
	(0.0692)	(0.0676)	(0.0300)	(0.0298)	(0.0264)	(0.0264)	(0.145)	(0.146)	(0.0985)	(0.0988)	(0.113)	(0.116)	(0.0418)	(0.0431)
Single (0,1)	-0.0790	-0.0878	-0.0467	-0.0507	0.0503	0.0508	-0.992***	-0.998***	-0.217	-0.211	-0.0818	-0.0926	-0.0921	-0.0954*
	(0.0794)	(0.0825)	(0.0382)	(0.0402)	(0.0396)	(0.0393)	(0.280)	(0.281)	(0.181)	(0.181)	(0.188)	(0.190)	(0.0557)	(0.0558)
Literate (0,1)	0.0454	0.0499	0.0371	0.0349	0.0864	0.0842	0.603*	0.642*	-0.115	-0.144	-0.371	-0.355	-0.102	-0.0971
	(0.0694)	(0.0716)	(0.0565)	(0.0566)	(0.0627)	(0.0626)	(0.359)	(0.349)	(0.241)	(0.240)	(0.293)	(0.295)	(0.0855)	(0.0856)
Elementary education (0,1)	-0.0554	-0.0422	-0.0290	-0.0212	-0.124*	-0.123*	0.189	0.181	0.504**	0.508**	0.635**	0.647**	0.109	0.112
	(0.0928)	(0.0935)	(0.0607)	(0.0611)	(0.0663)	(0.0669)	(0.409)	(0.400)	(0.216)	(0.211)	(0.260)	(0.261)	(0.0822)	(0.0818)
Secondary education (0,1)	-0.0848	-0.0744	-0.0348	-0.0260	-0.170**	-0.169**	0.307	0.279	0.500*	0.519**	0.580**	0.584**	0.146	0.146
	(0.109)	(0.111)	(0.0685)	(0.0687)	(0.0695)	(0.0699)	(0.438)	(0.423)	(0.261)	(0.257)	(0.282)	(0.285)	(0.0947)	(0.0948)
Higher education (0,1)	0.275	0.284	0.103	0.114	-0.0868	-0.0844	0.831*	0.784*	1.178***	1.211***	0.422	0.419	0.150	0.148
	(0.182)	(0.183)	(0.0883)	(0.0877)	(0.0883)	(0.0890)	(0.474)	(0.470)	(0.382)	(0.380)	(0.319)	(0.316)	(0.111)	(0.108)
Household:														
Size (# members)	0.0245	0.0196	0.00127	-0.000116	0.00104	0.00172	0.0438	0.0333	0.00651	0.0147	0.0893**	0.0813**	0.0295***	0.0270***
	(0.0160)	(0.0159)	(0.00775)	(0.00791)	(0.00693)	(0.00681)	(0.0369)	(0.0366)	(0.0282)	(0.0276)	(0.0343)	(0.0339)	(0.00988)	(0.00993)
Dependence ratio (%)	-0.115	-0.111	-0.0101	-0.00713	0.0621*	0.0625*	-0.482**	-0.490**	-0.127	-0.122	-0.170	-0.167	-0.111**	-0.110**
	(0.0775)	(0.0771)	(0.0352)	(0.0348)	(0.0350)	(0.0354)	(0.213)	(0.208)	(0.150)	(0.148)	(0.171)	(0.168)	(0.0496)	(0.0491)
	-0.0369	-0.0276	0.0311	0.0349	-0.0255	-0.0261	0.465*	0.474*	0.440*	0.432*	0.144	0.156	-0.000960	0.00274

H belongs to an agric. coop. (0, 1)	(0.0966)	(0.0887)	(0.0546)	(0.0523)	(0.0494)	(0.0491)	(0.256)	(0.260)	(0.241)	(0.239)	(0.240)	(0.229)	(0.0626)	(0.0600)
Geographic:														
Geographic Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Altitude	0.000459	0.000424	0.000306*	0.000271*	-0.000170	-0.000178	-0.000419	-0.000274	-0.000993*	-0.00109**	-0.000688	-0.000686	-0.000421***	-0.000417***
	(0.000287)	(0.000258)	(0.000173)	(0.000163)	(0.000147)	(0.000141)	(0.000920)	(0.000837)	(0.000525)	(0.000550)	(0.000437)	(0.000455)	(0.000128)	(0.000137)
Altitude^2	-9.43e-08	-8.61e-08	-6.78e-08*	-6.12e-08*	6.22e-08*	6.31e-08*	1.28e-07	1.09e-07	1.88e-07*	2.01e-07*	1.35e-07	1.39e-07	8.26e-08***	8.31e-08**
	(6.30e-08)	(5.66e-08)	(3.83e-08)	(3.67e-08)	(3.33e-08)	(3.23e-08)	(2.05e-07)	(1.89e-07)	(1.10e-07)	(1.14e-07)	(1.02e-07)	(1.05e-07)	(3.02e-08)	(3.17e-08)
Constant	-0.210	0.248	0.00887	0.252**	0.595***	0.587***	1.472**	1.466**	1.743***	1.697***	1.471***	1.952***	0.324**	0.462***
	(0.199)	(0.160)	(0.115)	(0.104)	(0.139)	(0.120)	(0.711)	(0.575)	(0.513)	(0.619)	(0.427)	(0.396)	(0.138)	(0.131)
Observations	805	805	805	805	805	805	805	805	805	805	805	805	805	805
R-squared	0.045	0.065	0.076	0.084	0.181	0.182	0.147	0.149	0.201	0.204	0.063	0.076	0.124	0.136

Notes: All models are estimated by OLS. Robust standard errors clustered at the community level are in parentheses. Income, cost, and production value variables were adjusted for extreme outliers. Annex B presents the results of the full regressions. * Significant at 10% level. ** Significant at 5% level. *** Significant at 1% level. [a] As a robustness analysis, probit models were estimated, yielding results consistent with those in this table. Additional results are available upon request. [b] Similar results were found with the Simpson index.

Table 9. Medium term indirect impacts

Variables (unit)	Total income (log)		Net income (log)		Value of agricultural production (log)		Value of agricultural production per HA (log)		Household sells agricultural production (1=yes)[a]		Prop. of agricultural production sold (%)		Value of sales (USD)		Food insecurity (1= Insecurity)[a]	
	Dummy	Km	Dummy	Km	Dummy	Km	Dummy	Km	Dummy	Km	Dummy	Km	Dummy	Km	Dummy	Km
Indirect effect:	0.426**	-0.00102	0.0571*	0.000221	0.638***	-0.00257	0.467*	-0.00870***	0.0391	0.00119	0.000622	0.000909*	221.2	-0.726	0.0357	-0.00157*
	(0.179)	(0.00216)	(0.0311)	(0.000377)	(0.181)	(0.00243)	(0.252)	(0.00314)	(0.0564)	(0.000722)	(0.0399)	(0.000524)	(133.8)	(1.459)	(0.0568)	(0.000916)
Head of household:																
Male (0,1)	0.289*	0.297*	0.0195	0.0212	0.341**	0.352**	0.177	0.175	-0.0250	-0.0222	-0.0265	-0.0251	43.64	47.82	-0.101	-0.101
	(0.153)	(0.159)	(0.0235)	(0.0240)	(0.142)	(0.149)	(0.157)	(0.158)	(0.0415)	(0.0415)	(0.0279)	(0.0279)	(90.51)	(91.52)	(0.0648)	(0.0647)
Age (years)	0.00832*	0.00751*	0.00108	0.00102	0.00969*	0.00833	0.00864	0.00667	0.00257*	0.00268*	9.69e-05	0.000225	4.270	3.820	0.00184	0.00159
	(0.00423)	(0.00427)	(0.00144)	(0.00139)	(0.00525)	(0.00542)	(0.00597)	(0.00622)	(0.00152)	(0.00144)	(0.000952)	(0.000890)	(2.711)	(2.675)	(0.00181)	(0.00182)
Speak Spanish (0,1)	0.0575	-0.00914	0.0398	0.0267	-0.0227	-0.110	0.113	0.128	-0.0146	-0.0355	0.0529	0.0422	88.02	55.69	-0.0204	-0.0135
	(0.142)	(0.135)	(0.0383)	(0.0379)	(0.179)	(0.173)	(0.221)	(0.214)	(0.0468)	(0.0450)	(0.0342)	(0.0329)	(88.05)	(88.13)	(0.0739)	(0.0738)

Indigenous (0,1)	0.220**	0.209**	-0.00768	-0.00826	0.0483	0.0294	0.120	0.0894	0.0752**	0.0774**	0.0328	0.0350	119.5	113.3	0.0980*	0.0905*
	(0.1000)	(0.101)	(0.0247)	(0.0246)	(0.0980)	(0.102)	(0.120)	(0.123)	(0.0357)	(0.0365)	(0.0224)	(0.0221)	(72.87)	(72.09)	(0.0541)	(0.0529)
Single (0,1)	-0.179	-0.182	0.0286	0.0289	0.0632	0.0575	0.214	0.198	0.0570	0.0590	-0.0339	-0.0323	-48.05	-49.72	-0.141	-0.136
	(0.189)	(0.192)	(0.0325)	(0.0326)	(0.190)	(0.192)	(0.199)	(0.200)	(0.0638)	(0.0629)	(0.0342)	(0.0340)	(134.1)	(134.3)	(0.105)	(0.104)
Literate (0,1)	0.122	0.0867	-0.0192	-0.0259	-0.0193	-0.0663	0.528	0.531	-0.00581	-0.0160	-0.0117	-0.0167	124.4	107.2	-0.0532	-0.0538
	(0.283)	(0.289)	(0.0473)	(0.0483)	(0.276)	(0.284)	(0.330)	(0.326)	(0.0768)	(0.0795)	(0.0387)	(0.0393)	(163.6)	(165.6)	(0.229)	(0.225)
Elementary education (0,1)	0.141	0.162	0.0364	0.0390	0.350	0.382	-0.414	-0.388	0.178**	0.179**	0.0695*	0.0691*	154.2	165.0	0.0479	0.0556
	(0.288)	(0.292)	(0.0499)	(0.0507)	(0.268)	(0.274)	(0.287)	(0.281)	(0.0770)	(0.0792)	(0.0375)	(0.0379)	(172.0)	(173.4)	(0.271)	(0.271)
Secondary education (0,1)	0.337	0.376	0.0567	0.0627	0.522*	0.577*	-0.541	-0.517	0.224**	0.231**	0.0818*	0.0840*	288.1	307.6	0.0104	0.0171
	(0.325)	(0.330)	(0.0567)	(0.0573)	(0.307)	(0.311)	(0.331)	(0.333)	(0.0859)	(0.0882)	(0.0450)	(0.0449)	(189.5)	(193.5)	(0.275)	(0.276)
Higher education (0,1)	0.149	0.205	0.0641	0.0734	0.351	0.431	-1.209***	-1.184***	0.134	0.145	0.0333	0.0378	373.7	402.2*	-0.0574	-0.0642
	(0.376)	(0.371)	(0.0720)	(0.0719)	(0.397)	(0.393)	(0.427)	(0.419)	(0.105)	(0.106)	(0.0472)	(0.0470)	(235.0)	(237.1)	(0.298)	(0.298)
Household:																
Size (# members)	0.101***	0.107***	0.00976	0.0112	0.0344	0.0411	0.0108	0.00281	0.0134	0.0163*	-0.00376	-0.00203	36.90*	39.52*	0.0159	0.0140
	(0.0265)	(0.0278)	(0.00800)	(0.00781)	(0.0284)	(0.0296)	(0.0389)	(0.0387)	(0.00929)	(0.00936)	(0.00475)	(0.00471)	(20.42)	(20.48)	(0.0139)	(0.0142)
Dependence ratio (%)	-0.463***	-0.451**	-0.00443	-0.00268	-0.559***	-0.542***	-0.362*	-0.353*	-0.0494	-0.0476	-0.0196	-0.0191	-216.8*	-210.8*	-0.0157	-0.0126
	(0.175)	(0.172)	(0.0661)	(0.0655)	(0.179)	(0.174)	(0.217)	(0.208)	(0.0546)	(0.0551)	(0.0358)	(0.0360)	(121.5)	(121.4)	(0.0860)	(0.0846)
H belongs to an agric. coop. (0, 1)	0.647***	0.648***	0.129***	0.129***	0.595**	0.597**	0.107	0.124	0.169**	0.166**	0.0501	0.0481	455.2***	455.8***	0.0144	0.0185
	(0.185)	(0.183)	(0.0379)	(0.0369)	(0.247)	(0.257)	(0.265)	(0.258)	(0.0664)	(0.0676)	(0.0411)	(0.0407)	(165.7)	(164.3)	(0.0911)	(0.0899)
Geographic:																
Geographic Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Altitude	-0.000448	-0.000629	-0.000124	-0.000153*	-0.00106**	-0.00132**	-9.76e-05	-0.000187	-0.000138	-0.000173	0.000152	0.000139	-0.0675	-0.159	-1.51e-05	2.12e-05
	(0.000400)	(0.000418)	(7.81e-05)	(8.01e-05)	(0.000468)	(0.000541)	(0.000674)	(0.000650)	(0.000132)	(0.000141)	(0.000121)	(0.000119)	(0.294)	(0.295)	(0.000174)	(0.000162)
Altitude^2	1.02e-07	1.30e-07	3.23e-08**	3.66e-08**	2.34e-07**	2.74e-07**	6.19e-08	8.11e-08	8.62e-10	5.35e-09	-5.35e-08*	-5.21e-08*	6.57e-06	2.07e-05	7.60e-09	1.17e-09
	(9.23e-08)	(9.81e-08)	(1.56e-08)	(1.65e-08)	(1.07e-07)	(1.25e-07)	(1.48e-07)	(1.42e-07)	(2.98e-08)	(3.22e-08)	(2.70e-08)	(2.70e-08)	(6.37e-05)	(6.51e-05)	(3.91e-08)	(3.65e-08)
Constant	4.848***	5.307***	8.281***	8.324***	4.817***	5.558***	5.375***	6.268***	0.577***	0.553***	0.361***	0.315***	-175.7	72.89	0.416*	0.517**
	(0.444)	(0.393)	(0.0761)	(0.0732)	(0.513)	(0.472)	(0.609)	(0.607)	(0.151)	(0.125)	(0.115)	(0.0957)	(306.8)	(243.9)	(0.212)	(0.234)
Observations	805	805	805	805	805	805	805	805	805	805	805	805	805	805	349	349
R-squared	0.116	0.103	0.031	0.028	0.092	0.069	0.206	0.216	0.170	0.175	0.187	0.195	0.108	0.101	0.089	0.098

Notes: All models are estimated by OLS. Robust standard errors clustered at the community level are in parentheses. Income, cost, and production value variables were adjusted for extreme outliers. Annex B presents the results of the full regressions. * Significant at 10% level. ** Significant at 5% level. *** Significant at 1% level. [a] As a robustness analysis, probit models were estimated, yielding results consistent with those in this table. Additional results are available upon request.

7. Conclusions

This study evaluates the impacts of the second phase of the "Creación de Iniciativas Agroalimentarias Rurales" (CRIAR II) program, an intervention aimed at promoting the adoption of climate-smart agricultural technologies in Bolivia. The program offered a non-refundable voucher that financed 90% of the cost for the agricultural technologies selected by producers, along with technical assistance in agronomic and commercialization. The analysis presented in this study assesses both direct and indirect effects experienced by beneficiary and non-beneficiary smallholder farmers.

Relying on the program's randomized assignment, the econometric approach employs an instrumental variable (IV) methodology, calculated with two-stage least squares (2SLS), to estimate the direct effects of the program on short-term and medium-term outcomes. Additionally, leveraging on the program's two-stage experimental design, the study measures spillover effects among farmers living in close proximity to program beneficiaries.

The results confirm that program participation improved household income, total production value, and agricultural sales. These medium-term effects appear to result from technological adoption and increased crop diversification, which intensified the cultivation of non-traditional crops. Furthermore, most of these effects appear to intensify over time.

Additionally, the program's impact on technology adoption extended beyond beneficiary farmers, as spillover effects are observed among control farmers residing near treated communities. This finding suggest that the intervention led to behavioral changes that contributed to increased income and value of production –partly through enhanced crop diversification.

This paper contributes to the literature on agricultural development and technology adoption by providing robust experimental evidence from a large-scale, government-led intervention in a developing country. It expands our understanding of how demand-driven subsidy programs can generate both direct and indirect effects on smallholder farmers, not only improving economic outcomes but also fostering behavioral change and community-level spillovers. Furthermore, by documenting sustained impacts over the medium term, the study adds valuable insight into the durability of such interventions and their potential to contribute to long-term rural transformation.

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Appendix

A. Descriptive statistics – Household characteristics of the subsample

Variables (units)	Total	Treated	Controls: Contaminated	Controls: Pure	Diff. in means: (ii)- (iv)	Diff. in means: (iii-iv)
	(i)	(ii)	(iii)	(iv)	(v)	(vi)
Household and Head of Household Characteristics						
H size (# members)	3.94	4.05	4.18	3.59	0.46**	0.59***
H dependency ratio (%)	0.34	0.34	0.36	0.34	0.00	0.02
H belongs to agric. cooperative (0, 1)	0.12	0.15	0.5	0.11	0.04	-0.06**
Male HH (0,1)	0.84	0.85	0.85	0.80	0.05	0.04
Single HH (0,1)	0.07	0.06	0.04	0.10	-0.04*	-0.07**
Indigenous or native HH (0, 1)	0.68	0.71	0.63	0.67	0.04	-0.05
Age HH (years)	52.01	53.18	48.89	51.98	1.20	-3.09
Speak Spanish HH (0,1)	0.26	0.24	0.21	0.34	-0.10*	-0.13*
Speak Quechua HH (0,1)	0.42	0.37	0.36	0.53	-0.16*	-0.18
Speak Aymara HH (0,1)	0.35	0.41	0.33	0.25	0.16*	0.08
Literate HH (0,1)	0.96	0.96	0.95	0.97	-0.01	-0.02
No education HH (0,1)	0.03	0.03	0.01	0.02	0.01	-0.01
With elementary education HH (0,1)	0.55	0.57	0.53	0.51	0.06	0.01
With secondary education HH (0,1)	0.33	0.31	0.37	0.34	-0.03	0.03
With higher education HH (0,1)	0.09	0.08	0.08	0.12	-0.03	-0.04

P-values are obtained controlling for clusters at the community level. *Difference in means is significant at the 10% level. **Difference in means is significant at the 5%. ***Difference in means is significant at the 1%. The subsample includes 371 treated households, 137 impure controls and 212 pure controls.

B. Direct and indirect effects – full regressions

B1. Direct effects - Results of the second stage: Short-term outcomes

Variables (unit)	Number of crops that use some type of technology	Prop. of land with traditional crops (%)	Input costs (log)	Cultivated Ha. (#)	Number of crops (#)	Shannon index[a]
Direct effect:						
Technology adoption (0,1)	2.558***	-0.113*	0.643**	0.536*	1.581***	0.337***
	(0.209)	(0.0639)	(0.321)	(0.298)	(0.326)	(0.0963)
Head of household:						
Male (0,1)	0.127	0.0278	0.0261	0.0958	0.254*	0.0439
	(0.0913)	(0.0250)	(0.145)	(0.158)	(0.130)	(0.0408)
Age (years)	-0.000573	-0.000176	0.00127	0.00288	0.00493	0.00125
	(0.00308)	(0.000732)	(0.00469)	(0.00453)	(0.00454)	(0.00129)
Speak Spanish (0,1)	-0.213	0.0196	-0.0948	-0.183	-0.351*	-0.0216
	(0.147)	(0.0283)	(0.149)	(0.193)	(0.198)	(0.0455)
Indigenous (0,1)	0.211***	0.0153	-0.0476	-0.0143	0.211*	0.0480
	(0.0812)	(0.0195)	(0.117)	(0.101)	(0.127)	(0.0373)
Single (0,1)	0.0309	-0.0350	-0.552**	0.0282	0.215	0.0149
	(0.149)	(0.0354)	(0.220)	(0.211)	(0.219)	(0.0543)
Literate (0,1)	-0.201	0.0144	0.572**	0.0471	-0.0427	-0.0217
	(0.180)	(0.0463)	(0.274)	(0.284)	(0.233)	(0.0701)
Elementary education (0,1)	0.327*	-0.00307	-0.0198	0.251	0.126	-0.0401
	(0.168)	(0.0451)	(0.306)	(0.320)	(0.231)	(0.0746)
Secondary education (0,1)	0.252	-0.0489	-0.0116	0.283	-0.196	-0.0685
	(0.178)	(0.0529)	(0.345)	(0.330)	(0.252)	(0.0814)
Higher education (0,1)	0.0196	-0.0185	0.113	0.403	-0.390	-0.110
	(0.224)	(0.0587)	(0.388)	(0.378)	(0.292)	(0.0923)
Household:						
Size (# members)	0.0187	-0.00536	0.0457	0.0185	0.0790***	0.0196**

	(0.0231)	(0.00442)	(0.0309)	(0.0266)	(0.0294)	(0.00865)
Dependence ratio (%)	-0.166	0.0563**	-0.282*	-0.00703	-0.0341	-0.0721
	(0.115)	(0.0247)	(0.152)	(0.142)	(0.189)	(0.0440)
H belongs to an agric. coop. (0, 1)	-0.0505	0.00722	0.629***	0.451**	0.0402	0.00928
	(0.152)	(0.0279)	(0.195)	(0.184)	(0.184)	(0.0487)
Geographic:						
La Paz (0,1)	-0.0331	0.0264	-1.822***	-0.00346	0.179	-0.0756
	(0.161)	(0.0577)	(0.260)	(0.228)	(0.257)	(0.0660)
Cochabamba (0,1)	-0.654***	0.265***	-1.367***	0.724***	-0.922***	-0.321***
	(0.119)	(0.0486)	(0.242)	(0.182)	(0.212)	(0.0727)
Oruro (0,1)	0.242	0.0573	-1.725***	0.419	0.336	-0.235**
	(0.278)	(0.0845)	(0.270)	(0.265)	(0.480)	(0.0948)
Potosi (0,1)	0.728**	0.0720	-2.523***	0.465**	1.053***	-0.163**
	(0.303)	(0.0485)	(0.231)	(0.187)	(0.352)	(0.0794)
Santa Cruz (0,1)	-0.353	0.287	-1.352*	2.170***	-0.399	-0.198
	(0.266)	(0.190)	(0.756)	(0.549)	(0.510)	(0.146)
Beni (0,1)	-0.176	0.424*	-2.781***	0.272	-0.482	-0.0758
	(0.365)	(0.225)	(0.990)	(1.035)	(0.667)	(0.203)
Pando (0,1)	0.167	0.371*	-2.113**	0.420	0.318	-0.0504
	(0.385)	(0.212)	(1.053)	(1.038)	(0.652)	(0.207)
Altitude	0.000777***	0.000125	0.000677	-0.00166**	0.000662	0.000177
	(0.000289)	(0.000172)	(0.000754)	(0.000845)	(0.000543)	(0.000158)
Altitude^2	-2.00e-07***	5.02e-09	-1.15e-07	3.21e-07**	-1.91e-07*	-3.99e-08
	(5.93e-08)	(3.07e-08)	(1.33e-07)	(1.54e-07)	(1.06e-07)	(2.98e-08)
Constant	-0.613	0.171	3.984***	1.468	1.203	0.417*
	(0.428)	(0.241)	(1.067)	(1.230)	(0.740)	(0.223)
Observations	1,289	1,289	1,289	1,289	1,289	1,289
R-squared	0.437	0.181	0.136	0.184	0.147	0.062

Notes: All models are estimated by 2SLS. Robust standard errors clustered at the community level are in parentheses. Income, cost, and production value variables were adjusted for extreme outliers. For the geographical dummies, Chuquisaca is the reference category. * Significant at 10% level. ** Significant at 5% level. *** Significant at 1% level. [a] Similar results were found with the Simpson index.

B2. Direct effects - Results of the second stage – Medium-term outcomes

Variables (unit)	Total income (log)	Net income (log)	Value of agricultural production (log)	Value of agricultural production per HA (log)	Household sells agricultural production (1=yes)[a]	Prop. of agricultural production sold (%)	Value of sales (USD)	Food insecurity (1= Insecurity)[a]
Direct effect:								
Technology adoption (0,1)	0.994***	0.165***	1.033***	0.301	0.113	-0.00983	623.3***	-0.0166
	(0.260)	(0.0498)	(0.283)	(0.384)	(0.0898)	(0.0620)	(158.3)	(0.0610)
Head of household:								
Male (0,1)	0.344***	0.0466	0.424***	0.0565	0.0624*	0.0201	58.49	-0.00854
	(0.109)	(0.0306)	(0.115)	(0.132)	(0.0352)	(0.0259)	(79.70)	(0.0551)
Age (years)	0.00353	0.000399	-0.000892	-0.00249	-0.000974	-0.00172**	-0.167	0.00203
	(0.00355)	(0.000727)	(0.00417)	(0.00465)	(0.00109)	(0.000818)	(2.882)	(0.00139)
Speak Spanish (0,1)	0.0201	-0.0137	-0.100	-0.0452	0.00715	-0.0224	73.59	-0.0554
	(0.135)	(0.0386)	(0.130)	(0.154)	(0.0380)	(0.0292)	(110.9)	(0.0549)
Indigenous (0,1)	0.268***	0.0859**	0.149	0.0853	0.0686**	0.0130	100.4*	0.0635
	(0.0904)	(0.0393)	(0.0991)	(0.112)	(0.0298)	(0.0184)	(60.97)	(0.0447)
Single (0,1)	-0.138	0.0306	0.0303	-0.0396	0.0810*	-0.0168	-163.2	0.0118
	(0.150)	(0.0392)	(0.165)	(0.183)	(0.0466)	(0.0307)	(104.6)	(0.0810)
Literate (0,1)	0.351*	0.0353	0.319	0.480	0.0439	0.0199	132.2	-0.0939
	(0.204)	(0.0354)	(0.243)	(0.296)	(0.0667)	(0.0400)	(131.5)	(0.167)
Elementary education (0,1)	-0.0193	0.00248	-0.0953	-0.512**	0.00498	0.00215	154.9	0.0726
	(0.203)	(0.0351)	(0.225)	(0.246)	(0.0690)	(0.0414)	(135.9)	(0.174)
Secondary education (0,1)	-0.0798	-0.0712	-0.166	-0.721***	-0.0316	-0.0148	115.4	0.0565
	(0.215)	(0.0754)	(0.231)	(0.264)	(0.0760)	(0.0465)	(146.5)	(0.174)
Higher education (0,1)	-0.0814	0.0219	-0.223	-1.067***	-0.0930	-0.0773	263.1	-0.00362
	(0.255)	(0.0541)	(0.308)	(0.356)	(0.0893)	(0.0502)	(194.8)	(0.207)
Household:								
Size (# members)	0.0715***	0.0189***	0.0455*	0.0346	0.0147**	-0.00118	33.15*	0.0201**
	(0.0202)	(0.00585)	(0.0247)	(0.0301)	(0.00717)	(0.00457)	(17.64)	(0.0101)
Dependence ratio (%)	-0.311***	-0.00280	-0.201	-0.101	0.0206	-0.0104	-95.67	0.0528
	(0.112)	(0.0364)	(0.136)	(0.168)	(0.0452)	(0.0271)	(90.76)	(0.0629)
H belongs to an agric. coop.	0.833***	0.192***	0.576***	0.109	0.0504	0.0221	792.0***	0.0332
(0, 1)	(0.138)	(0.0433)	(0.145)	(0.150)	(0.0590)	(0.0348)	(145.8)	(0.0583)
Geographic:								
La Paz (0,1)	-0.753***	0.0224	-0.594***	-0.726***	-0.165**	-0.180***	-541.0***	0.229***

	(0.212)	(0.0380)	(0.216)	(0.255)	(0.0701)	(0.0577)	(115.3)	(0.0614)
Cochabamba (0,1)	-0.393**	0.00951	-0.481**	-1.593***	-0.0954	-0.116**	-54.76	0.282***
	(0.169)	(0.0893)	(0.233)	(0.298)	(0.0617)	(0.0525)	(129.2)	(0.0447)
Oruro (0,1)	-0.766***	0.00453	-1.183***	-2.017***	-0.245	-0.163*	-577.4***	0.250***
	(0.275)	(0.0482)	(0.436)	(0.399)	(0.165)	(0.0885)	(175.5)	(0.0827)
Potosi (0,1)	-0.820***	0.0399	-0.573***	-1.161***	-0.0622	-0.0963*	-430.0***	0.0666
	(0.214)	(0.0420)	(0.202)	(0.215)	(0.0598)	(0.0499)	(139.3)	(0.0574)
Santa Cruz (0,1)	0.0909	0.124	0.0302	-2.289***	-0.423**	-0.253	216.0	0.542***
	(0.418)	(0.0819)	(0.509)	(0.801)	(0.210)	(0.208)	(270.1)	(0.140)
Beni (0,1)	-0.235	-0.00418	0.337	-1.972**	-0.266	-0.190	-450.7	0.637***
	(0.616)	(0.120)	(0.697)	(0.889)	(0.224)	(0.223)	(446.1)	(0.193)
Pando (0,1)	-0.144	0.0817	-0.197	-2.384**	-0.388	-0.283	-161.6	0.424
	(0.667)	(0.138)	(0.961)	(1.002)	(0.253)	(0.214)	(435.3)	(0.315)
Altitude	6.32e-05	-0.000160	0.000309	9.19e-05	-6.62e-06	3.38e-05	-0.102	0.000232*
	(0.000515)	(0.000103)	(0.000562)	(0.000711)	(0.000185)	(0.000181)	(0.362)	(0.000121)
Altitude^2	1.19e-09	3.40e-08*	-4.95e-08	-2.17e-08	-3.10e-08	-3.20e-08	6.81e-06	-3.96e-08*
	(1.01e-07)	(2.04e-08)	(1.05e-07)	(1.31e-07)	(3.49e-08)	(3.31e-08)	(6.72e-05)	(2.12e-08)
Constant	5.356***	8.302***	4.824***	8.141***	0.906***	0.733***	570.6	-0.0212
	(0.642)	(0.126)	(0.741)	(0.929)	(0.250)	(0.236)	(515.1)	(0.241)
Observations	1,289	1,289	1,289	1,289	1,289	1,289	1,289	583
R-squared	0.136	0.065	0.088	0.099	0.168	0.211	0.167	0.082

Notes: All models are estimated by 2SLS. Robust standard errors clustered at the community level are in parentheses. Income, cost, and production value variables were adjusted for extreme outliers. For the geographical dummies, Chuquisaca is the reference category. * Significant at 10% level. ** Significant at 5% level. *** Significant at 1% level. [a] As a robustness analysis, biprobit models were estimated, yielding results consistent with those in this table. Additional results are available upon request.

B3. Direct effects - Time effects on short term variables

Variables (unit)	Number of crops that use some type of technology	Prop. of land with traditional crops (%)	Input costs (log)	Cultivated Ha. (#)	Number of crops (#)	Shannon index[a]
Direct effect:						
Years as beneficiary	0.368***	-0.0224**	0.0428	0.0215	0.224***	0.0602***
	(0.0430)	(0.0106)	(0.0587)	(0.0404)	(0.0464)	(0.0142)
Head of household:						

Male (0,1)	0.186*	0.0267	0.0529	0.122	0.292**	0.0489
	(0.109)	(0.0245)	(0.149)	(0.155)	(0.127)	(0.0383)
Age (years)	-0.00336	-4.41e-05	0.000648	0.00238	0.00321	0.000867
	(0.00377)	(0.000751)	(0.00483)	(0.00477)	(0.00442)	(0.00124)
Speak Spanish (0,1)	-0.145	0.0165	-0.0784	-0.169	-0.309	-0.0126
	(0.165)	(0.0289)	(0.146)	(0.190)	(0.199)	(0.0466)
Indigenous (0,1)	0.355***	0.00872	-0.0128	0.0143	0.300**	0.0674*
	(0.0979)	(0.0189)	(0.117)	(0.101)	(0.118)	(0.0342)
Single (0,1)	-0.0482	-0.0298	-0.558**	0.0270	0.167	0.00120
	(0.189)	(0.0357)	(0.225)	(0.212)	(0.229)	(0.0548)
Literate (0,1)	-0.253	0.0142	0.538*	0.0131	-0.0763	-0.0236
	(0.211)	(0.0456)	(0.277)	(0.294)	(0.221)	(0.0685)
Elementary education (0,1)	0.498**	-0.0109	0.0208	0.285	0.232	-0.0170
	(0.206)	(0.0442)	(0.309)	(0.334)	(0.217)	(0.0721)
Secondary education (0,1)	0.490**	-0.0612	0.0330	0.316	-0.0507	-0.0337
	(0.228)	(0.0519)	(0.348)	(0.342)	(0.240)	(0.0798)
Higher education (0,1)	0.321	-0.0335	0.175	0.451	-0.205	-0.0676
	(0.252)	(0.0602)	(0.395)	(0.390)	(0.282)	(0.0938)
Household:						
Size (# members)	0.0250	-0.00547	0.0487	0.0214	0.0831***	0.0201**
	(0.0293)	(0.00444)	(0.0327)	(0.0274)	(0.0293)	(0.00833)
Dependence ratio (%)	-0.283**	0.0614**	-0.311**	-0.0312	-0.106	-0.0876**
	(0.133)	(0.0250)	(0.153)	(0.136)	(0.178)	(0.0417)
H belongs to an agric. coop. (0, 1)	0.287	-0.00975	0.697***	0.503***	0.248	0.0577
	(0.181)	(0.0292)	(0.200)	(0.182)	(0.186)	(0.0487)
Geographic:						
La Paz (0,1)	0.848***	-0.0144	-1.616***	0.164	0.722***	0.0440
	(0.248)	(0.0530)	(0.231)	(0.194)	(0.258)	(0.0568)
Cochabamba (0,1)	0.347	0.210***	-1.207***	0.831***	-0.311	-0.168**
	(0.228)	(0.0554)	(0.317)	(0.191)	(0.208)	(0.0748)
Oruro (0,1)	0.735*	0.0355	-1.601***	0.522**	0.641	-0.170
	(0.438)	(0.0922)	(0.293)	(0.258)	(0.557)	(0.106)

Potosi (0,1)	1.754***	0.0163	-2.349***	0.586***	1.681***	-0.00796
	(0.429)	(0.0508)	(0.251)	(0.174)	(0.411)	(0.0820)
Santa Cruz (0,1)	0.894*	0.237	-1.000	2.475***	0.374	-0.0434
	(0.473)	(0.195)	(0.767)	(0.551)	(0.499)	(0.148)
Beni (0,1)	2.061***	0.338	-2.118**	0.854	0.908*	0.195
	(0.522)	(0.213)	(0.944)	(0.890)	(0.543)	(0.170)
Pando (0,1)	1.668***	0.329	-1.541	0.953	1.261**	0.101
	(0.532)	(0.207)	(1.011)	(0.984)	(0.577)	(0.188)
Altitude	0.00157***	0.000115	0.00108	-0.00126	0.00117**	0.000232*
	(0.000471)	(0.000173)	(0.000764)	(0.000774)	(0.000467)	(0.000137)
Altitude^2	-3.62e-07***	7.41e-09	-1.94e-07	2.44e-07*	-2.94e-07***	-5.22e-08**
	(9.67e-08)	(3.06e-08)	(1.33e-07)	(1.37e-07)	(9.37e-08)	(2.49e-08)
Constant	-1.854**	0.217	3.600***	1.127	0.430	0.270
	(0.722)	(0.243)	(1.084)	(1.175)	(0.713)	(0.216)
Observations	1,289	1,289	1,289	1,289	1,289	1,289
R-squared	0.227	0.174	0.122	0.198	0.165	0.103

Notes: All models are estimated by OLS. Robust standard errors clustered at the community level are in parentheses. Income, cost, and production value variables were adjusted for extreme outliers. For the geographical dummies, Chuquisaca is the reference category. * Significant at 10% level. ** Significant at 5% level. *** Significant at 1% level. [a] Similar results were found with the Simpson index.

B4. Direct effects - Time effects on medium term variables

Variables (unit)	Total income (log)	Net income (log)	Value of agricultural production (log)	Value of agricultural production per HA (log)	Household sells agricultural production (1=yes)[a]	Prop. of agricultural production sold (%)	Value of sales (USD)	Food insecurity (1= Insecurity)[a]
Direct effect:								
Years as beneficiary	0.0965**	0.0225**	0.0961**	0.0300	0.0139	-0.00423	39.59	0.00411
	(0.0409)	(0.00972)	(0.0458)	(0.0542)	(0.0156)	(0.0102)	(25.16)	(0.0119)
Head of household:								
Male (0,1)	0.378***	0.0507	0.460***	0.0666	0.0656*	0.0205	84.88	-0.00945

	(0.112)	(0.0326)	(0.120)	(0.137)	(0.0360)	(0.0259)	(82.39)	(0.0568)
Age (years)	0.00252	0.000222	-0.00193	-0.00280	-0.00109	-0.00170**	-0.769	0.00201
	(0.00362)	(0.000774)	(0.00434)	(0.00477)	(0.00112)	(0.000817)	(3.134)	(0.00143)
Speak Spanish (0,1)	0.0459	-0.00937	-0.0734	-0.0374	0.0101	-0.0227	89.48	-0.0555
	(0.127)	(0.0381)	(0.126)	(0.158)	(0.0388)	(0.0294)	(109.4)	(0.0562)
Indigenous (0,1)	0.322***	0.0952**	0.206**	0.102	0.0749**	0.0124	134.1**	0.0632
	(0.0875)	(0.0391)	(0.0941)	(0.107)	(0.0291)	(0.0185)	(60.94)	(0.0450)
Single (0,1)	-0.156	0.0259	0.0129	-0.0452	0.0782	-0.0157	-168.6	0.0117
	(0.150)	(0.0385)	(0.163)	(0.184)	(0.0478)	(0.0315)	(103.4)	(0.0825)
Literate (0,1)	0.312	0.0314	0.276	0.468	0.0407	0.0189	98.77	-0.0946
	(0.212)	(0.0365)	(0.246)	(0.303)	(0.0685)	(0.0402)	(128.0)	(0.172)
Elementary education (0,1)	0.0449	0.0134	-0.0287	-0.492**	0.0124	0.00135	194.2	0.0729
	(0.199)	(0.0342)	(0.216)	(0.243)	(0.0703)	(0.0417)	(134.2)	(0.180)
Secondary education (0,1)	-0.00175	-0.0562	-0.0857	-0.697***	-0.0219	-0.0166	158.0	0.0577
	(0.208)	(0.0734)	(0.224)	(0.264)	(0.0775)	(0.0473)	(142.5)	(0.180)
Higher education (0,1)	0.0230	0.0409	-0.116	-1.035***	-0.0803	-0.0792	322.9*	-0.00210
	(0.248)	(0.0528)	(0.291)	(0.350)	(0.0919)	(0.0511)	(191.1)	(0.213)
Household:								
Size (# members)	0.0753***	0.0193***	0.0495*	0.0357	0.0151**	-0.00112	36.10*	0.0194*
	(0.0221)	(0.00605)	(0.0265)	(0.0305)	(0.00742)	(0.00462)	(19.17)	(0.0101)
Dependence ratio (%)	-0.356***	-0.0103	-0.248*	-0.115	0.0155	-0.00995	-123.9	0.0539
	(0.111)	(0.0369)	(0.134)	(0.171)	(0.0467)	(0.0274)	(90.55)	(0.0649)
H belongs to an agric. coop.	0.948***	0.213***	0.695***	0.144	0.0645	0.0198	857.4***	0.0344
(0, 1)	(0.141)	(0.0465)	(0.131)	(0.150)	(0.0579)	(0.0332)	(152.5)	(0.0607)
Geographic:								
La Paz (0,1)	-0.425**	0.0788**	-0.255	-0.626***	-0.127**	-0.185***	-341.6***	0.223***
	(0.194)	(0.0327)	(0.201)	(0.230)	(0.0636)	(0.0485)	(113.2)	(0.0589)
Cochabamba (0,1)	-0.0910	0.0717	-0.174	-1.500***	-0.0557	-0.125**	96.31	0.286***
	(0.189)	(0.0822)	(0.240)	(0.285)	(0.0732)	(0.0569)	(160.0)	(0.0502)
Oruro (0,1)	-0.574**	0.0363	-0.984**	-1.960***	-0.224	-0.165*	-457.6***	0.242***
	(0.273)	(0.0430)	(0.453)	(0.414)	(0.171)	(0.0870)	(162.3)	(0.0873)
Potosi (0,1)	-0.500**	0.104**	-0.247	-1.063***	-0.0209	-0.105**	-264.5*	0.0697
	(0.201)	(0.0416)	(0.202)	(0.221)	(0.0624)	(0.0491)	(154.9)	(0.0558)
Santa Cruz (0,1)	0.612	0.205***	0.575	-2.132***	-0.366*	-0.256	559.0*	0.527***
	(0.390)	(0.0656)	(0.551)	(0.765)	(0.208)	(0.194)	(296.7)	(0.138)
Beni (0,1)	0.728	0.142	1.347**	-1.682**	-0.163	-0.192	195.9	0.601***
	(0.533)	(0.100)	(0.658)	(0.751)	(0.195)	(0.192)	(412.2)	(0.184)
Pando (0,1)	0.622	0.183	0.615	-2.155**	-0.313	-0.278	401.3	0.384

	(0.644)	(0.125)	(1.047)	(0.949)	(0.245)	(0.192)	(430.3)	(0.315)
Altitude	0.000562	-0.000104	0.000845	0.000240	3.80e-05	4.24e-05	0.297	0.000196
	(0.000460)	(0.000102)	(0.000563)	(0.000678)	(0.000179)	(0.000170)	(0.348)	(0.000119)
Altitude^2	-9.76e-08	2.27e-08	-1.55e-07	-5.10e-08	-4.00e-08	-3.36e-08	-7.13e-05	-3.28e-08
	(8.63e-08)	(1.98e-08)	(1.02e-07)	(1.25e-07)	(3.35e-08)	(3.09e-08)	(6.30e-05)	(2.08e-08)
Constant	4.806***	8.220***	4.246***	7.976***	0.848***	0.733***	195.3	0.00695
	(0.648)	(0.115)	(0.792)	(0.878)	(0.250)	(0.222)	(530.8)	(0.237)
Observations	1,289	1,289	1,289	1,289	1,289	1,289	1,289	583
R-squared	0.155	0.073	0.113	0.099	0.154	0.215	0.170	0.081

Notes: All models are estimated by OLS. Robust standard errors clustered at the community level are in parentheses. Income, cost, and production value variables were adjusted for extreme outliers. For the geographical dummies, Chuquisaca is the reference category. * Significant at 10% level. ** Significant at 5% level. *** Significant at 1% level. [a] As a robustness analysis, probit models were estimated, yielding results consistent with those in this table. Additional results are available upon request.

B5. Indirect effects - Short term indirect impacts

Variables (unit)	Number of crops that use some type of technology		Technology adoption (1=yes)[a]		Prop. of land with traditional crops (%)		Input costs (log)		Cultivated Ha. (#)		Number of crops (#)		Shannon index[b]	
	Dummy	Km	Dummy	Km	Dummy	Km	Dummy	Km	Dummy	Km	Dummy	Km	Dummy	Km
Indirect effect:	0.224***	-0.00477***	0.142***	-0.00209***	0.00711	0.000291	-0.201	-0.00364	0.121	0.00316	0.183	-0.00599**	0.0472	-0.00181**
	(0.0840)	(0.00112)	(0.0443)	(0.000501)	(0.0526)	(0.000682)	(0.277)	(0.00345)	(0.155)	(0.00315)	(0.184)	(0.00242)	(0.0691)	(0.000822)
Head of household:														
Male (0,1)	0.0654	0.0637	0.0264	0.0266	0.0441	0.0447	-0.311	-0.321*	-0.0186	-0.0110	0.105	0.101	0.0574	0.0559
	(0.0661)	(0.0662)	(0.0304)	(0.0313)	(0.0286)	(0.0288)	(0.196)	(0.191)	(0.135)	(0.135)	(0.136)	(0.136)	(0.0447)	(0.0448)
Age (years)	0.00229	0.00126	-0.000703	-0.00122	-0.00200**	-0.00197**	0.00987	0.00967	0.000889	0.00115	0.0172***	0.0160***	0.00577***	0.00544***
	(0.00182)	(0.00186)	(0.00101)	(0.00101)	(0.000990)	(0.000962)	(0.00638)	(0.00635)	(0.00447)	(0.00458)	(0.00446)	(0.00437)	(0.00138)	(0.00136)
Speak Spanish (0,1)	-0.0974*	-0.0834*	-0.0167	-0.0186	-0.00323	-0.00792	0.133	0.212	0.0993	0.0403	-0.309*	-0.273	-0.119**	-0.107**
	(0.0506)	(0.0455)	(0.0357)	(0.0322)	(0.0405)	(0.0417)	(0.227)	(0.221)	(0.253)	(0.260)	(0.176)	(0.179)	(0.0536)	(0.0536)
Indigenous (0,1)	-0.00999	-0.0262	0.00625	-0.00173	0.0295	0.0301	0.178	0.173	-0.0288	-0.0234	0.0772	0.0588	0.0374	0.0320
	(0.0692)	(0.0676)	(0.0300)	(0.0298)	(0.0264)	(0.0264)	(0.145)	(0.146)	(0.0985)	(0.0988)	(0.113)	(0.116)	(0.0418)	(0.0431)
Single (0,1)	-0.0790	-0.0878	-0.0467	-0.0507	0.0503	0.0508	-0.992***	-0.998***	-0.217	-0.211	-0.0818	-0.0926	-0.0921	-0.0954*
	(0.0794)	(0.0825)	(0.0382)	(0.0402)	(0.0396)	(0.0393)	(0.280)	(0.281)	(0.181)	(0.181)	(0.188)	(0.190)	(0.0557)	(0.0558)
Literate (0,1)	0.0454	0.0499	0.0371	0.0349	0.0864	0.0842	0.603*	0.642*	-0.115	-0.144	-0.371	-0.355	-0.102	-0.0971

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
	(0.0694)	(0.0716)	(0.0565)	(0.0566)	(0.0627)	(0.0626)	(0.359)	(0.349)	(0.241)	(0.240)	(0.293)	(0.295)	(0.0855)	(0.0856)
Elementary education (0,1)	-0.0554	-0.0422	-0.0290	-0.0212	-0.124*	-0.123*	0.189	0.181	0.504**	0.508**	0.635**	0.647**	0.109	0.112
	(0.0928)	(0.0935)	(0.0607)	(0.0611)	(0.0663)	(0.0669)	(0.409)	(0.400)	(0.216)	(0.211)	(0.260)	(0.261)	(0.0822)	(0.0818)
Secondary education (0,1)	-0.0848	-0.0744	-0.0348	-0.0260	-0.170**	-0.169**	0.307	0.279	0.500*	0.519**	0.580**	0.584**	0.146	0.146
	(0.109)	(0.111)	(0.0685)	(0.0687)	(0.0695)	(0.0699)	(0.438)	(0.423)	(0.261)	(0.257)	(0.282)	(0.285)	(0.0947)	(0.0948)
Higher education (0,1)	0.275	0.284	0.103	0.114	-0.0868	-0.0844	0.831*	0.784*	1.178***	1.211***	0.422	0.419	0.150	0.148
	(0.182)	(0.183)	(0.0883)	(0.0877)	(0.0883)	(0.0890)	(0.474)	(0.470)	(0.382)	(0.380)	(0.319)	(0.316)	(0.111)	(0.108)
Household:														
Size (# members)	0.0245	0.0196	0.00127	-0.000116	0.00104	0.00172	0.0438	0.0333	0.00651	0.0147	0.0893**	0.0813**	0.0295***	0.0270***
	(0.0160)	(0.0159)	(0.00775)	(0.00791)	(0.00693)	(0.00681)	(0.0369)	(0.0366)	(0.0282)	(0.0276)	(0.0343)	(0.0339)	(0.00988)	(0.00993)
Dependence ratio (%)	-0.115	-0.111	-0.0101	-0.00713	0.0621*	0.0625*	-0.482**	-0.490**	-0.127	-0.122	-0.170	-0.167	-0.111**	-0.110**
	(0.0775)	(0.0771)	(0.0352)	(0.0348)	(0.0350)	(0.0354)	(0.213)	(0.208)	(0.150)	(0.148)	(0.171)	(0.168)	(0.0496)	(0.0491)
H belongs to an agric. coop. (0, 1)	-0.0369	-0.0276	0.0311	0.0349	-0.0255	-0.0261	0.465*	0.474*	0.440*	0.432*	0.144	0.156	-0.000960	0.00274
	(0.0966)	(0.0887)	(0.0546)	(0.0523)	(0.0494)	(0.0491)	(0.256)	(0.260)	(0.241)	(0.239)	(0.240)	(0.229)	(0.0626)	(0.0600)
Geographic:														
La Paz (0,1)	-0.188*	-0.347***	-0.135**	-0.196***	-0.0512	-0.0375	0.767***	0.573*	-0.824***	-0.667***	0.166	-0.0525	0.248***	0.180**
	(0.112)	(0.130)	(0.0532)	(0.0608)	(0.0511)	(0.0573)	(0.279)	(0.317)	(0.185)	(0.232)	(0.213)	(0.227)	(0.0748)	(0.0731)
Cochabamba (0,1)	-0.524**	-0.672***	-0.301**	-0.339**	0.246**	0.268**	2.167***	1.821***	0.0579	0.324	0.154	-0.0935	0.315**	0.235*
	(0.246)	(0.249)	(0.141)	(0.142)	(0.111)	(0.108)	(0.666)	(0.638)	(0.355)	(0.392)	(0.443)	(0.481)	(0.126)	(0.132)
Santa Cruz (0,1)	-0.183	-0.202	-0.0596	-0.0610	0.223**	0.228**	1.138**	1.061*	0.649	0.707	-0.306	-0.346	-0.0868	-0.100
	(0.133)	(0.140)	(0.0725)	(0.0718)	(0.0952)	(0.0951)	(0.532)	(0.543)	(0.441)	(0.452)	(0.214)	(0.229)	(0.0690)	(0.0729)
Altitude	0.000459	0.000424	0.000306*	0.000271*	-0.000170	-0.000178	-0.000419	-0.000274	-0.000993*	-0.00109**	-0.000688	-0.000686	-0.000421***	-0.000417***
	(0.000287)	(0.000258)	(0.000173)	(0.000163)	(0.000147)	(0.000141)	(0.000920)	(0.000837)	(0.000525)	(0.000550)	(0.000437)	(0.000455)	(0.000128)	(0.000137)
Altitude^2	-9.43e-08	-8.61e-08	-6.78e-08*	-6.12e-08*	6.22e-08*	6.31e-08*	1.28e-07	1.09e-07	1.88e-07*	2.01e-07*	1.35e-07	1.39e-07	8.26e-08***	8.31e-08**
	(6.30e-08)	(5.66e-08)	(3.83e-08)	(3.67e-08)	(3.33e-08)	(3.23e-08)	(2.05e-07)	(1.89e-07)	(1.10e-07)	(1.14e-07)	(1.02e-07)	(1.05e-07)	(3.02e-08)	(3.17e-08)
Constant	-0.210	0.248	0.00887	0.252**	0.595***	0.587***	1.472**	1.466**	1.743***	1.697***	1.471***	1.952***	0.324**	0.462***
	(0.199)	(0.160)	(0.115)	(0.104)	(0.139)	(0.120)	(0.711)	(0.575)	(0.513)	(0.619)	(0.427)	(0.396)	(0.138)	(0.131)
Observations	805	805	805	805	805	805	805	805	805	805	805	805	805	805
R-squared	0.045	0.065	0.076	0.084	0.181	0.182	0.147	0.149	0.201	0.204	0.063	0.076	0.124	0.136

Notes: All models are estimated by OLS. Robust standard errors clustered at the community level are in parentheses. Income, cost, and production value variables were adjusted for extreme outliers. For the geographical dummies, the reference category groups Chuquisaca, Oruro, Potosí, Pando, and Beni. * Significant at 10%

level. ** Significant at 5% level. *** Significant at 1% level. [a] As a robustness analysis, probit models were estimated, yielding results consistent with those in this table. Additional results are available upon request. [b] Similar results were found with the Simpson index.

B6. Indirect effects - Medium term indirect impacts

Variables (unit)	Total income (log)		Net income (log)		Value of agricultural production (log)		Value of agricultural production per HA (log)		Household sells agricultural production (1=yes)[a]		Prop. of agricultural production sold (%)		Value of sales (USD)		Food insecurity (1= Insecurity)[a]	
	Dummy	Km	Dummy	Km	Dummy	Km	Dummy	Km	Dummy	Km	Dummy	Km	Dummy	Km	Dummy	Km
Indirect effect:	0.426**	-0.00102	0.0571*	0.000221	0.638***	-0.00257	0.467*	-0.00870***	0.0391	0.00119	0.000622	0.000909*	221.2	-0.726	0.0357	-0.00157*
	(0.179)	(0.00216)	(0.0311)	(0.000377)	(0.181)	(0.00243)	(0.252)	(0.00314)	(0.0564)	(0.000722)	(0.0399)	(0.000524)	(133.8)	(1.459)	(0.0568)	(0.000916)
Head of household:																
Male (0,1)	0.289*	0.297*	0.0195	0.0212	0.341**	0.352**	0.177	0.175	-0.0250	-0.0222	-0.0265	-0.0251	43.64	47.82	-0.101	-0.101
	(0.153)	(0.159)	(0.0235)	(0.0240)	(0.142)	(0.149)	(0.157)	(0.158)	(0.0415)	(0.0415)	(0.0279)	(0.0279)	(90.51)	(91.52)	(0.0648)	(0.0647)
Age (years)	0.00832*	0.00751*	0.00108	0.00102	0.00969*	0.00833	0.00864	0.00667	0.00257*	0.00268*	9.69e-05	0.000225	4.270	3.820	0.00184	0.00159
	(0.00423)	(0.00427)	(0.00144)	(0.00139)	(0.00525)	(0.00542)	(0.00597)	(0.00622)	(0.00152)	(0.00144)	(0.000952)	(0.000890)	(2.711)	(2.675)	(0.00181)	(0.00182)
Speak Spanish (0,1)	0.0575	-0.00914	0.0398	0.0267	-0.0227	-0.110	0.113	0.128	-0.0146	-0.0355	0.0529	0.0422	88.02	55.69	-0.0204	-0.0135
	(0.142)	(0.135)	(0.0383)	(0.0379)	(0.179)	(0.173)	(0.221)	(0.214)	(0.0468)	(0.0450)	(0.0342)	(0.0329)	(88.05)	(88.13)	(0.0739)	(0.0738)
Indigenous (0,1)	0.220**	0.209**	-0.00768	-0.00826	0.0483	0.0294	0.120	0.0894	0.0752**	0.0774**	0.0328	0.0350	119.5	113.3	0.0980*	0.0905*
	(0.1000)	(0.101)	(0.0247)	(0.0246)	(0.0980)	(0.102)	(0.120)	(0.123)	(0.0357)	(0.0365)	(0.0224)	(0.0221)	(72.87)	(72.09)	(0.0541)	(0.0529)
Single (0,1)	-0.179	-0.182	0.0286	0.0289	0.0632	0.0575	0.214	0.198	0.0570	0.0590	-0.0339	-0.0323	-48.05	-49.72	-0.141	-0.136
	(0.189)	(0.192)	(0.0325)	(0.0326)	(0.190)	(0.192)	(0.199)	(0.200)	(0.0638)	(0.0629)	(0.0342)	(0.0340)	(134.1)	(134.3)	(0.105)	(0.104)
Literate (0,1)	0.122	0.0867	-0.0192	-0.0259	-0.0193	-0.0663	0.528	0.531	-0.00581	-0.0160	-0.0117	-0.0167	124.4	107.2	-0.0532	-0.0538
	(0.283)	(0.289)	(0.0473)	(0.0483)	(0.276)	(0.284)	(0.330)	(0.326)	(0.0768)	(0.0795)	(0.0387)	(0.0393)	(163.6)	(165.6)	(0.229)	(0.225)
Elementary education (0,1)	0.141	0.162	0.0364	0.0390	0.350	0.382	-0.414	-0.388	0.178**	0.179**	0.0695*	0.0691*	154.2	165.0	0.0479	0.0556
	(0.288)	(0.292)	(0.0499)	(0.0507)	(0.268)	(0.274)	(0.287)	(0.281)	(0.0770)	(0.0792)	(0.0375)	(0.0379)	(172.0)	(173.4)	(0.271)	(0.271)
Secondary education (0,1)	0.337	0.376	0.0567	0.0627	0.522*	0.577*	-0.541	-0.517	0.224**	0.231**	0.0818*	0.0840*	288.1	307.6	0.0104	0.0171
	(0.325)	(0.330)	(0.0567)	(0.0573)	(0.307)	(0.311)	(0.331)	(0.333)	(0.0859)	(0.0882)	(0.0450)	(0.0449)	(189.5)	(193.5)	(0.275)	(0.276)
Higher education (0,1)	0.149	0.205	0.0641	0.0734	0.351	0.431	-1.209***	-1.184***	0.134	0.145	0.0333	0.0378	373.7	402.2*	-0.0574	-0.0642
	(0.376)	(0.371)	(0.0720)	(0.0719)	(0.397)	(0.393)	(0.427)	(0.419)	(0.105)	(0.106)	(0.0472)	(0.0470)	(235.0)	(237.1)	(0.298)	(0.298)
Household:																
Size (# members)	0.101***	0.107***	0.00976	0.0112	0.0344	0.0411	0.0108	0.00281	0.0134	0.0163*	-0.00376	-0.00203	36.90*	39.52*	0.0159	0.0140
	(0.0265)	(0.0278)	(0.00800)	(0.00781)	(0.0284)	(0.0296)	(0.0389)	(0.0387)	(0.00929)	(0.00936)	(0.00475)	(0.00471)	(20.42)	(20.48)	(0.0139)	(0.0142)

Dependence ratio (%)	-0.463***	-0.451**	-0.00443	-0.00268	-0.559***	-0.542***	-0.362*	-0.353*	-0.0494	-0.0476	-0.0196	-0.0191	-216.8*	-210.8*	-0.0157	-0.0126
	(0.175)	(0.172)	(0.0661)	(0.0655)	(0.179)	(0.174)	(0.217)	(0.208)	(0.0546)	(0.0551)	(0.0358)	(0.0360)	(121.5)	(121.4)	(0.0860)	(0.0846)
H belongs to an agric. coop. (0, 1)	0.647***	0.648***	0.129***	0.129***	0.595**	0.597**	0.107	0.124	0.169**	0.166**	0.0501	0.0481	455.2***	455.8***	0.0144	0.0185
	(0.185)	(0.183)	(0.0379)	(0.0369)	(0.247)	(0.257)	(0.265)	(0.258)	(0.0664)	(0.0676)	(0.0411)	(0.0407)	(165.7)	(164.3)	(0.0911)	(0.0899)
Geographic:																
La Paz (0,1)	0.0374	0.0774	0.0303	0.0509	0.104	0.119	1.379***	1.100***	0.00942	0.0675	-0.0540	-0.0153	-90.38	-78.00	0.0872	0.0212
	(0.185)	(0.219)	(0.0300)	(0.0367)	(0.192)	(0.238)	(0.283)	(0.302)	(0.0606)	(0.0685)	(0.0393)	(0.0443)	(104.9)	(129.6)	(0.0697)	(0.0771)
Cochabamba (0,1)	0.515	0.720*	0.155**	0.204***	0.315	0.558	-0.272	-0.505	0.153	0.249**	-0.0366	0.0186	446.0*	540.2*	0.212	0.118
	(0.365)	(0.415)	(0.0656)	(0.0762)	(0.402)	(0.501)	(0.642)	(0.639)	(0.111)	(0.124)	(0.0912)	(0.0917)	(258.3)	(288.3)	(0.151)	(0.147)
Santa Cruz (0,1)	0.618**	0.676***	0.162**	0.174**	0.0374	0.112	-0.627	-0.653	-0.263**	-0.242**	-0.126	-0.115	359.1	386.9	0.375***	0.356***
	(0.240)	(0.233)	(0.0785)	(0.0784)	(0.419)	(0.438)	(0.482)	(0.518)	(0.110)	(0.107)	(0.0964)	(0.0927)	(255.6)	(239.4)	(0.0907)	(0.0938)
Altitude	-0.000448	-0.000629	-0.000124	-0.000153*	-0.00106**	-0.00132**	-9.76e-05	-0.000187	-0.000138	-0.000173	0.000152	0.000139	-0.0675	-0.159	-1.51e-05	2.12e-05
	(0.000400)	(0.000418)	(7.81e-05)	(8.01e-05)	(0.000468)	(0.000541)	(0.000674)	(0.000650)	(0.000132)	(0.000141)	(0.000121)	(0.000119)	(0.294)	(0.295)	(0.000174)	(0.000162)
Altitude^2	1.02e-07	1.30e-07	3.23e-08**	3.66e-08**	2.34e-07**	2.74e-07**	6.19e-08	8.11e-08	8.62e-10	5.35e-09	-5.35e-08*	-5.21e-08*	6.57e-06	2.07e-05	7.60e-09	1.17e-09
	(9.23e-08)	(9.81e-08)	(1.56e-08)	(1.65e-08)	(1.07e-07)	(1.25e-07)	(1.48e-07)	(1.42e-07)	(2.98e-08)	(3.22e-08)	(2.70e-08)	(2.70e-08)	(6.37e-05)	(6.51e-05)	(3.91e-08)	(3.65e-08)
Constant	4.848***	5.307***	8.281***	8.324***	4.817***	5.558***	5.375***	6.268***	0.577***	0.553***	0.361***	0.315***	-175.7	72.89	0.416*	0.517**
	(0.444)	(0.393)	(0.0761)	(0.0732)	(0.513)	(0.472)	(0.609)	(0.607)	(0.151)	(0.125)	(0.115)	(0.0957)	(306.8)	(243.9)	(0.212)	(0.234)
Observations	805	805	805	805	805	805	805	805	805	805	805	805	805	805	349	349
R-squared	0.116	0.103	0.031	0.028	0.092	0.069	0.206	0.216	0.170	0.175	0.187	0.195	0.108	0.101	0.089	0.098

Notes: All models are estimated by OLS. Robust standard errors clustered at the community level are in parentheses. Income, cost, and production value variables were adjusted for extreme outliers. For the geographical dummies, the reference category groups Chuquisaca, Oruro, Potosí, Pando, and Beni. * Significant at 10% level. ** Significant at 5% level. *** Significant at 1% level. [a] As a robustness analysis, probit models were estimated, yielding results consistent with those in this table. Additional results are available upon request.

C. Placebo tests

		Direct effect			Indirect effects (dummy)			Indirect effects (km)		
	Variables (unit)	**Higher education (1=yes)**	**Dependence ratio (%)**	**Single (1=yes)**	**Higher education (1=yes)**	**Dependence ratio (%)**	**Single (1=yes)**	**Higher education (1=yes)**	**Dependence ratio (%)**	**Single (1=yes)**
Effect		-0.00534	-0.0411	0.00655	0.0190*	0.0165	-0.000688	-0.00102	-0.000107	-4.85e-05
		(0.0160)	(0.0399)	(0.0274)	(0.00987)	(0.0316)	(0.0174)	(0.00216)	(0.000148)	(0.000449)
	Male (0,1)	0.0398***	-0.0218	-0.202***	0.0358**	-0.0317	-0.152***	0.297*	0.0361**	-0.0314
		(0.0131)	(0.0233)	(0.0300)	(0.0157)	(0.0349)	(0.0332)	(0.159)	(0.0157)	(0.0348)
	Age (years)	-0.00221***	0.00688***	-0.00313***	-0.00189***	0.00651***	-0.00137	0.00751*	-0.00194***	0.00648***
		(0.000376)	(0.000826)	(0.000695)	(0.000455)	(0.00104)	(0.000829)	(0.00427)	(0.000456)	(0.00104)
	Speak Spanish (0,1)	0.0193**	0.0677***	0.0210	0.0381***	0.0444	0.0341	-0.00914	0.0359***	0.0420
		(0.00943)	(0.0256)	(0.0196)	(0.0104)	(0.0337)	(0.0252)	(0.135)	(0.0103)	(0.0341)
	Indigenous (0,1)	-0.00560	-0.0328*	-0.0144	0.000748	-0.00670	0.00306	0.209**	0.000111	-0.00715
		(0.00871)	(0.0193)	(0.0152)	(0.0105)	(0.0261)	(0.0210)	(0.101)	(0.0105)	(0.0260)
Head of household	Single (0,1)	0.0143	-0.0514		0.0306	-0.0457		-0.182	0.0305	-0.0459
		(0.0161)	(0.0334)		(0.0260)	(0.0455)		(0.192)	(0.0260)	(0.0456)
	Literate (0,1)	0.391***	-0.0193	0.0586*	0.409***	-0.0378	0.0454	0.0867	0.409***	-0.0392
		(0.0392)	(0.0496)	(0.0330)	(0.0554)	(0.0574)	(0.0485)	(0.289)	(0.0557)	(0.0574)
	Elementary education (0,1)	-0.570***	-0.0735	0.0417	-0.598***	-0.0570	0.0508	0.162	-0.598***	-0.0563
		(0.0417)	(0.0501)	(0.0327)	(0.0500)	(0.0676)	(0.0569)	(0.292)	(0.0501)	(0.0675)
	Secondary education (0,1)	-0.617***	-0.0542	0.0356	-0.644***	0.0357	0.0316	0.376	-0.644***	0.0372
		(0.0426)	(0.0544)	(0.0370)	(0.0507)	(0.0691)	(0.0661)	(0.330)	(0.0507)	(0.0689)
	Higher education (0,1)		-0.0850	0.0398		-0.0132	0.0910	0.205		-0.0110
			(0.0633)	(0.0457)		(0.0800)	(0.0775)	(0.371)		(0.0803)
	Size (# members)	-0.00101	0.0200***	-0.0238***	-0.00351	0.0266***	-0.0223***	0.107***	-0.00338	0.0268***
		(0.00234)	(0.00461)	(0.00464)	(0.00302)	(0.00624)	(0.00571)	(0.0278)	(0.00307)	(0.00626)
Household	Dependence ratio (%)	-0.0209		-0.0339	-0.00300		-0.0310	-0.451**	-0.00252	
		(0.0149)		(0.0224)	(0.0182)		(0.0311)	(0.172)	(0.0183)	
	H belongs to an agric. coop. (0, 1)	0.0256	-0.0262	0.00978	0.0511**	-0.0177	-0.00890	0.648***	0.0513**	-0.0177
		(0.0163)	(0.0322)	(0.0233)	(0.0245)	(0.0403)	(0.0360)	(0.183)	(0.0246)	(0.0404)
Geographic location	La Paz (0,1)	-0.139***	0.117***	-0.0347	-0.0364***	-0.00848	-0.0171	0.0774	-0.0373***	-0.00732
		(0.0136)	(0.0330)	(0.0236)	(0.0111)	(0.0364)	(0.0213)	(0.219)	(0.0122)	(0.0433)
	Cochabamba (0,1)	-0.131***	0.0335	-0.0191	-0.0407**	-0.00414	-0.0253	0.720*	-0.0353*	0.00322

	(0.0165)	(0.0228)	(0.0246)	(0.0180)	(0.0661)	(0.0319)	(0.415)	(0.0200)	(0.0711)
Oruro (0,1)	-0.0754***	0.212**	0.0385						
	(0.0261)	(0.0836)	(0.0430)						
Potosi (0,1)	-0.132***	0.0746**	-0.0368**						
	(0.0148)	(0.0297)	(0.0187)						
Santa Cruz (0,1)	-0.120***	0.175***	-0.0278	-0.000980	-0.119***	0.000832	0.676***	0.000886	-0.117***
	(0.0281)	(0.0651)	(0.0440)	(0.0165)	(0.0440)	(0.0322)	(0.233)	(0.0170)	(0.0437)
Beni (0,1)	-0.118***	0.293***	0.0128						
	(0.0367)	(0.0975)	(0.0777)						
Pando (0,1)	-0.104**	0.294**	-0.0723						
	(0.0445)	(0.137)	(0.0714)						
Altitude	-1.15e-05	0.000125	-8.56e-06	8.35e-05***	-0.000131	2.68e-05	-0.000629	7.65e-05***	-0.000138*
	(3.01e-05)	(7.68e-05)	(6.10e-05)	(2.62e-05)	(8.39e-05)	(4.11e-05)	(0.000418)	(2.75e-05)	(8.20e-05)
Altitude^2	4.98e-09	-2.00e-08	3.06e-09	-1.52e-08***	2.67e-08	-5.41e-09	1.30e-07	-1.41e-08**	2.78e-08
	(5.65e-09)	(1.47e-08)	(1.11e-08)	(5.63e-09)	(1.88e-08)	(9.08e-09)	(9.81e-08)	(5.89e-09)	(1.84e-08)
Constant	0.412***	-0.220*	0.442***	0.214***	0.122	0.259***	5.307***	0.238***	0.140
	(0.0507)	(0.114)	(0.0956)	(0.0474)	(0.0965)	(0.0765)	(0.393)	(0.0460)	(0.0972)
Observations	1,289	1,289	1,289	805	805	805	805	805	805
R-squared	0.602	0.123	0.149	0.634	0.103	0.098	0.103	0.633	0.103

Notes: All models are estimated by 2SLS and OLS. For the geographical dummies, Chuquisaca is the reference category in the direct effects model, while in the indirect effects model, the reference category groups Chuquisaca, Oruro, Potosí, Pando, and Beni. Robust standard errors clustered at the community level are in parentheses. * Significant at 10% level. ** Significant at 5% level. *** Significant at 1% level.