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Lina Salazar
Jossie Fahsbender
Namho Kim

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Livestock Transfers, Food Security and Women's Empowerment: Evidence from a Randomized Phased-in Program in Nicaragua

Lina Salazar, Jossie Fahsbender and Namho Kim

Abstract

This paper explores the impact of a livestock transfer program, that targeted small-holder female farmers with high levels of food insecurity in Nicaragua. For this purpose, the three dimensions of food security are assessed (i.e. access, availability and food use). The analysis uses a double difference estimation combined with a propensity score matching to capture the effects of program participation on a sample of 1200 farmers, representative of treatment and control groups. Also, taking advantage of a randomized phased-in, the findings are tested for a smaller sample of beneficiary farmers. The results confirm that program participation improve households' food security through higher income from livestock sales and home consumption from own production (i.e. access and availability). Also, some evidence is found that food use is also improved by greater protein intake. Moreover, positive impacts on women's empowerment and gender parity within the household are found, mainly driven by higher level of associativity.

Keywords: impact evaluation, randomized phased-in, food security, livestock transfer, Nicaragua, women's empowerment, gender parity.

I. INTRODUCTION

Livestock production is instrumental for food security it contributes to its four dimensions, namely: food access, availability, utilization and stability. Food availability refers to the supply of food at the national or local level, food access refers to the ability of households to obtain food (i.e. financial resources, income, in-kind payments), food utilization refers to the amount and quality of nutrients obtained from food, and food stability refers to the steadiness of food supply (Salazar et. al, 2016; FAO, 2006).

Livestock production not only increases the supply of animal-source foods for households in rural areas, but it is also proven to improve crop yields by enhancing soil fertility through manure and animal traction (*food availability*). Also, livestock production constitutes a stable source of cash and in-kind income in rural areas as farmers can sell foods of animal origin to improve income flows or increase home consumption from livestock production (*food access*) (Pica-Ciamarra et. al, 2011). Moreover, there is substantial evidence suggesting that in some countries, the contribution from livestock production to income is more important for the poor (Delgado et al.,1999; Ifft, 2005; Akter et al. 2007).

Benefits associated with sustainable livestock production in rural areas far exceed income generation and food consumption improvements. In fact, it is well established that animal food is a source of dietary diversity for rural households and provides vital nutrients that are crucial for the healthy development of children (*food utilization*) (Randolph et al., 2007). Finally, livestock production is far more stable than crop production. Therefore, access to livestock reduces vulnerability to crop production variability and other unexpected shocks serving as a mechanism to smooth consumption (*food stability*) (Fafchamps and Gavian, 1997; Randolph et al., 2007).

Additional benefits from livestock production also include: (i) employment generation; (ii) agricultural waste recycling; and (iii) energy use for cooking; among others (FAO, 2009). Moreover, livestock programs that target women have the potential to reduce gender inequality by increasing women's empowerment and reducing the gender gap on asset ownership (FAO, 2011; Zezza et. al, 2016).

For all this, it is expected that policies that aim to improve livestock production and promote consumption of animal-source food will have important impacts on reducing hunger and improving nutrition (Zezza et. al, 2016). However, few studies have analyzed the potential of livestock agriculture to improve household well-being through food security and women's empowerment. This is particularly true for Latin American countries where the empirical evidence on the effectiveness of livestock programs is scarce. This

study aims to contribute to the empirical evidence on livestock transfer programs, by analyzing the "Productive Support for Agri-food Program"[1] (APAGRO). This program aimed at increasing income and food security of small female producers in Nicaragua by providing vouchers to access livestock assets and technical assistance.

This paper is structured as follows, Section II presents a review of the literature on livestock interventions and their effects on food security, and provides evidence of the relationship between agriculture, women and food security. Section III describes the APAGRO program and Section IV presents the descriptive statistics. Section V and VI present the econometric methodology and the results, respectively. Section VII displays the gender analysis and Section VIII the robustness tests for the results. Section IX concludes.

II. LIVESTOCK, FOOD SECURITY AND WOMEN'S EMPOWERMENT

Livestock ownership contributes to food security through different channels, enabling access to livestock products (milk, eggs, meat, etc.), contributing to higher yields using manure and traction, providing cash income for purchasing food, improving diets and reducing variability of food consumption (Zezza, 2016). It is well known that livestock production is particularly relevant for food security, especially in areas that are not suitable for crop production or where crop production presents high variability. However, few rigorous impact evaluations have addressed the impact of livestock projects on food security and analyze the pathways for that improvement.

Sustainable livestock production is rather appealing as it has the potential to contribute to all dimensions of food security. Specifically, livestock ownership can lead to increase food supply at the local and national level by increasing production of animal-source foods as well as higher crop production through increased manure and animal traction, which increases *food availability*. Second, livestock ownership and production represent an important source of cash and in-kind income, enabling food consumption through own production or cash expenditures, which improves *food access*. Third, livestock ownership and production improve diets and dietary diversity through increased consumption of animal-source foods that offer key nutrients and high levels of protein, which enhances *food utilization* (Hoddinot, 2014; Carletto et al, 2016). Lastly, livestock production is steadier than agricultural crop production enabling consumption smoothing and reducing vulnerability to shocks, which increases *food stability*. However, despite the great potential of

[1] "Apoyos Productivos Agroalimentarios" in Spanish.

livestock production for food security, few rigorous impact evaluations have addressed their impact on food security and the pathway for that improvement. This section presents different studies that addressed the impact of livestock ownership and production on the different pathways that affect food security.

The first path through which livestock production can improve food security is by boosting food availability through increased food supply. Overall, livestock ownership increases production of animal-sourced foods (ASF) and improves crop production. Evidence from 2001 to 2003, shows that intensive systems of livestock contribute 45% of the world's meat, while crop-livestock systems supply 46% of the meat, 88% of the milk and 50% of the world's cereals; and grazing systems provide 12% of the milk and 9% of the meat (Steinfeld et al., 2006; Thornton and Herrero 2009). In Ethiopia, Ayele and Peacock (2003) analyze the impacts of a women-focused goat development program on the supply of animal-based food. A simple data analysis before and after the intervention suggests improvements in ASF for program participants, finding increases in the availability of milk (109%), energy from animal sources (39%), protein (39%) and animal fat (63%). On the other hand, literature suggests that livestock tenure has a positive impact on the total farm economy as the animals can be used for traction purposes for plowing or transportation of the products to the markets. Additionally, they consume the crop residuals and byproducts, and the manure is a source of nutrients for the crops, factors that contribute to increasing the efficiency of the total farming system (Neumann and Harris, 2002).

The second path through which livestock production can improve food security is by enhancing food access through increased cash and in-kind income (home consumption from own production). Indeed, about 50% of the poorest people in the world rely partially or fully on livestock production as a source of livelihood (Robinson, 2011). The evidence shows that there is a positive relationship between livestock ownership and consumption of animal source foods. For instance, in Uganda, it is shown that large ruminants ownership increases dairy consumption but has no significant effect on beef consumption, while chicken consumption increases with the number of poultry owned (Azzari, 2014). Similarly, Hetherington et al. (2006) study the relationship between livestock ownership and animal-source foods consumption in seven rural villages located in Sub-Saharan Africa and confirm that households with livestock ownership are more likely to consume animal-base foods.

Livestock production can also enhance food security through food utilization, particularly by improving diet, protein consumption and dietary diversity. In fact, it is estimated that about one-third of global

protein consumption is from animal products (Godber and Wall, 2014). The existing literature is mainly focused on the relationship between farm and dietary diversification. Romeo et al. (2016) find a positive association between farm production diversification and household dietary diversity in East Africa. This correlation was especially strong with poultry ownership, probably due to an income effect, and with cattle holdings, that increased milk consumption due to a production-for-own-consumption effect. Sibhatu et al. (2015) analyze this relationship for households in Kenya, Ethiopia and Malawi, showing that one additional crop or livestock species on farm production leads to a 0.9% increase on the food groups consumed. And this effect is higher for Indonesia, where the initial production diversity is lower. Furthermore, Jones et al. (2014) encounter that the linkage between farm and dietary diversity, when including livestock in the measure for diversification, is stronger in woman-headed households.

On the other hand, there is mixed evidence on the link between livestock production and nutritional outcomes. For instance, Hoddinott et al. (2014) find that ownership of cows increases dairy consumption and reduces stunting of children by seven to nine percentage points in Ethiopia. Azzari et al. (2014) show that small ruminant ownership decreases the probability of weight loss and underweight on children between three and five years old, while large ruminant ownership has the opposite effect probably due to animal health issues. Hetherington et al. (2006) also show that the link between animal-based foods consumption and anthropometric measurements is not clear, as their findings vary between negative and positive effects, depending on the food commodity and the villages.

Lastly, livestock ownership is a source of food stability. Access to livestock reduces vulnerability to crop production variability and it serves as a mechanism to smooth consumption (Fafchamps and Gavian, 1997; Randolph et al., 2007). In fact, livestock assets are often considered a form of savings and insurance, particularly among the poorest households (FAO, 2009). Lange and Reimers (2014) find that in the event of a drought there is a significant increase in livestock sales in order to finance food consumption. Also, the availability of animal-sourced food from own production, allows the household to save money or assets that would have been exchanged to access this kind of food in the absence of own livestock (Ayele and Peacock, 2003). However, other studies present mixed evidence on whether livestock is used as a buffer stock when facing income shocks (Rosenzweig and Wolpin, 1993; Udry, 1995; Fafchamps et al., 1998; Ali, 2015). The mixed responses can be due to poverty traps and different levels of productive assets, as households above a

certain threshold practice consumption smoothing by selling their assets but the poorest tend to maintain their assets even when facing income shocks, which leads to high consumption fluctuations (Zimmerman and Carter, 2003; Carter and Lybbert, 2012). The findings suggest that although livestock production reduces vulnerability to crop production variability poorer households do not always use it as a buffer stock to smooth consumption.

Despite the direct benefits associated with access to livestock, technical assistance is crucial to improve production efficiency, reduce risks of animal borne diseases and enhance sustainability of impacts over time. Banerjee et al. (2015) analyze a multifaceted program that combines asset transfer, mainly livestock assets, with consumption support, training, coaching, savings encouragement and health education. A randomized control trial is implemented in six countries and the results indicate that this intervention increases consumption and food security, not only after the first year of the program but also after the second year. In the same line, Argent et al. (2014) evaluate the impact of a Rwanda's livestock asset transfer program, primarily focused on the distribution of cows. They analyze the differentiated effect of the program with and without complementary training. The findings suggest significant impacts of the training on household's milk production, livestock productivity, earnings and asset accumulation. Also, they find evidence that some of these impacts are self-perpetuating and increase over time.

A more transversal issue that influences global food security is women's empowerment. Women are crucial actors in the food systems and therefore gender equality is key to ensure the pillars of food security. Indeed, it has been proved that women have a key role in agricultural production, however, gaps on asset ownership and inputs negatively affect their productivity which in turns reduces food availability (Kilic et al., 2015). In fact, the FAO (2011) estimates that if rural women were to have the same access to productive assets than men, agricultural production in developing countries could increase from 2.5% to 4%, reducing the number of hungry people in the world by 12% to 17% (FAO, 2011). Moreover, in many developing countries women are responsible for small-animal husbandry and commercialization which is a crucial for food security in several rural areas. However, agricultural technology transfer programs or innovation initiatives do not generally consider gender dynamics and social norms which might reduce opportunities to increase food supply. Food access can also be threatened by gender disparities and income inequality. Particularly, in rural areas men tend to control the most profitable crops while women are often in charge of subsistence crops and minor livestock, which are mostly used for household feeding (Pehu et al., 2009). This household division of labor can perpetuate women's disadvantageous position in society and reduce women's participation in income

management decisions. This in turn decreases food access as women are more likely to allocate a larger share of their income to food consumption. (World Bank, 2009; Quisumbing et al., 1995).

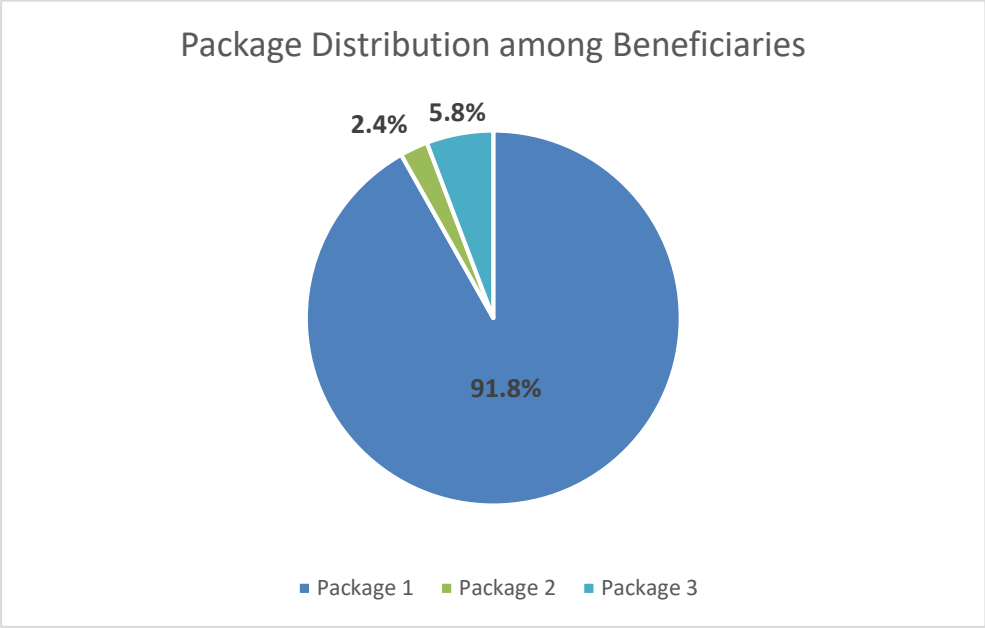
Lastly, women's role in food use or utilization is crucial as they are generally responsible for food purchases and preparation, as well as childcare. Therefore, empowering women is positively associated with better household nutrition, dietary diversity and child development indicators (Sraboni et al., 2014; Malapit et al., 2015). Also, Duflo and Udry (2004) find that increasing women's share of cash income increases the share allocated to food consumption and Zambrano et al. (2011) show that women invest their additional income in their family's nutrition, education and health.

For these reasons, it is not surprising that agricultural interventions that include complementary training and strategies to enhance women's empowerment are more likely to improve food security and nutritional outcomes. An example of this practice are the projects financed by Helen Keller International, which combine interventions on family vegetable gardens with training on gender equality and women's empowerment (Meinzen-Dick et al., 2011). Accordingly, Banerjee et al. (2015) find a positive relation between a program of asset transfer (mainly livestock) and women's empowerment, but these results occur only during the first year of the program. On the other hand, Kariuki et al (2013), highlight the importance of considering the intra-household dynamics when analyzing livestock transfer programs. In particular, positive results on household nutritional outcomes are more likely to take place when women's ownership of livestock is promoted. The authors mention that women's ownership increases their probability to participate in the decision making about livestock allocation, production and income. As shown, there is growing evidence that suggests that increasing women's control over assets has positive effects on food security, child nutrition and education, and women's well-being.

Overall, the literature has focused on measuring the impacts of livestock ownership on specific outcomes related to production, consumption or nutrition without addressing the full scope of food security. This study aims to address this knowledge gap by analyzing the pathways through which livestock ownership might affect food security and its effect on women's empowerment by evaluating the impacts of a livestock transfer program that specifically target rural women in Nicaragua.

III. THE APAGRO PROGRAM

The "Productive Support for Agri-food Program" (APAGRO) is a livestock transfer program implemented in Nicaragua from 2011 to 2014. This is one of the few national programs in Latin America that specifically targeted women in order to enhance food security and nutritional outcomes through livestock transfers. The APAGRO aimed at boosting food security of small-scale farmers in Nicaragua, by increasing livestock production and income. Specifically, the program financed the acquisition of livestock assets and the provision of technical assistance[2]. Beneficiaries could select among three different livestock packages depending on their economic means and resources: i) one cow, one pig, and chickens; ii) one pig, goats and chickens; or iii) one cow, sheep and chickens[3]. As shown in Figure 1, most of the households received the first package (92%), followed by the second and third packages, respectively (6% and 2%). At the time of the evaluation, only 27 households (5%) had not received the full package but some of the livestock assets.



Technical assistance was provided by extension workers who visited individual households and held group training sessions once a month. In particular, technical assistance included training on livestock management, commercialization, associativity and financial education. On average, the cost of the livestock package and the technical assistance amounted to US$ 1,400.[4]

[2] Livestock assets also included forage as well as materials for corral construction.
[3] APAGRO was implemented by the Ministry of Agriculture and Forests (MAGFOR) from 2009 to 2012, and by the Ministry of Family, Community and Associative Economics (MEFCCA) from 2012 to 2014.

Market features were integrated into the program to guarantee competition and reduce market distortions. Specifically, beneficiaries received vouchers to purchase the livestock assets in the market of their choice. In the same manner, producers were provided with vouchers to pay the extension workers in exchange for technical assistance. These vouchers were later presented by the extension workers to the executing unit to obtain their monthly payment. By empowering beneficiaries through decision making, the program guaranteed that beneficiaries monitored the quality of the technical assistance provided. In fact, although the technical assistance provided by the program consisted of 22 months of training, farmers continued this process after project completion hiring the extension workers with their own resources.

The eligibility criteria for program participation included: (i) having access to at least one manzana of land and maximum 10 manzanas of land (0.7 to 7 hectares); (ii) not being beneficiary of the Zero Hunger program[5]; and (iii) being a female producer[6]. The total number of persons registered for program participation were 21,548, out of which 14,247 were considered eligible as they fulfilled all the requirements. From these eligible households, 11,543 benefited from the program and 3,247 did not receive the program for reasons unrelated to fulfillment of eligibility criteria such as: (i) the extension worker was not able to locate the farmer in the initial visit; (ii) the farmer did not provide appropriate identification; and/or (iii) limited resources for the maintenance of livestock package. Then, beneficiary farmers were grouped in 223 clusters comprised of 45 to 55 beneficiaries. Each cluster was assigned an agricultural extension worker who was responsible of providing the technical assistance.

The program began its implementation in 2010 and finalized in 2014. The program roll-out led to two different groups of beneficiaries. The first group was a pilot group composed of 4,283 farmers who entered the program between November 2010 and March 2011. These farmers were selected based on logistical convenience in terms of geographical location to facilitate the start-up of the program. Specifically, these beneficiaries were located in close proximity to the executing unit, in the departments of Jinotega and Matagalpa.

[5] The Zero Hunger Program delivers a Food Production Package (BPA) with the objective of strengthening food subsistence production in rural families in Nicaragua. Also, it sells their surplus in the domestic market and encourages agribusiness production chains.
[6] Producer is defined as a person whose main economic activity is agriculture. The program mainly targeted female producers, therefore around 90% of the beneficiaries were women. Also, 73% of the beneficiary women received technical assistance as part of the APAGRO program, while 22% of the men in the beneficiary households also received technical assistance.

The second group of beneficiaries, the randomized phased-in group (RPI), was composed of 6,647 farmers who entered the program after March, 2011. These beneficiaries were in four departments: Jinotega, Matagalpa, Nueva Segovia and Estelí. For these second group of beneficiaries, the time of program entry was randomly assigned by clusters in each of the departments. For this purpose, the executing unit assigned a random number to each of the clusters in every department which determined the order of entry to the program. Hence, clusters that were randomly assigned to number 1 would be the initial beneficiaries, followed by clusters assigned with number 2, 3, 4, etc. The executive unit followed this randomized phased-in for program execution to assure a more homogeneous distribution of beneficiaries across departments.

Sample Design and Counterfactual Identification

For conducting an impact evaluation, a control group was selected prior to program implementation from the 3,247 households that registered and fulfilled all the eligibility criteria but did not received the program. For the pilot group, the required number of clusters were randomly selected for each Department. Then, all the beneficiaries and comparable non-beneficiaries of these clusters were listed, and they were paired using a Propensity Score Matching (PSM). Finally, the number of pairs required for the optimal sample size were randomly selected, resulting on 300 pilot beneficiaries and 300 pilot controls.

For the randomized phased-in (RPI) group, a representative sample of program beneficiaries was randomly selected. Then, the control group was constructed using a PSM to find the most comparable pairs for the sample of the treatment group from the same clusters, resulting on 300 RPI beneficiaries and 300 RPI controls.

The implementation of a Propensity Score Matching (PSM), using a nearest neighbor matching, assured comparability between the treated and control groups. The PSM considered all relevant observable characteristics including age and education of the head of the household, number of household members, land size, agroecological zone and distance to the city (Bravo-Ureta, B., 2011). The final sample was composed of 1,200 observations (300 pilot beneficiaries, 300 RPI beneficiaries; 300 pilot controls and 300 RPI controls). The farmers of the control group never participated in the APAGRO program, they did not receive the livestock packages nor the technical assistance.

In the next section, we will analyze the comparability between treated and control groups and present descriptive statics.

IV. DATA AND DESCRIPTIVE STATISTICS

The sample was composed of 1200 observations equally divided into beneficiaries and control groups for the pilot and the RPI samples. Two surveys were collected before and after program implementation to the same group, creating a panel data. The baseline survey collected information on the agricultural cycle comprised between April 2010 to March 2011 and was collected in 2011. Later, the follow-up survey collected information on the agricultural cycle comprised between April 2013 and March 2014 and was collected in 2014. After deleting some outliers and dropping incomplete questionnaires, a final sample of 1089 will be the focus of this analysis.

The questionnaire implemented was an agricultural household survey that included information about socio-demographic and economic characteristics of the household members including education, assets, distance to important locations (i.e. market, road, etc.), participation in agricultural and nonagricultural associations, among other characteristics. Also, detailed agricultural information on cultivated area, agricultural inputs, livestock holdings, agricultural and livestock income, value of production, and food security, was included as part of the questionnaire.

To assure further comparability between the treatment and control groups we estimated a second Propensity Score Matching based on baseline characteristics (Appendix 1), considering the selection process and the eligibility criteria as well as the outcomes of interest. The propensity score was constructed using a Probit model that regressed a program participation dummy on a set of variables that included gender, literacy and education of the head of the household, household characteristics, distance to important places, participation in agricultural and non-agricultural associations, access to technical assistance, value of livestock and crop production, etc. Also, outcome variables such as total agricultural income, sales and food consumption were included. The common support area obtained from the PSM is the region were the propensity scores of the treated and control farmers overlap, therefore it indicates the most comparable beneficiaries and non-beneficiaries. In this case, the common support included 99% of the farmers in the sample (1081), which confirms baseline comparability and certifies the effectiveness of the initial PSM to select a proper counterfactual. The remaining 8 observations were dropped from the analysis (1%).

Next, we explore comparability at the baseline between beneficiaries and control groups[7] using t-test of difference in means. Tables 1, 2 and 3 present the descriptive statistics and the difference in means between the treated and non-treated households for the pooled sample (pilot and RPI), for relevant variables in 2011. Regarding household socio-demographic characteristics, table 1 shows that heads of household were primarily women (83%) who were about 41 years old. Heads of household presented low levels of education (6 years on average) and literacy (64%). The average household was composed of five members, had dirt floor (75%) and low level of assets[8]. These households were located about 1.7 km from a road, 13 km from the closest market and 18 km to the department' s capital city. Also 20% of the households participated in another governmental project, 28% of the households belonged to a local association, 16% had received some type of technical assistance in agriculture and 25% of the families had access to credit.

The difference in means show no statistically significant differences at 1% or 5% levels confirming comparability of socio-demographic characteristics between treatment and control groups.

Table 1: Descriptive Statistics – Socio-economic characteristics

	Variables (unit)	**Total**	**Treated**	**Control**	**Diff in Mean**
Household	Household Size (members)	5.35	5.42	5.27	0.151
	Dirt floor (0,1)	0.75	0.78	0.72	0.057*
	Assets index	0.95	0.90	1.01	-0.108*
Head of Household	Woman (0,1)	0.83	0.86	0.80	0.057*
	Literacy (0,1)	0.64	0.63	0.64	-0.009
	Education (years)	6.39	6.47	6.30	0.167
	Age (years)	41.64	40.97	42.39	-1.414
Distance to facilities	Distance to road (km)	1.74	1.95	1.51	0.442
	Distance to market (km)	13.50	13.76	13.20	0.563
	Distance to head city (km)	18.03	17.93	18.15	-0.222
	Distance to health center (km)	4.16	4.48	3.80	0.675*
	Distance to primary school (km)	1.21	1.31	1.10	0.212
Associativity	Participation in other project (0,1)	0.20	0.19	0.20	-0.010
	Participation in local group (0,1)	0.28	0.28	0.28	0.007
	Technical assistance (0,1)	0.16	0.16	0.15	0.014
	Access to credit service (1,0)	0.25	0.27	0.23	0.037
N		**1081**	**570**	**511**	

Difference in means is significant at the *** 1%, ** 5%, * 10%, level

[7] Also, we explore comparability between the beneficiary subgroups of *Pilot* and *RPI.* The results showed similarity among both groups and therefore, the sample was pooled.

[8] The asset index that ranges from 0 to 3 is 0.95, on average.

Table 2 presents descriptive statistics of variables related to agricultural production, livestock holdings, agricultural sales, income and food security at the baseline. On average, households owned 2.76 Has.[9] and cultivated 3.14 Has. Average expenditures on inputs amounted to C$1,825 per manzana (US$82)[10], and only 32% had access to irrigation. The total livestock unit (TLU) equaled 0.54 and the annual costs for livestock breeding were C$821 (US$37). Also, value of livestock production was approximately C$3398 (US$154) and the livestock production ratio was 15% (percentage value of total production from livestock). Interestingly, regarding the adoption of good practices of livestock maintenance (i.e. deworming, vaccination, artificial insemination, improved pastures), which was part of the content provided during the technical training, households practiced, on average, only one of these techniques.

The average household income per year, which includes livestock and crops sales as well as home consumption from own production, amounted to C$34,423 (US$1,564). Specifically, the income from livestock sales and from crop sales represented about C$670 (US$30) and C$20,134 (US$915), respectively. The average value of production per manzana was C$9,112 (US$410), out of which households sold only 34% and allocated the rest for home consumption. Regarding food security, average food expenditures amounted to C$2,974 (US$135) per month, from which C$1,134 (US$52) come from household's own production (38%). In addition, 25% of total food consumption corresponded to protein intake (C$736). On average, 60% of the households had experienced a food shortage the previous year, and the average length of food shortages was 8.5 weeks. Lastly, only 7% of the households had migrants[11] and the quantity of annual remittances amounted to C$ 523 (US$23). In general, these descriptive statistics show that households had small landholdings, low income and face high levels of food insecurity.

Overall, there were no relevant significant differences in income variables or consumption indicators. In fact, there were not statistically significant differences at 1% level, and there was only one significant difference at 5% level for home consumption. At 10% level, however, land owned by the household, livestock ratio, Total agricultural income, sales ratio, food shortage and migration, presented statistically significant differences. Compared with control households, beneficiaries had about 1 more Ha. of land, lower level of livestock production, higher income and were 6% less likely to face a food shortage.

[9] 1 hectare (Has.) = 1.42 manzanas (Mz.)
[10] Exchange rate in 2011: US$ 1 = C$ 22
[11] It makes reference to permanent migration from the household, which includes those individuals who are living abroad.

Table 2: Descriptive Statistics – Agriculture, Livestock, Income and Consumption

	Variables (unit)	Total	Treated	Control	Diff in Mean
Agricultural Practice	Land owned by HH (mz)	3.92	4.32	3.49	0.827*
	Cultivated land area (mz)	4.46	4.68	4.22	0.465
	Agricultural input costs (cord/mz)	1825.2	1758.86	1899.2	-140.3
	Cost for hired labor (cord/mz)	877.94	896.22	857.55	38.669
	Irrigation (1,0)	0.32	0.34	0.30	0.041
Livestock	Total Livestock Unit	0.54	0.48	0.60	-0.118
	Livestock production (cord)	3397.82	2919.29	3931.59	-1012.3*
	Livestock ratio (livestock prod/total prod)	0.15	0.13	0.17	-0.037*
	Livestock costs (cord)	821.23	809.68	834.12	-24.439
Income	Total agricultural income (cord)	34423.07	37827.88	30625.14	7202.7*
	Income from livestock sales (cord)	670.84	522.54	836.26	-313.714
	Income from crop sales (cord)	20134.09	22659.06	17317.58	5341.482
	Value productivity (cord/mz)	9112.13	8834.02	9422.34	-588.312
	Sales ratio	0.34	0.37	0.31	0.0546*
Consumption	Home consumption (cord)	1134.85	1220.52	1039.28	181.2**
	Food consumption (cord)	2974.80	3056.53	2883.64	172.898
	Protein consumption (cord)	736.04	756.34	713.39	42.954
	Food shortage in past year (1,0)	0.60	0.57	0.64	-0.0623*
	Food shortage intensity (weeks)	8.49	8.28	8.73	-0.451
Migration	Migration (0,1)	0.07	0.05	0.08	-0.0315*
	Quantity of remittance (cord)	522.97	489.33	560.49	-71.15
N		**1081**	**570**	**511**	

Difference in means is significant at the *** 1%, ** 5%, * 10%, level

Finally, table 3 presents the descriptive statistics for the women heads of household or the female spouse[12]. The analysis shows that only 20% of the women in the household participated on the decision-making about crop production or marketing of agricultural production. On the other hand, 92% of the women in the household participated on the decisions about income either by making joint decisions with their spouses or by partly contributing to the decisions, but only 21% of the women were part of a community group or participated in a community project. Regarding the main occupation of the female head of household[13], 4.5% performed agricultural activities (work in the farm) and 4.9% performed non-agricultural income-generating activities (i.e. salaried employee, own business, extractive activities), while almost 87% dedicated exclusively

[12] This data also makes reference to the baseline year (2011). Some information not captured in the baseline survey was retrieved in the follow-up survey with questions regarding the baseline period.

[13] The survey collected information on the main activity or occupation for each member of the household. We take this information for the woman head of household.

to domestic work (i.e. cooking, taking care of the children, etc.). Also, 33% of women requested credit in the last year but only 32% received it.

Notice that there were no significant differences between treated and control households at 1% or 5% level. However, women in treated households were more likely to participate in domestic work (4.6%) (significant at 10% confidence level).

Table 3: Descriptive Statistics – Gender Variables

	Variables (unit)	N	Total	Treated	Control	Diff in Mean
Production	Women decision-making over production (0,1)	960	0.201	0.184	0.220	-0.036
Resources	Women's access to credit (0,1)	273	0.330	0.312	0.353	-0.041
Income	Women receives income (0,1)	921	0.327	0.317	0.338	-0.021
	Women decision-making over use of income (0,1)	908	0.925	0.930	0.919	0.011
Associativity	Women part of a community group (0,1)	1081	0.213	0.195	0.233	-0.038
Time Distribution	Women participate in agricultural work (0,1)	1081	0.045	0.035	0.057	-0.022
	Women participate in non-agricultural work (0,1)	1081	0.049	0.047	0.051	-0.004
	Women participate in domestic work (0,1)	1081	0.866	0.888	0.841	0.046*

Difference in means is significant at the *** 1%, ** 5%, * 10%, level

Later on, beneficiary households who declared not having received any livestock package are dropped from the sample (3%), in order to measure average treatment effect. Also, we exclude those beneficiary households receive technical assistance from another program that was not related to APAGRO (2%). After data cleaning, the sample used for the final estimations comprises 1049 households, corresponding to 538 in the treatment group and 511 in the control group.

V. ECONOMETRIC METHODOLOGY

The methodology to capture the program's impact is a difference in differences (DD) estimation. The strength of this methodology compared with other quasi-experimental techniques is that it allows to identify the causal effect of the program by accounting for time-invariant unobserved heterogeneity as well as observable heterogeneity (Abadie, 2005; Angrist and Pischke, 2009; Villa, 2016). However, the main assumption behind this methodology is that, in the absence of treatment, the beneficiaries will present an outcome that resembles the trend of those in the control group (Villa, 2016; Bertrand, Duflo and Mullainathan, 2004).

The following equation shows the basic difference in difference model to be estimated:

$$Y_i = \alpha_i + \beta_1\, t + \beta_2 D_i + \beta_3 (t * D_i) + \delta_{ij} X_{ij} + \varepsilon_i \quad (1)$$

Where:

Y_i= outcome variable of interest for household *i*;

t = dummy variable equals to 0 if year 2011 (baseline) and 1 if year 2014 (follow-up);

D_i= dummy variable equals to 1 if household *i* is treated;

X_{ij}= a vector of observable characteristics for household *i*, measured at baseline;

ε_i = error term;

α, β, δ are unknown parameters.

The outcome variables to be assessed are related to the four dimensions of food security: availability (agricultural and livestock production), access (total agricultural income[14] and income from livestock sales), utilization (home consumption and protein consumption) and stability (production diversification measured with the livestock ratio). Additionally, the analysis will consider measures of empowerment (disempowerment headcount, disempowerment score, gender disparity and empowerment gap). The parameter of interest is β_3 that represents the double-difference estimator or the causal effect of the program. The parameter β_1 captures the time trend of the outcome variable and the parameter β_2 represents the initial differences between treated and control groups. For robustness, the regression will be estimated for the pooled sample as well as for the *randomized phased-in* sample separately. For the pooled analysis, a dummy variable is included to control for potential heterogeneity between the two sub-groups of beneficiaries (pilot and randomized phased-in).

Technical Assistance

To identify the additional impact of receiving technical assistance, this analysis will estimate differential impacts for those households that received only the livestock assets without the technical assistance (Treatment 1), and those households that received the livestock assets and the technical assistance (Treatment 2)[15].

[14] The agricultural income is considered a good measure for food access because it includes cash and in-kind income for the household, as it includes earnings from crops and livestock sales as well as home consumption from own production. Therefore, it directly reflects the ability of households to obtain food.

[15] 154 beneficiaries received only the livestock assets (Treatment 1) and 384 beneficiaries received the livestock package plus technical assistance (Treatment2).

The program effects are expected to be higher for those households that received Treatment 2 as knowledge from technical assistance must have influenced livestock management, sales and production. The proposed model is the following:

$$Y_i = \pi_i + \sigma_1\, t + \gamma_1 T_1 + \gamma_2 T_2 + \delta_1(t * T_1) + \delta_2(t * T_2) + \vartheta_{ij} X_{ij} + \mu_i \qquad (2)$$

Where:

Y_i, t, X_{ij}= are the same as defined in equation (1);

$T_1 =$ is a dummy variable that takes the value of 1 if the household has received only the livestock package (Treatment 1)

$T_2 =$ is a dummy variable that takes the value of 1 if the household has received the livestock package plus the technical assistance (Treatment 2)

$\pi, \sigma, \gamma, \delta, \vartheta$ are unknown parameters;

The parameters of interest are δ_1, δ_2 that capture the effect of treatment 1 and treatment2, respectively.

Exposure to Treatment

In addition to program participation, information on the exposure to treatment is useful to analyze differential impacts overtime. It is expected that farmers who have been exposed to treatment for a longer period will have learnt to use their assets more efficiently and therefore, impacts on income and consumption might increase overtime. Also, some empirical evidence has shown that interventions might have initial negative effects, which is referred as the Ashenfelter dip, followed by positive effects in the medium term (Heckman, 1999). For this reason, it is fundamental to consider timing and exposure when measuring project impacts (King and Behrman,2009; Woolcock,2009).

To capture possible impacts overtime, we have modified the model presented in equation (1) to include the number of years exposed to treatment. As a proxy for treatment exposure we have included the number of years with technical assistance. The program was designed such that access to technical assistance started at the same moment when farmers received their transfer of livestock. Therefore, exposure to technical assistance is a good proxy for program participation.[16] The exposure to treatment model is the following:

[16] Only 16 beneficiary farmers reported having access to technical assistance from outside the APAGRO Program and were dropped from these estimations.

$$Y_i = \pi_i + \sigma_1\, t + \rho_0 D_0 + \rho_1 D_1 + \rho_2 D_2 + \rho_3 D_3 + \rho_4 D_4 + \delta_0(t * D_0) + \delta_1(t * D_1) + \delta_2(t * D_2) + \delta_3(t * D_3) + \delta_4(t * D_4) + \vartheta_{ij} X_{ij} + \mu_i \qquad (3)$$

Where:

Y_i, t, D, X_{ij}= are the same as defined in equation (1);

$D_j =$ is a dummy variable that takes the value of 1 if the household has received the program for *j* years;

$\pi, \rho, \sigma, \vartheta$ are unknown parameters;

The parameters of interest are $\delta_0, \delta_1, \delta_2\ \delta_3\ \delta_4$, that capture exposure to treatment for less than one year, one year, two years, three years and four years, respectively.

Randomized Phased-in Sample (RPI):

A final equation to capture impacts from program exposure has been estimated only for the sample of beneficiaries whose date of entry to the program was randomized (RPI group):

$$Y_i = \pi_i + \sigma_1\, t + \varphi_1 Y_1 + \varphi_2 Y_2 + \varphi_3 Y_3 + \varphi_4 Y_4 + \vartheta_{ij} X_{ij} + \mu_i \qquad (4)$$

For this sample, the timing for program participation was randomly assigned. Therefore, $\varphi_1, \varphi_2, \varphi_3,$ and φ_4 will capture the true impact of program exposure overtime.

Despite its potential to deal with many sources of endogeneity, the DD methodology has its limitations. In particular, the assumption of parallel trends is the most restrictive as it implies that without treatment, outcomes of treated and control groups must follow similar trends. In other words, this methodology "is appropriate when the interventions are as good as random, conditional on time and group fixed effects" (Bertrand, Duflo and Mullainathan, 2004). This assumption can be tested when various pre-treatment rounds of data are collected, which is not the case for this analysis. To circumvent this, several measures have been implemented: (i) the sampling methodology relied on a propensity score estimation for the identification of an appropriate counterfactual group ex ante, this assures comparability between treatment and control groups prior to data collection and program implementation; (ii) using the data for this analysis, a second propensity score was estimated to eliminate those observations that fall out the region of common support and, therefore are not comparable; (iii) different models are estimated for different samples in order to test the robustness of the results (pooled sample and randomized group); and (iv) placebo tests on baseline outcomes are performed.

VI. RESULTS

6.1. Pooled Sample - Diff in Diff Basic Model and Technical Assistance Model

The difference in differences model measures the program causal effects by comparing the average change in the outcome variables for the treatment and control groups overtime. Therefore, the model compares the outcome values in the baseline and follow-up, that represent the situation before and after program implementation.

Table 4 presents the results for the basic model (equation 1—column I) and the differentiated effect with and without technical assistance (equation 2—columns II and III). The results show that program participants increased livestock units, which is the result of the intervention per se (i.e. providing more livestock to farmers), but the effect was higher for those who received technical assistance. As expected, more livestock increases the maintenance expenditures, reaching a 140% increase with respect to the control group. The increase is higher when technical assistance is provided, probably due training activities that informed about the importance of investing on additional livestock technologies (i.e. deworming, vaccination, genetic selection, artificial insemination, among others).

Regarding food availability, the results show that agricultural productivity increased by 38% compared to the control group (measured as total agricultural production per manzana including crop and livestock production). When disaggregating the impact to differentiate beneficiaries with and without technical assistance, we find that the productivity effect is mainly driven by farmers who received training. Also, this increase in agricultural production seems to be mainly associated to the impact on livestock production, which amounts to a 187% increase in comparison to the control group.

On food access, the total agricultural income, that includes crops and livestock sales and home consumption from own production, does not present a significant impact. However, a positive significant impact of C$1,115 (US$51) is found on income from livestock sales, which represents a 133% increase compared to the control group. The estimations for the second model confirm that program effects are stronger for those farmers who received training. In fact, the impact of the program on livestock sales is 77 percentage points higher (US$29) with technical assistance than the impact with for livestock package only.

Increased livestock production is not only reflected on greater income from sales but also on the third dimension of food security, food utilization. The results indicate that program participation led to higher

household consumption from own production. Interestingly, those households who only received the livestock package present negative impacts on household consumption from own production, while those who received livestock and technical assistance present significant positive effects of 18% on home consumption and 12% on protein intake, with respect to the control group.

Finally, on the stability dimension, a proxy indicator is the production diversification, which is represented by the livestock ratio. This indicator shows that livestock production has increased as a percentage of total production, suggesting changes in the portfolio of agricultural activities within the household economy. Specifically, treated farmers have obtained 17% more of their value of production from livestock activities than control farmers and this effect is 9 percentage points higher when technical assistance is provided than when they only receive the livestock package.

Table 4. Pooled Sample – Basic Model and Technical Assistance Model

Food Security Dimension		**Basic Model** I Time*Treatment	**Technical Assistance Model** II Time*Treat1 (Only Livestock)	Time*Treat2 (Livestock + TA)
	Outcome Variables			
Food Availability	Agricultural Production (C$)	3,604***	2,266	4,301***
		(1,193)	(1,382)	(1,368)
	Livestock Production (C$)	7,351***	4,240***	9,047***
		(905.7)	(911.0)	(1,104)
Food Access	Total agricultural income (C$)	3,056	-3,197	5,695
		(3,889)	(5,925)	(4,592)
	Income from livestock sales (C$)	1,115***	707.5***	1,347***
		(248.9)	(263.8)	(294.9)
Food Use	Home consumption (crops and livestock) (C$)	56.22	-195.9**	182.4**
		(63.47)	(91.72)	(73.68)
	Protein consumption (C$)	40.58	-49.53	86.35*
		(43.49)	(61.04)	(49.22)
Stability	Livestock Ratio (livestock prod/total prod)	0.170***	0.108***	0.204***
		(0.0215)	(0.029)	(0.024)
Other variables	Total Livestock Unit	1.194***	1.125***	1.255***
		(0.151)	(0.172)	(0.162)
	Livestock Costs (C$)	1,170***	1,048***	1,265***
		(145.8)	(210.4)	(169.1)
	Controls	yes	yes	yes
	Obs in Baseline	**1049**		
	Obs in Follow-Up	**1049**		

***p<0.01, **p<0.05, *p<0.1

*Robust standard errors

*Controls included: dirt floor, assets index, female head of household, age, education level, distance to locations, participation in groups, contract farming, credit access, migration, remittances, department, type of beneficiary group (1 if pilot)

6.2. Pooled Sample - Exposure to Treatment Model

Table 5 presents the results of the model that captures exposure to treatment (equation 3) which shows, with respect to the control group, the differentiated effects for beneficiaries that: (i) did only receive livestock assets; and (ii) received one to four years of technical assistance[17]. Overall, the coefficients show a positive trend which indicates that program impacts increase with treatment exposure and length. First, the results suggest that total livestock units did not increase only because of the intervention but there is evidence of accumulation overtime. On the contrary, the costs of livestock maintenance did not increase overtime and there is evidence of a small decline after the third year of exposure to treatment, probably due to higher production efficiency. With regard to food access, the annual increase in agricultural production seems to be driven by higher livestock production, which reaches a peak on the third year of treatment (an increase of 261%).

The exposure to treatment model confirms that higher livestock production results on increased sales and home consumption from own production (i.e. food availability and utilization). The positive trend is particularly strong in the case of income from livestock sales which is positive and significant for almost every year of treatment, reaching a peak in the third year and flattening out in year 4. The lack of effect on the last year does not necessarily indicate that it is not sustainable in the long-term, and further analysis would be needed. In the case of protein consumption, the results do not present evidence of improvement. On the other hand, the effects are persistent on the stability dimension, as the proportion of production obtained from livestock activities (livestock to total production ratio) increases overtime reaching its peak (30%) for the group that received four years of technical assistance. In general, these findings suggest that treatment effects are stronger overtime[18].

[17] The number of beneficiaries corresponding to each number of years of technical assistance (TA) is as follows: no TA (154), 1 year of TA (40), 2 years of TA (165), 3 years of TA (135), 4 years of TA (44).

[18] Surprisingly the coefficient for the time trend suggests that, for this sample of farmers, real income has declined sharply from 2011 to 2014. Therefore, the positive impacts of the program might have served as an insurance mechanism to face this negative shock. Also, it is worth noticing that the treatment dummies (without time interactions) are not statistically significant for total agricultural income, which confirms initial comparability between treated and control groups. In the case of income from livestock sales, this coefficient is significant at 10% level.

Table 5. Pooled Sample – Exposure to Treatment

Food Security Dimension		Exposure to Treatment Model				
	Treatment Dummies	Time* No TA	Time* 1yearTA	Time* 2yearsTA	Time* 3yearsTA	Time* 4yearsTA
	Outcome Variables					
Food Availability	Agricultural Production (C$)	2,288*	4,209**	2,270	6,834***	4,696
		(1,385)	(1,727)	(1,674)	(1,783)	(5,112)
	Livestock Production (C$)	4,267***	6,728***	9,193***	10,265***	7,270***
		(912.6)	(1,907)	(1,534)	(1,628)	(2,691)
Food Access	Total agricultural income (C$)	-3,142	9,470	-3,917	14,247***	13,358
		(5,936)	(6,498)	(6,546)	(5,305)	(17,757)
	Income from livestock sales (C$)	703.3***	2,080**	1,186***	1,432***	970.8
		(264.2)	(820.4)	(333.9)	(491.0)	(774.9)
Food Use	Home consumption (C$)	-194.6**	239.8*	117.3	356.8***	-146.2
		(91.78)	(141.2)	(105.7)	(108.8)	(204.7)
	Protein consumption (C$)	-47.15	120.2	125.8*	37.58	90.24
		(61.12)	(108.3)	(64.35)	(76.27)	(97.27)
Stability	Livestock Ratio (livestock prod/total prod)	0.109***	0.126**	0.216***	0.188***	0.298***
		(0.0287)	(0.0562)	(0.0312)	(0.0350)	(0.0548)
Other variables	Total Livestock Unit	1.125***	1.119***	1.364***	1.100***	1.446***
		(0.172)	(0.303)	(0.176)	(0.186)	(0.515)
	Livestock Costs (C$)	1,055***	855.2***	1,770***	901.0***	948.4***
		(210.5)	(291.9)	(215.5)	(279.8)	(316.1)
	Controls	yes	yes	yes	yes	yes
	Obs in Baseline	**1049**				
	Obs in Follow-Up	**1049**				

***p<0.01, **p<0.05, *p<0.1

*Robust standard errors

*Controls included: dirt floor, assets index, female head of household, age, education level, distance to locations, participation in groups, contract farming, credit access, migration, remittances, department, type of beneficiary group (1 if pilot)

6.3. Randomized Phased-in

This section analyzes the estimation of equation 4, using the randomized phased-in sample of beneficiaries for the outcomes of interest. In this case, we are analyzing the effects of the length of exposure to technical assistance. Hence, the sample is restricted to the beneficiary farmers of the RPI sample, and the comparison group is the beneficiaries who only received livestock and have not yet received technical assistance. The results confirm that compared to those who did not receive technical assistance, beneficiaries with two or three years of training, increased total livestock units and livestock maintenance costs (53% higher). While total agricultural production does not change over time, livestock production presents annual increases with a peak on the third year of treatment (183%).

This model confirms that the length of exposure to technical assistance increases household income through higher livestock sales, which shows an annual increase that reaches up to 254% on the third year of exposure to technical assistance. Also, positive and significant impacts are found for home consumption from own production, and protein consumption for the first three years of exposure to technical assistance. Once more, the effects are stronger in the third year of program participation seem to disappear after the fourth year of training. Specifically, farmers with exposure to three years of training increased home consumption by 58% and protein consumption by 53%, compared to farmers who did not receive training. Again, the results are significant on the three dimensions of food security (i.e. access, availability and use). And there is also evidence in the stability dimension of a sustained increase in the proportion of agricultural production that comes from livestock (16%).

Table 6. Randomized Phased-in Sample (only treated)

Food Security Dimension	Treatment Dummies	**Randomized Phased-in Model** 1 year of exposure	2 years of exposure	3 years of exposure	4 years of exposure
	Outcome Variables				
Food Availability	Agricultural Production (C$)	-650.4	1,174	935.4	693.1
		(1,212)	(1,267)	(1,865)	(1,559)
	Livestock Production (C$)	3,814**	7,580***	7,667**	7,130*
		(1,915)	(1,870)	(3,522)	(4,074)
Food Access	Total agricultural income (C$)	-1,584	-1,835	2,092	-93.65
		(5,261)	(4,614)	(7,499)	(7,629)
	Income from livestock sales (C$)	1,626*	986.4***	1,683*	1,472*
		(894.3)	(349.7)	(932.9)	(777.9)
Food Use	Home consumption (C$)	243.9*	355.0***	544.3***	282.2
		(127.7)	(116.6)	(181.3)	(227.2)
	Protein consumption (C$)	184.2**	215.1***	231.1**	55.21
		(92.45)	(70.43)	(113.0)	(96.59)
Stability	Livestock Ratio (livestock prod/total prod)	0.0718	0.157***	0.119**	0.161**
		(0.0514)	(0.0384)	(0.0565)	(0.0737)
Other variables	Total Livestock Unit	0.0879	0.366*	0.422*	1.805
		(0.251)	(0.200)	(0.241)	(1.239)
	Livestock Costs	-469.7	823.2**	869.9*	494.0
		(376.1)	(335.3)	(468.8)	(446.3)
	Controls	yes	yes	yes	yes
	Obs in Baseline	**281**			
	Obs in Follow-Up	**281**			

***p<0.01, **p<0.05, *p<0.1

*Robust standard errors

*Controls included: dirt floor, assets index, female head of household, age, education level, distance to locations, participation in groups, contract farming, credit access, migration, remittances, department, type of beneficiary group (1 if pilot)

VII. GENDER ANALYSIS

7.1. Women's Empowerment in Agriculture Index

In this section we will study the impact of program's participation on women's empowerment. For this purpose, the analysis will rely on a proxy indicator that follows the construction of the Women's Empowerment in Agriculture Index (WEAI), which is a survey-based index designed to measure empowerment, agency and inclusion of women in the agricultural sector (Sabina et al., 2012).

Five Domains of Empowerment

The WEAI considers five dimensions of empowerment, namely: (i) production, refers to women's participation in decisions on agricultural production; (ii) resources, concerns ownership of assets, access to and decisions over credit, (iii) income, refers to control over income and expenditures decisions, (iv) leadership, refers to membership to an economic and/or social organization; and (v) time, refers to the allocation of time to productive and domestic activities. Each of these domains of empowerment is measured by specific indicators, the WEAI is constructed using a total of ten indicators, while the Abbreviated Women's Empowerment in Agriculture Index (A-WEAI) only considers six indicators. In this paper we will use a proxy for the A-WEAI index that includes only four domains of empowerment and four indicators.

Although the survey implemented to measure APAGRO's impact was not specifically designed to construct the WEAI index, we have selected related questions to develop a gender empowerment indicator, following the guidelines of the WEAI. Specifically, to measure participation in production decisions, there were specific questions regarding the decision-making process on crop planting and selling. Second, to measure control over income, the survey included questions on the decision process for income allocation and utilization within the household (i.e. independently, jointly, exclusively the man, exclusively the woman). Finally, to measure empowerment on resources and leadership, information about access to credit and participation in social or economic organizations was requested to each household member. All these indicators were available for both, women and men in the household.

With the available data, a proxy indicator for the A-WEAI was constructed, based on four dimensions of empowerment. The available dimensions are production, resources, income and leadership. The survey did

not capture detailed information on time distribution[19] and therefore, the time dimension will not be part of the analysis. Table 7 presents the indicators for the four available dimensions, which are assigned the same weight (1/4) for the construction of the proxy index.

Table 7: Domains, indicators and weights for the proxy A-WEAI

Domain	Indicator	Weight
Production	Input in productive decisions	1/4
Resources	Access to credit	1/4
Income	Control over income utilization	1/4
Leadership	Group membership and participation	1/4

The domains of empowerment are used for the construction of two sub-indexes: the four domains of empowerment (4DE index), which measures each dimension of empowerment; and the Gender Parity Index (GPI), that measures gender parity in empowerment within the household. The total women's empowerment score is the weighted sum of the two sub-indexes (4DE and GPI), with weights of 90 percent for the 4DE and 10 percent for the GPI.

The 4DE Index

This sub-index evaluates women's empowerment across the four domains of empowerment. The multi-dimensionality allows us to identify the dimensions in which women are more disempowered. For the construction, each indicator takes the value of 0 or 1 if the woman is empowered or disempowered, respectively. Then, an inadequacy score (A) is calculated using the weighted sum of the all the indicators from the four domains. This inadequacy score results on a score between 0 and 1. Notice that when the number of inadequacies increases (number of domains where women are disempowered), the score increases. Also, the score equals 1 when the person experiences inadequacy on all indicators and 0 when the person is empowered in all dimensions.

In the traditional WEAI approach, a disempowerment cut-off is used to determine the disempowerment headcount (H). In other words, women with scores higher than the cut-off are considered to

[19] The construction of the traditional A-WEAI includes a time distribution dimension, where the indicator is whether the individual is above a "time poverty line". An individual is "time poor" if he works more than 10.5 hours per day. The information captured by the APAGRO survey does not provide the detailed distribution of time per hour, therefore this indicator cannot be constructed.

be disempowered. In this study, we consider a woman to be disempowered (H) when she faces inadequacies in more than one domain (i.e. a woman faces disempowerment in more than one domain). The inadequacy score (A) is calculated for all women in the sample.

Finally, the disempowerment index (M0) is obtained as the product of the disempowerment headcount (H) and the inadequacy score (A). And the 4DE is computed as the complement of the disempowerment index (1-M0).

The GPI Index

The Gender Parity Index (GPI) measures the relative empowerment inequality -in the four domains- between the primary adult male and female in the household. Thus, the GPI only takes into consideration the dual-adult households in the sample (77%). The first component of this sub-index is the proportion of gender parity-inadequate households (H_{GPI}), which is the percentage of households where the female is disempowered (i.e. her inadequacy score is greater than of the male head of household). The second component is the average empowerment gap (I_{GPI}), which is the percentage difference between the inadequacy score of the primary woman and man in the household. Again, the empowerment gap is calculated for the dual households in the sample.

Empowerment measures as outcome variables

The 4DE, GPI and the proxy A-WEAI indexes give an aggregated value for all the households in the sample. This allows us to assess the general empowerment situation for a specific sample (i.e. average empowerment). However, for the construction of these indexes, the indicators are calculated at the individual level and these can be used as outcome variables in the econometric analysis. From the construction of the 4DE and GPI sub-indexes, the following empowerment measures are obtained at the individual level: (i) female disempowerment, a dummy variable that takes the value of 1 if the woman is disempowered in more than one domain, and 0 otherwise; (ii) female disempowerment score, a continuous variable ranging from 0 to 1, where 1 implies complete disempowerment; (iii) gender disparity, a dummy variable that takes the value of 1 if the woman is disempowered or less empowered than her male counterpart in the household, and 0 otherwise; and (iv) gender empowerment gap, a continuous variable ranging from 0 to 1, where 1 represents the most extreme situation of gender disparity in the household.

Proxy A-WEAI Descriptive Analysis

Table 8 presents the calculation of the empowerment index or the proxy A-WEAI. First, the four empowerment indicators were calculated for women and men. Then, we constructed the proxy A-WEAI, which is the weighted average of the GPI and the 4DE sub-indexes. Overall, the 4DE is higher for men than for women in the baseline (0.729 vs. 0.389) as well as in the follow-up (0.703 vs. 0.516), meaning that men are more empowered than women. However, women's empowerment increased over time, as their 4DE increased from 0.389 to 0.516. Indeed, the disempowered headcount shows that approximately 93% of the women in the baseline were disempowered compared to 83% in the follow-up.

Regarding the GPI, the percentage of women with no gender parity within the household (H_{GPI}) is 75% at the baseline, while in the follow-up the GPI is reduced to 54%. This is similar for the empowerment gap between men and women in the household (I_{GPI}) which is lower at the follow-up (31%) than at the baseline (43%). This implies that the gender empowerment gap was reduced significantly between the years of 2011 and 2014. The GPI, obtained by combining the H_{GPI} and the I_{GPI}, also confirms a more equitable situation between mean and women at the follow-up (0.691) than at the baseline (0.575). Finally, the proxy A-WEAI, obtained by combining the 4DE and the GPI, suggests that women's empowerment has improved. Indeed, the proxy A-WEAI is higher at the follow-up (0.533) than at the baseline (0.408). Overall, this suggests that during these four years, women's empowerment improved within the households and in their communities.

Table 8: Women's Empowerment Index or Proxy A-WEAI

	Baseline		**Follow - up**	
Indexes	**Women**	**Men**	**Women**	**Men**
Disempowered Headcount (H)	**92.8%**	**65.8%**	**83.3%**	**69.6%**
Average Inadequacy Score (A)	65.8%	41.2%	58.1%	42.6%
Disempowerment Index (M0)	0.611	0.271	0.484	0.297
4DE Index (1-M0)	**0.389**	**0.729**	**0.516**	**0.703**
No. of observations	816	816	803	803
% of Data used	77.8%	77.8%	76.5%	76.5%
% of women with no gender parity (H_{GPI})	**75.1%**		**54.5%**	
Average Empowerment Gap (I_{GPI})	**42.5%**		**30.9%**	
GPI	**0.575**		**0.691**	
No. of women in dual households	816		803	
% of Data Used	77.8%		76.5%	
Empowerment Index (Proxy A-WEAI)	**0.408**		**0.533**	

7.2. Difference in difference Models: Impact on female empowerment and gender gap

In this section, we analyze the outcome variables at individual-level to assess the causal impact of APAGRO on women's empowerment[20]. For results interpretation, it is important to consider that a reduction in the indicators imply an improvement on women's empowerment.

Table 9 presents the results for these four gender variables using the basic model of difference in differences (equation 1), and the model that differentiates treatment with and without technical assistance (equation 2)[21]. The basic model shows that, beneficiary women reduced their probability of being disempowered by 5% and the disempowerment score by 7%, compared to the control group. Moreover, when disaggregating the effects for beneficiaries with and without technical assistance, the effects on women's empowerment are only significant for the latter group. When analyzing gender disparities within the household, the results confirm that program participation reduced the probability of gender disparity by 18% and the empowerment gap by 10%. These findings are supported by the second model, showing stronger impacts for women who received livestock and technical assistance.

Table 9. Pooled Sample – Basic Model and Technical Assistance Model

	Basic Model	**Technical Assistance Model**	
	I	II	
	Time*Treatment	Time*Treat1 (Only Livestock)	Time*Treat2 (Livestock + TA)
Outcome Variables			
Female Disempowerment Account	-0.049*	0.008	-0.078**
	(0.029)	(0.037)	(0.034)
Female Disempowerment Score	-0.047***	-0.028	-0.058***
	(0.018)	(0.026)	(0.020)
Gender Disparity	-0.181***	-0.134**	-0.204***
	(0.045)	(0.063)	(0.050)
Empowerment Gap	-0.102***	-0.091**	-0.111***
	(0.029)	(0.044)	(0.031)
Controls	yes	yes	yes
Obs in Baseline	**816**		
Obs in Follow-Up	**803**		

***p<0.01, **p<0.05, *p<0.1

*Robust standard errors

*Controls included: dirt floor, assets index, female head of household, age, education level, distance to locations, participation in groups, contract farming, credit access, migration, remittances, department, type of beneficiary group (1 if pilot)

[20] The information for the construction of these empowerment measures was captured in the follow-up survey, but included information for both periods of time, the baseline year (2011) and the endline year (2014).

[21] Appendix 5 presents the complete results for the empowerment outcomes using the different models.

Furthermore, the results of the exposure to treatment model, presented in Table 10, indicate that the improvements on women's empowerment are persistent over time. Specifically, the probability of being disempowered presents a 15% reduction after the first year of treatment, and a 10% reduction after two years of exposure to treatment. On the other hand, the reductions on the disempowerment score are significant for all the levels of exposure, except for those who did not receive technical assistance. Likewise, the effects on the gender disparity indicators are significant for all years of exposure, with the greatest reduction on the first year of treatment. These results confirm that technical assistance plays a major role on women's empowerment.

Table 10. Pooled Sample – Exposure to Treatment Model

	Exposure to Treatment Model				
Treatment Dummies	Time*NoTA	Time*1yearTA	Time*2yearsTA	Time*3yearsTA	Time*4yearsTA
Outcome Variables					
Female Disempowerment Account	0.008	-0.150**	-0.094**	-0.043	-0.045
	(0.037)	(0.075)	(0.044)	(0.047)	(0.083)
Female Disempowerment Score	-0.028	-0.115***	-0.052**	-0.050*	-0.061*
	(0.026)	(0.035)	(0.025)	(0.026)	(0.034)
Gender Disparity	-0.134**	-0.353***	-0.138**	-0.227***	-0.269***
	(0.063)	(0.105)	(0.064)	(0.069)	(0.104)
Empowerment Gap	-0.091**	-0.185***	-0.074*	-0.122***	-0.160***
	(0.044)	(0.058)	(0.039)	(0.044)	(0.054)
Controls	yes	yes	yes	yes	yes
Obs in Baseline	**816**				
Obs in Follow-Up	**803**				

***p<0.01, **p<0.05, *p<0.1
*Robust standard errors
*Controls included: dirt floor, assets index, female head of household, age, education level, distance to locations, participation in groups, contract farming, credit access, migration, remittances, department, type of beneficiary group (1 if pilot)

VIII. ROBUSTNESS TESTS

To test the robustness of the estimations we regressed the outcome variables at the baseline (Table 11) The results show no effects on agricultural outcomes with the exception of a negative significant sign in income from livestock sales which implies that treated farmers started the program in a more disadvantageous situation than the control group. Therefore, if the bias was not corrected with the implementation of the difference in differences estimation, an underestimation of the impact might be possible. Regarding the empowerment indicators, there robustness checks show no significant impacts, except for the disempowerment score and the empowerment gap in the case of women from households that received only livestock in the model that captures exposure to technical assistance. However, these results are only significant at the 10% level. Overall, these placebo analyses suggest that the results capture the true impacts from program participation.

Table 11. Placebo – Basic Model and Technical Assistance Model

	Basic Model I	**Technical Assistance Model** II	
	Time*Treatment	Time*Treat1 (Only Livestock)	Time*Treat2 (Livestock + TA)
Outcome Variables			
Total Agricultural Income (C$)	362.2	4,819	-1,375
	(2,828)	(4,582)	(3,221)
Income from Livestock Sales (C$)	-394.9**	-565.4***	-328.4
	(194.7)	(191.7)	(210.7)
Home Consumption (C$)	35.39	44.38	31.88
	(53.86)	(82.08)	(61.06)
Protein Consumption (C$)	51.76	65.97	46.23
	(37.94)	(53.21)	(41.77)
Female Disempowerment Account	0.015	0.016	0.014
	(0.017)	(0.024)	(0.019)
Female Disempowerment Score	0.005	0.032*	-0.005
	(0.010)	(0.017)	(0.011)
Gender Disparity	0.023	0.041	0.016
	(0.027)	(0.039)	(0.030)
Empowerment Gap	0.003	0.051*	-0.014
	(0.018)	(0.030)	(0.019)
Controls	yes	yes	yes

***p<0.01, **p<0.05, *p<0.1

*Robust standard errors

*Controls included: dirt floor, assets index, female head of household, age, education level, distance to locations, participation in groups, contract farming, credit access, migration, remittances, department, type of beneficiary group (1 if pilot)

IX. CONCLUSION

This paper analyzes the impact of a livestock transfer program implemented in Nicaragua with the objective of improving food security and empower female farmers. The program effectiveness is assessed in the four dimensions of food security: access, availability, food use and stability. To assess program's impact, a combination of Propensity Score Matching and Difference in Differences was implemented. These results were also tested for a sample of treated farmers, taking advantage of the program randomized phased-in.

The results present evidence that program participation boosted income from livestock sales and food consumption from own production. These findings imply that program participation increased food security primarily by increasing food access and availability (income and home consumption). Besides, some evidence is found on the positive impacts of the program on the third dimension of food security (i.e. food use). Specifically, treated farmers that received technical assistance, and especially those from the randomized phased-in sample, have increased their protein intake as a result of the program. However, these latter findings are not robust across estimations and further analysis is needed to assess the sustainability issue.

In addition, the program increased on-farm income diversification by increasing the share of agricultural production obtained from livestock. This finding suggests that households might be less vulnerable to income and consumption shocks as livestock production is less risky and more stable than crop production due to less dependability on weather patterns. Hence, on-farm diversification might serve as a form of insurance and as a mechanism to smooth income and consumption which might explain the positive impacts of the program on income from livestock sales and home consumption from own production despite the overall decline in these variables over the period of analysis.

However, the results demonstrate that livestock investments must be coupled with thorough technical assistance. Livestock management is a complex process that requires training and practice to assure long-term sustainability. In fact, this study confirms that effects from livestock transfers occur rapidly but are strengthened overtime when accompanied by technical support. Moreover, livestock maintenance is costly, therefore farmers will be able to obtain greater benefits when production techniques aim towards greater efficiency.

This program targeted female producers with the purpose of increasing women's empowerment. The gender analysis demonstrates that women in the treatment group are more empowered than those in the control group. Specifically, the intervention reduces the probability of being disempowered and the disempowerment score of women as well as the probability of gender inequality within the household. In addition, this improvement in strengthened when technical assistance is provided. This suggests that acquisition of human and social capital, provided through training and associativity, can be important mechanisms to empower women in rural areas.

Overall, the analysis presented confirms that agricultural policies that focus on livestock production coupled with technical assistance can play an important role on the food security agenda by improving food availability, access, use and stability. In addition, as livestock is a store of value and a source of wealth, targeting women and vulnerable groups through these interventions can generate greater empowerment and reduce inequality gaps. However, further analysis is needed to assess whether program impacts are sustainable overtime.

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Appendix 1. Propensity Score Matching

This section shows the participation model implemented to estimate the propensity score of the household, which represents the probability of being part of the APAGRO program. The dependent variable is $Y = 1$ for treated households and $Y = 0$ for controls. The independent variables included in the vector X are those that could determine the participation in the program.

The proposed participation model to predict the probability of the producer to participate in the program is reflected in the following equation:

$$\Pr(APAGRO = 1|X) = \alpha + \beta \sum C_i + \delta \sum H_i + \theta \sum A_i + \varphi \sum L_i + \rho \sum W_i + \gamma \sum D_i + \varepsilon_i$$

Where:

- $\Pr(APAGRO = 1|X)$ is the probability that the producer *i* participates in the APAGRO Program
- C_i is a vector of socio-demographic characteristics of the household, including number of household members, dirt floor, assets index, distance to facilities
- H_i is a vector of head of household characteristics, including gender, marital status, literacy and education level
- A_i is a vector that captures the associativity of the producer, including the participation in other projects, local groups, technical assistance, contract farming and access to credit
- L_i is a vector that captures agricultural characteristics, including total area owned by the household, cultivated area, irrigation and TLU
- W_i is a vector of wealth characteristics that includes agricultural and household income, value of production, sales ratio and total income, remittances and consumption
- D_i is a vector of dummy variables for each department (fixed effects). There are 4 departments in the sample
- ε_i is the error term.

The results of the estimation for the participation model, using a PROBIT, are presented in Table 1A. It is shown that the main determinants for program participation were the gender of the head of

household and the index for total livestock units owned (TLU). Indeed, those households where the head was a woman were 11% more likely to participate in the program, and those with a higher TLU had a lower probability of participating in the program. Also, those households that have migrated were 15% less likely to being part of APAGRO.

Table 1A: APAGRO Participation Model

	Variable (unit)	Marginal Effects
Household	Household Size (# members)	-0.003
	Dirt floor (0,1)	0.041
	Assets index	-0.021
Head of Household	Woman (0,1)	0.113***
	Literacy (0,1)	-0.029
	Education (years)	0.004
Distance to facilities	Distance to road (km)	0.005
	Distance to market (km)	-0.002
	Distance to head city (km)	0.002*
	Distance to health center (km)	0.004
	Distance to primary school (km)	0.001
Associativity	Participation in other project (0,1)	0
	Participation in local group (0,1)	0.055
	Technical assistance (0,1)	0.031
	Contract farming (1,0)	0.034
	Access to credit service (1,0)	0.029
Agricultural Practice	Land owned by HH (mz)	0.005
	Cultivated land area (mz)	0.001
	Irrigation (1,0)	0.025
	Total Livestock Unit	-0.034**
Income	Income from sales of crop production (cord)	0
	Value of livestock production (cord)	0
	Value of agriculture and livestock production (cord)	0
	Sales ratio	0.034
	Total income	0
Others	Migration (0,1)	-0.152**
	Quantity of remittance (cord)	0
	Food consumption	0
Fixed Effects	Fixed Effects at the department level	yes
	N	**1089**

***p<0.01, **p<0.05, *p<0.1

Table 1A also shows that income and consumption variables have no effect on the participation probability of the households, not the agricultural or total income, neither the value of production or food consumption. This result is evidence that supports that there are not income preferences for the program implementation, strengthening the assumption that program beneficiaries are similar to non-beneficiaries.

After the PSM we find the common support area in order to keep only those farmers that have more comparable characteristics. Figure 1A shows that there is an important overlap of the Propensity Scores between the treatment and control groups. Observations outside the common support are removed; in our case, all the removed group corresponds to farmers in the control group whose propensity scores are very low.

Figure 1A: Distribution of the Propensity Score between Treated and Controls

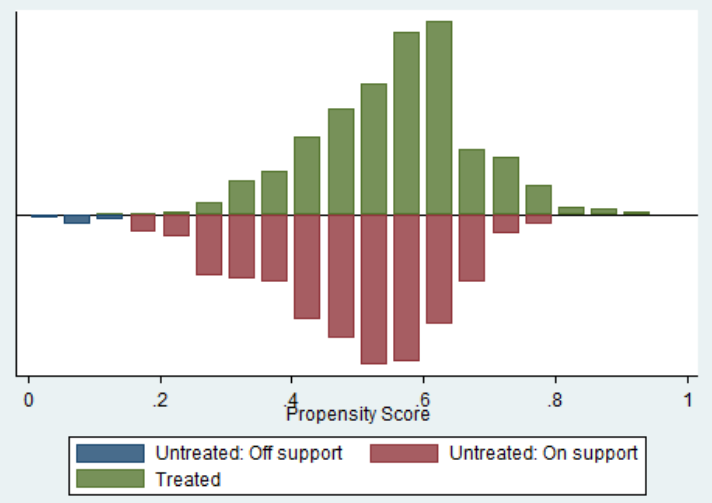
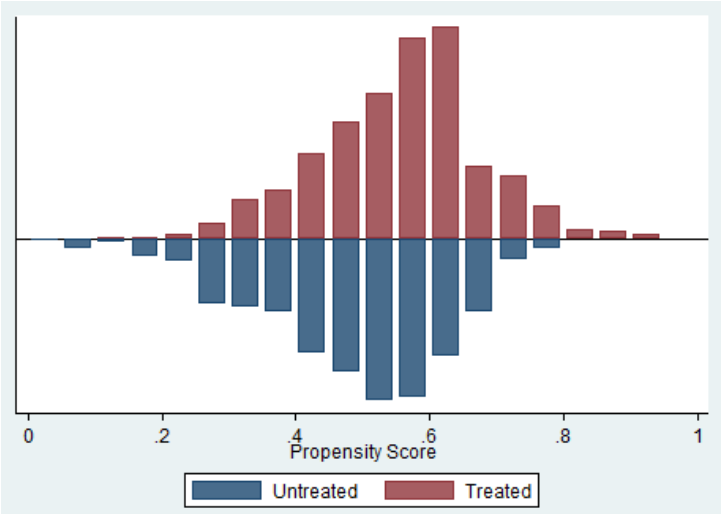


Figure 1B presents the distribution of the propensity scores of producers, both beneficiaries and non-beneficiaries, in the common support area. For the control group, 8 farmers are eliminated (1.5% of the control sample) and no treated farmer is removed. Summing both treated and control farmers located in the common support area gives a total sample size of 1081 producers (99% of the total sample).

Figure 1B: Distribution of the Propensity Score between Treated and Controls in the Common Support Area



Appendix 2. Different Models for the Production Outcomes

Table 2A. Model I, Basic Difference in Difference

Variables	Total Livestock Unit	Livestock Costs	Agricultural Production (C$)	Livestock Production (C$)	Livestock Ratio	Total agricultural income (C$)	Income from livestock sales (C$)	Home consumption (C$)	Protein consumption (C$)
Period	0.0540	-100.9	-3,281***	-839.0	-0.0447***	-7,895***	-209.8	-350.5***	-293.8***
	(0.132)	(84.45)	(988.9)	(609.3)	(0.0159)	(2,771)	(192.5)	(44.24)	(31.57)
Treatment	-0.211**	62.44	-838.3	-1,406***	-0.0174	1,454	-352.9*	76.71	57.67
	(0.0820)	(89.24)	(949.1)	(528.9)	(0.0144)	(2,854)	(183.1)	(54.20)	(36.25)
Period*Treatment	**1.194*** **	**1,170*** **	**3,604*** **	**7,351*** **	**0.170*** **	**3,056**	**1,115*** **	**56.22**	**40.58**
	(0.151)	**(145.8)**	**(1,193)**	**(905.7)**	**(0.0215)**	**(3,889)**	**(248.9)**	**(63.47)**	**(43.49)**
Dirt floor (0,1)	-0.0276	153.0*	439.6	-466.0	0.00442	1,225	133.7	47.91	-64.66**
	(0.0861)	(90.13)	(836.3)	(533.3)	(0.0139)	(2,695)	(161.0)	(38.21)	(27.05)
Assets index	0.0310	137.7**	1,857***	225.7	0.00572	7,859***	38.72	-56.40**	156.5***
	(0.0551)	(62.93)	(627.5)	(322.0)	(0.00857)	(2,360)	(82.55)	(26.54)	(18.54)
Female head of hh (0,1)	0.178***	-148.9*	567.5	-74.02	-0.0199	602.5	-127.6	52.06	-44.41*
	(0.0635)	(88.11)	(725.5)	(540.7)	(0.0140)	(1,908)	(139.8)	(37.82)	(25.25)
Age (years)	0.00775	-11.89	12.81	-41.92	-0.00114	165.1	-36.87	16.98**	7.567*
	(0.0123)	(16.33)	(104.9)	(75.09)	(0.00244)	(355.1)	(28.06)	(6.814)	(4.258)
Age squared	-8.95e-05	0.117	-0.239	0.160	1.19e-05	-1.621	0.307	-0.153**	-0.0891**
	(0.000134)	(0.168)	(1.032)	(0.810)	(2.55e-05)	(3.587)	(0.294)	(0.0686)	(0.0416)
Primary education, incomplete	0.0801	-109.4	-317.1	132.5	-0.0116	395.3	112.5	-20.18	10.93
	(0.0968)	(76.20)	(712.4)	(502.0)	(0.0121)	(2,109)	(151.0)	(43.55)	(26.27)
Primary education, complete	0.0131	85.62	-1,194	986.4	0.00823	-413.6	165.9	-101.5*	56.95
	(0.0915)	(111.8)	(912.3)	(756.9)	(0.0172)	(3,560)	(236.2)	(53.39)	(34.71)
Secondary education, incomplete	0.0385	-27.26	-2,095**	451.5	0.0497*	-6,548*	114.8	-151.7**	-37.16
	(0.122)	(129.5)	(922.5)	(811.9)	(0.0260)	(3,502)	(260.9)	(66.76)	(45.50)

Secondary education, complete	0.230	655.4*	-2,003	1,818	0.0486	-9,450***	695.8	-282.7***	-9.263
	(0.232)	(372.3)	(1,693)	(1,554)	(0.0417)	(3,328)	(596.0)	(74.15)	(62.70)
Terciary education	0.357	82.15	-2,777	2,996	0.107	-9,326**	940.9	-29.16	104.4
	(0.224)	(453.6)	(3,576)	(2,736)	(0.0738)	(4,130)	(826.1)	(121.7)	(77.80)
Distance to road (km,ln)	0.0578	-93.92**	-91.11	-296.1	-0.00948	686.6	-167.4**	23.90	20.14
	(0.0381)	(45.30)	(386.8)	(235.0)	(0.00630)	(1,547)	(67.65)	(20.21)	(13.52)
Distance to market (km,ln)	-0.0351	24.03	-12.40	-428.3	-0.0125	2,322	-180.8*	-8.630	-28.83*
	(0.0463)	(53.02)	(481.8)	(300.9)	(0.00864)	(1,768)	(109.7)	(23.25)	(17.13)
Distance to head city (km,ln)	0.00309	-31.99	-107.6	-16.49	0.00615	-2,490	63.08	-22.77	-14.21
	(0.0376)	(48.84)	(447.0)	(265.2)	(0.00785)	(2,183)	(94.05)	(20.52)	(16.45)
Owned land area (mz, ln)	0.471***	63.25	970.2***	1,912***	0.0310***	6,106***	520.5***	108.9***	32.56*
	(0.102)	(51.56)	(293.2)	(345.7)	(0.00820)	(1,433)	(128.4)	(28.05)	(17.76)
Cultivated land area (mz, ln)	0.125*	154.5**	-1,869***	263.8	-0.127***	18,736***	-81.38	421.4***	73.10***
	(0.0646)	(67.18)	(557.2)	(379.1)	(0.0122)	(1,796)	(114.0)	(28.75)	(19.75)
Participation in other project (0,1)	0.183**	215.3**	1,876**	2,235***	0.0369***	1,083	418.3**	147.1***	37.39
	(0.0894)	(99.17)	(739.1)	(648.8)	(0.0137)	(2,414)	(185.7)	(49.81)	(33.26)
Participation in local group (0,1)	0.0538	188.0**	1,037	1,879***	0.0630***	2,438	598.7***	7.493	19.89
	(0.0709)	(93.00)	(704.1)	(573.9)	(0.0134)	(2,619)	(173.5)	(40.61)	(26.13)
Contract farming (0,1)	-0.164	138.3	5,606***	-750.9	-0.0587***	26,521***	-375.5**	64.10	-21.55
	(0.122)	(141.5)	(1,281)	(883.7)	(0.0131)	(6,351)	(181.0)	(90.78)	(43.28)
Access to credit service (0,1)	-0.0460	59.80	1,787**	27.40	-0.0174	9,212***	163.8	73.51	43.64
	(0.0767)	(89.44)	(781.7)	(540.0)	(0.0121)	(2,737)	(169.2)	(45.28)	(28.95)
Migration (0,1)	0.292*	-7.265	741.6	806.6	0.0828**	7,745	-290.1	180.7	169.4*
	(0.168)	(253.9)	(2,837)	(1,486)	(0.0372)	(14,069)	(242.4)	(184.1)	(89.32)
Quantity of remittance (cord)	-5.25e-06	0.0534	-0.208*	-0.0185	-3.89e-07	-0.681	1.05e-05	0.000459	-0.000679
	(9.91e-06)	(0.0457)	(0.124)	(0.0645)	(2.88e-06)	(0.611)	(0.0146)	(0.00899)	(0.00753)
Esteli	0.143	761.9***	154.9	2,235***	0.0916***	-2,640	222.2	-31.71	49.21
	(0.0879)	(139.4)	(1,354)	(582.0)	(0.0189)	(2,884)	(175.3)	(52.84)	(42.61)
Jinotega	0.103	7.608	3,026**	4,062***	0.106***	17,839***	235.4	277.6***	8.650
	(0.0879)	(123.7)	(1,340)	(724.0)	(0.0194)	(2,865)	(181.7)	(67.98)	(40.32)
Matagalpa	0.0874	-40.14	5.200	4,549***	0.133***	2,630	408.6**	219.2***	4.611
	(0.119)	(121.4)	(1,256)	(741.0)	(0.0188)	(2,734)	(185.6)	(61.27)	(41.34)
Pilot (0,1)	-0.101	91.15	1,520***	-1,076*	-0.0179	-594.6	86.91	-227.7***	44.67
	(0.102)	(83.26)	(583.2)	(617.6)	(0.0144)	(2,081)	(160.9)	(50.68)	(27.55)
Constant	-0.499	401.5	5,934	221.0	0.245***	-24,970**	1,007	-109.1	366.6***
	(0.417)	(398.0)	(4,053)	(1,846)	(0.0639)	(10,880)	(707.5)	(184.5)	(115.8)
Observations	2,098	2,098	2,098	2,098	2,098	2,098	2,098	2,098	2,098
R-squared	0.162	0.163	0.064	0.156	0.206	0.216	0.068	0.273	0.171

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 2B. Model II, Difference in Difference with Technical Assistance

Variables	Total Livestock Unit	Livestock Costs	Agricultural Production (C$)	Livestock Production (C$)	Livestock Ratio	Total agricultural income (C$)	Income from livestock sales (C$)	Home consumption (C$)	Protein consumption (C$)
Period	0.0519	-103.8	-3,290***	-865.2	-0.0453***	-7,897***	-213.9	-351.9***	-294.4***
	(0.132)	(84.35)	(989.5)	(608.3)	(0.0159)	(2,773)	(192.3)	(44.28)	(31.60)
Treatment1	-0.440***	-230.7**	-913.3	-2,242***	-0.0369*	6,757	-554.3***	110.4	63.70
	(0.108)	(106.9)	(1,228)	(519.9)	(0.0191)	(4,605)	(183.8)	(78.85)	(51.41)
Treatment2	-0.122	175.8*	-815.9	-1,097*	-0.0102	-640.3	-276.6	62.34	54.88
	(0.0862)	(103.3)	(983.7)	(596.5)	(0.0158)	(3,186)	(198.9)	(61.90)	(40.02)
Period*Treatment1	**1.125*** **	**1,048*** **	**2,266**	**4,240*** **	**0.108*** **	**-3,197**	**707.5*** **	**-195.9** **	**-49.53**
	(0.172)	**(210.4)**	**(1,382)**	**(911.0)**	**(0.0287)**	**(5,925)**	**(263.8)**	**(91.72)**	**(61.04)**
Period*Treatment2	**1.255*** **	**1,265*** **	**4,301*** **	**9,047*** **	**0.204*** **	**5,695**	**1,347*** **	**182.4** **	**86.35***

	(0.162)	**(169.1)**	**(1,368)**	**(1,104)**	**(0.0242)**	**(4,592)**	**(294.9)**	**(73.68)**	**(49.22)**
Dirt floor (0,1)	-0.0247	156.5*	434.8	-467.9	0.00442	1,124	134.8	46.34	-65.14**
	(0.0861)	(89.99)	(840.1)	(533.3)	(0.0139)	(2,717)	(160.8)	(38.17)	(27.05)
Assets index	0.0352	143.4**	1,870***	266.8	0.00659	7,833***	45.55	-54.64**	157.2***
	(0.0549)	(63.05)	(628.5)	(322.2)	(0.00860)	(2,367)	(82.41)	(26.59)	(18.56)
Female head of hh (0,1)	0.177***	-151.1*	540.1	-137.2	-0.0212	469.6	-135.8	46.86	-46.26*
	(0.0638)	(87.96)	(725.6)	(540.3)	(0.0139)	(1,920)	(140.3)	(37.77)	(25.30)
Age (years)	0.00598	-14.24	8.380	-56.73	-0.00146	182.9	-39.44	16.47**	7.344*
	(0.0123)	(16.30)	(105.6)	(75.43)	(0.00244)	(349.9)	(28.20)	(6.753)	(4.255)
Age squared	-7.19e-05	0.141	-0.197	0.303	1.49e-05	-1.808	0.332	-0.148**	-0.0870**
	(0.000133)	(0.167)	(1.036)	(0.813)	(2.55e-05)	(3.521)	(0.296)	(0.0680)	(0.0416)
Primary education, incomplete	0.0811	-108.4	-327.2	113.2	-0.0120	310.4	110.6	-22.41	10.17
	(0.0968)	(75.86)	(712.2)	(496.3)	(0.0120)	(2,114)	(150.8)	(43.30)	(26.20)
Primary education, complete	0.0205	95.17	-1,189	1,019	0.00897	-569.2	173.1	-102.1*	56.95
	(0.0918)	(111.2)	(906.2)	(754.8)	(0.0171)	(3,518)	(237.0)	(53.40)	(34.86)
Secondary education, incomplete	0.0352	-32.05	-2,117**	393.9	0.0486*	-6,596*	106.4	-155.4**	-38.54
	(0.121)	(127.1)	(922.8)	(821.9)	(0.0259)	(3,507)	(260.3)	(66.29)	(45.62)
Secondary education, complete	0.232	658.3*	-1,987	1,858	0.0494	-9,404***	701.5	-280.0***	-8.250
	(0.234)	(372.8)	(1,686)	(1,551)	(0.0421)	(3,350)	(597.0)	(74.44)	(62.11)
Terciary education	0.370	98.59	-2,798	2,989	0.107	-9,788**	945.9	-36.23	102.3
	(0.226)	(452.9)	(3,570)	(2,782)	(0.0758)	(4,109)	(828.9)	(123.2)	(78.49)
Distance to road (km,ln)	0.0610	-89.40*	-71.40	-244.0	-0.00842	725.0	-159.7**	27.16	21.36
	(0.0381)	(45.71)	(384.9)	(233.2)	(0.00627)	(1,540)	(67.19)	(20.07)	(13.52)
Distance to market (km,ln)	-0.0391	18.37	-34.91	-489.0*	-0.0137	2,288	-189.9*	-12.27	-30.20*
	(0.0460)	(52.75)	(484.2)	(296.1)	(0.00855)	(1,774)	(109.5)	(23.09)	(17.12)
Distance to head city (km,ln)	0.0116	-20.39	-74.45	80.50	0.00817	-2,505	78.53	-17.95	-12.31
	(0.0378)	(48.39)	(451.0)	(262.3)	(0.00782)	(2,190)	(93.50)	(20.38)	(16.41)
Owned land area (mz, ln)	0.478***	71.73	981.9***	1,956***	0.0319***	6,013***	528.6***	109.9***	33.05*
	(0.102)	(51.53)	(292.9)	(346.0)	(0.00817)	(1,416)	(128.5)	(28.08)	(17.80)
Cultivated land area (mz, ln)	0.122*	150.9**	-1,862***	269.6	-0.127***	18,850***	-81.97	423.3***	73.71***
	(0.0645)	(66.55)	(558.0)	(375.9)	(0.0121)	(1,812)	(113.1)	(28.63)	(19.73)
Participation in other project (0,1)	0.133	145.3	1,635**	1,562**	0.0230*	899.2	314.8*	109.5**	22.97
	(0.0909)	(102.6)	(754.7)	(659.2)	(0.0138)	(2,549)	(185.2)	(50.97)	(33.98)
Participation in local group (0,1)	0.0508	183.6**	1,016	1,824***	0.0619***	2,385	590.7***	3.852	18.54
	(0.0706)	(92.68)	(701.8)	(566.1)	(0.0133)	(2,604)	(172.6)	(40.54)	(26.08)
Contract farming (0,1)	-0.170	131.2	5,582***	-818.5	-0.0601***	26,505***	-385.9**	60.37	-22.99
	(0.120)	(138.8)	(1,285)	(866.2)	(0.0129)	(6,354)	(179.1)	(90.67)	(43.09)
Access to credit service (0,1)	-0.0390	70.13	1,842**	167.6	-0.0145	9,364***	183.9	82.99*	47.14
	(0.0759)	(89.13)	(777.6)	(536.3)	(0.0120)	(2,718)	(168.6)	(45.24)	(29.02)
Migration (0,1)	0.288*	-11.81	763.6	842.7	0.0834**	7,978	-287.4	185.9	171.1*
	(0.168)	(253.7)	(2,831)	(1,486)	(0.0371)	(14,051)	(242.2)	(184.8)	(89.58)
Quantity of remittance (cord)	-5.80e-06	0.0527	-0.209*	-0.0226	-4.78e-07	-0.674	-0.000730	0.000343	-0.000733
	(1.00e-05)	(0.0454)	(0.125)	(0.0643)	(2.87e-06)	(0.612)	(0.0143)	(0.00917)	(0.00757)
Esteli	0.0517	640.8***	-71.42	1,477**	0.0754***	-1,715	90.67	-57.57	37.86
	(0.0933)	(137.4)	(1,426)	(580.5)	(0.0192)	(3,001)	(178.9)	(52.80)	(42.84)
Jinotega	0.0470	-67.82	2,874**	3,567***	0.0955***	18,347***	150.8	259.3***	0.823
	(0.0883)	(121.2)	(1,374)	(693.3)	(0.0194)	(2,807)	(185.0)	(66.34)	(40.35)
Matagalpa	-0.0166	-179.0	-266.8	3,653***	0.114***	3,610	254.7	187.0***	-9.299
	(0.125)	(120.9)	(1,334)	(726.2)	(0.0191)	(2,914)	(187.3)	(60.73)	(42.00)
Pilot (0,1)	-0.0887	107.9	1,564***	-944.0	-0.0152	-637.9	108.3	-221.5***	47.16*
	(0.102)	(82.47)	(591.1)	(607.3)	(0.0144)	(2,063)	(160.2)	(50.19)	(27.48)
Constant	-0.405	526.6	6,199	1,070	0.263***	-25,725**	1,151	-76.09	380.6***
	(0.413)	(394.4)	(4,100)	(1,848)	(0.0637)	(10,778)	(713.1)	(181.9)	(115.4)
Observations	2,098	2,098	2,098	2,098	2,098	2,098	2,098	2,098	2,098
R-squared	0.166	0.172	0.065	0.171	0.216	0.217	0.073	0.280	0.174

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 2C. Model III, Difference in Difference with exposure to Treatment

Variables	Total Livestock Unit	Livestock Costs	Agricultural Production (C$)	Livestock Production (C$)	Livestock Ratio	Total agricultural income (C$)	Income from livestock sales (C$)	Home consumption (C$)	Protein consumption (C$)
Period	0.0535	-104.3	-3,282***	-875.2	-0.0453***	-7,876***	-212.0	-352.2***	-294.0***
	(0.132)	(84.51)	(989.7)	(608.9)	(0.0159)	(2,776)	(192.6)	(44.34)	(31.62)
less than 1 year of exposure	-0.440***	-231.2**	-890.0	-2,239***	-0.0367*	6,842	-552.9***	111.2	64.64
	(0.109)	(107.0)	(1,229)	(521.7)	(0.0192)	(4,607)	(184.3)	(79.01)	(51.48)
1 year of exposure	-0.103	-54.12	-2,341**	-1,522	-0.000336	-5,901	-245.7	-183.9	-45.91
	(0.203)	(168.9)	(1,162)	(928.9)	(0.0373)	(4,579)	(247.7)	(119.0)	(83.85)
2 years of exposure	-0.166*	-42.71	55.55	-974.2	-0.0200	3,743	-363.1*	139.4	7.173
	(0.0933)	(112.0)	(1,330)	(729.7)	(0.0202)	(5,408)	(193.1)	(86.30)	(49.88)
3 years of exposure	-0.126	549.6***	-2,115**	-1,244	0.0184	-4,815	-232.7	-42.09	168.0***
	(0.118)	(201.7)	(1,017)	(824.2)	(0.0239)	(3,347)	(286.7)	(90.11)	(63.69)
4 years of exposure	0.0455	76.59	1,403	-652.3	-0.0682**	787.3	-125.8	327.0*	-15.54
	(0.271)	(205.9)	(2,700)	(1,846)	(0.0272)	(4,606)	(600.6)	(179.6)	(80.51)
Time*less than 1 year	**1.125*** **	**1,055*** **	**2,288***	**4,267*** **	**0.109*** **	**-3,142**	**703.3*** **	**-194.6*** **	**-47.15**
	(0.172)	**(210.5)**	**(1,385)**	**(912.6)**	**(0.0287)**	**(5,936)**	**(264.2)**	**(91.78)**	**(61.12)**
Time*1 year	**1.119*** **	**855.2*** **	**4,209*** **	**6,728*** **	**0.126*** **	**9,470**	**2,080*** **	**239.8*** **	**120.2**
	(0.303)	**(291.9)**	**(1,727)**	**(1,907)**	**(0.0562)**	**(6,498)**	**(820.4)**	**(141.2)**	**(108.3)**
Time*2 years	**1.364*** **	**1,770*** **	**2,270**	**9,193*** **	**0.216*** **	**-3,917**	**1,186*** **	**117.3**	**125.8*** **
	(0.176)	**(215.5)**	**(1,674)**	**(1,534)**	**(0.0312)**	**(6,546)**	**(333.9)**	**(105.7)**	**(64.35)**
Time*3 years	**1.100*** **	**901.0*** **	**6,834*** **	**10,265*** **	**0.188*** **	**14,247*** **	**1,432*** **	**356.8*** **	**37.58**
	(0.186)	**(279.8)**	**(1,783)**	**(1,628)**	**(0.0350)**	**(5,305)**	**(491.0)**	**(108.8)**	**(76.27)**
Time*4 years	**1.446*** **	**948.4*** **	**4,696**	**7,270*** **	**0.298*** **	**13,358**	**970.8**	**-146.2**	**90.24**
	(0.515)	**(316.1)**	**(5,112)**	**(2,691)**	**(0.0548)**	**(17,757)**	**(774.9)**	**(204.7)**	**(97.27)**
Dirt floor (0,1)	-0.0257	173.8*	461.2	-425.9	0.00665	1,180	132.9	46.15	-58.70**
	(0.0856)	(90.45)	(830.7)	(534.8)	(0.0139)	(2,679)	(164.8)	(38.23)	(27.28)
Assets index	0.0372	142.8**	1,878***	265.1	0.00678	7,823***	46.52	-55.67**	157.0***
	(0.0547)	(62.97)	(625.7)	(321.8)	(0.00858)	(2,349)	(82.15)	(26.54)	(18.61)
Female head of hh (0,1)	0.177***	-151.2*	526.1	-150.1	-0.0217	409.8	-129.8	46.30	-45.95*
	(0.0640)	(87.20)	(721.7)	(540.8)	(0.0139)	(1,918)	(139.6)	(37.65)	(25.37)
Age (years)	0.00556	-13.70	13.63	-53.00	-0.00133	205.7	-39.69	16.79**	7.737*
	(0.0123)	(16.25)	(105.1)	(75.86)	(0.00244)	(352.5)	(28.41)	(6.765)	(4.262)
Age squared	-6.97e-05	0.137	-0.266	0.276	1.37e-05	-2.068	0.331	-0.151**	-0.0911**
	(0.000133)	(0.167)	(1.034)	(0.813)	(2.55e-05)	(3.564)	(0.297)	(0.0678)	(0.0417)
Primary education, incomplete	0.0717	-89.62	-335.9	204.8	-0.0108	316.9	94.85	-16.44	13.50
	(0.0986)	(76.06)	(715.7)	(498.0)	(0.0120)	(2,084)	(150.4)	(43.59)	(26.50)
Primary education, complete	0.0159	108.9	-1,181	1,100	0.00923	-586.9	157.0	-94.33*	57.39*
	(0.0920)	(110.2)	(917.2)	(760.0)	(0.0171)	(3,561)	(236.2)	(53.23)	(34.67)
Secondary education, incomplete	0.0281	-2.588	-2,146**	491.7	0.0505*	-6,731*	91.76	-151.9**	-32.77
	(0.122)	(126.4)	(937.7)	(818.4)	(0.0259)	(3,522)	(253.1)	(66.47)	(45.78)
Secondary education, complete	0.230	643.5*	-2,079	1,820	0.0478	-9,465***	674.5	-279.4***	-17.63
	(0.237)	(378.5)	(1,647)	(1,564)	(0.0422)	(3,340)	(596.2)	(74.32)	(62.87)
Terciary education	0.367	85.66	-2,892	2,982	0.103	-10,074**	932.1	-29.82	90.93
	(0.230)	(451.5)	(3,609)	(2,805)	(0.0761)	(4,304)	(830.9)	(124.9)	(80.30)
Distance to road (km,ln)	0.0585	-85.57*	-85.89	-230.3	-0.00865	678.6	-160.6**	28.65	21.80
	(0.0386)	(45.83)	(391.1)	(234.8)	(0.00625)	(1,579)	(67.36)	(20.09)	(13.56)
Distance to market (km,ln)	-0.0373	19.46	-16.88	-486.2*	-0.0138	2,291	-186.8*	-11.56	-29.67*
	(0.0458)	(52.73)	(482.6)	(295.1)	(0.00856)	(1,765)	(109.1)	(23.13)	(17.14)
Distance to head city (km,ln)	0.0128	-24.64	-108.7	62.77	0.00782	-2,621	78.47	-21.14	-14.71
	(0.0382)	(48.42)	(452.5)	(262.2)	(0.00782)	(2,198)	(93.56)	(20.43)	(16.41)
Owned land area (mz, ln)	0.481***	77.06	972.8***	1,963***	0.0319***	5,924***	522.6***	111.1***	32.40*
	(0.102)	(51.31)	(293.7)	(347.5)	(0.00817)	(1,423)	(128.4)	(27.97)	(17.74)
Cultivated land area (mz, ln)	0.124*	140.9**	-1,841***	250.1	-0.128***	18,940***	-78.90	421.8***	72.04***
	(0.0653)	(66.14)	(555.8)	(377.6)	(0.0121)	(1,831)	(112.5)	(28.46)	(19.69)
Participation in other project (0,1)	0.131	127.2	1,555**	1,488**	0.0198	706.9	326.1*	107.4**	16.87
	(0.0914)	(102.2)	(753.3)	(668.9)	(0.0140)	(2,552)	(191.5)	(51.01)	(34.45)

Participation in local group (0,1)	0.0512	201.8**	975.8	1,839***	0.0626***	2,225	584.7***	4.192	22.08
	(0.0714)	(91.73)	(696.2)	(567.2)	(0.0133)	(2,561)	(173.0)	(40.28)	(26.07)
Contract farming (0,1)	-0.164	128.0	5,603***	-841.9	-0.0599***	26,570***	-389.1**	59.73	-23.78
	(0.120)	(138.2)	(1,280)	(861.6)	(0.0129)	(6,326)	(179.7)	(90.00)	(43.22)
Access to credit service (0,1)	-0.0425	70.99	1,898**	207.6	-0.0135	9,540***	186.7	84.48*	49.60*
	(0.0760)	(88.50)	(784.5)	(547.1)	(0.0121)	(2,733)	(170.9)	(45.19)	(28.96)
Migration (0,1)	0.294*	-0.381	729.7	813.5	0.0836**	7,747	-279.6	182.2	173.9*
	(0.169)	(249.6)	(2,788)	(1,476)	(0.0372)	(13,836)	(241.6)	(184.3)	(90.43)
Quantity of remittance (cord)	-6.20e-06	0.0519	-0.200	-0.0207	-6.05e-07	-0.637	-0.000849	0.00146	-0.000767
	(1.02e-05)	(0.0443)	(0.123)	(0.0640)	(2.83e-06)	(0.594)	(0.0143)	(0.00979)	(0.00788)
Esteli	0.0533	647.7***	80.04	1,517***	0.0780***	-1,301	103.7	-55.35	46.54
	(0.0948)	(136.2)	(1,421)	(586.7)	(0.0193)	(2,843)	(179.0)	(53.17)	(43.17)
Jinotega	0.0353	-78.20	2,834**	3,520***	0.0963***	18,300***	199.0	242.9***	7.749
	(0.0887)	(122.0)	(1,365)	(686.4)	(0.0194)	(2,691)	(181.1)	(66.00)	(40.47)
Matagalpa	-0.0263	-187.5	-300.0	3,627***	0.115***	3,601	284.2	175.5***	-5.107
	(0.126)	(120.8)	(1,338)	(740.0)	(0.0191)	(2,909)	(190.3)	(60.75)	(42.07)
Pilot (0,1)	-0.0787	92.36	1,503***	-971.8	-0.0184	-804.0	64.59	-212.9***	31.06
	(0.106)	(87.11)	(571.0)	(628.0)	(0.0148)	(1,990)	(165.2)	(50.34)	(28.01)
Constant	-0.397	512.0	6,164	977.9	0.260***	-25,829**	1,155	-75.52	374.8***
	(0.412)	(393.1)	(4,089)	(1,851)	(0.0635)	(10,738)	(715.9)	(181.3)	(115.6)
Observations	2,098	2,098	2,098	2,098	2,098	2,098	2,098	2,098	2,098
R-squared	0.168	0.183	0.069	0.173	0.220	0.221	0.075	0.285	0.180

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 2D. Model IV, Randomized Phased-in

Variables	Total Livestock Unit	Livestock Costs	Agricultural Production (C$)	Livestock Production (C$)	Livestock Ratio	Total agricultural income (C$)	Income from livestock sales (C$)	Home consumption (C$)	Protein consumption (C$)
Period	1.316***	980.5***	-1,058	1,843*	0.0434	-10,109***	474.2*	-619.0***	-387.8***
	(0.145)	(248.0)	(906.6)	(992.2)	(0.0338)	(3,683)	(243.8)	(98.55)	(65.84)
1 year of exposure	**0.0879**	**-469.7**	**-650.4**	**3,814****	**0.0718**	**-1,584**	**1,626***	**243.9***	**184.2****
	(0.251)	**(376.1)**	**(1,212)**	**(1,915)**	**(0.0514)**	**(5,261)**	**(894.3)**	**(127.7)**	**(92.45)**
2 years of exposure	**0.366***	**823.2****	**1,174**	**7,580*****	**0.157*****	**-1,835**	**986.4*****	**355.0*****	**215.1*****
	(0.200)	**(335.3)**	**(1,267)**	**(1,870)**	**(0.0384)**	**(4,614)**	**(349.7)**	**(116.6)**	**(70.43)**
3 years of exposure	**0.422***	**869.9***	**935.4**	**7,667****	**0.119****	**2,092**	**1,683***	**544.3*****	**231.1****
	(0.241)	**(468.8)**	**(1,865)**	**(3,522)**	**(0.0565)**	**(7,499)**	**(932.9)**	**(181.3)**	**(113.0)**
4 years of exposure	**1.805**	**494.0**	**693.1**	**7,130***	**0.161****	**-93.65**	**1,472***	**282.2**	**55.21**
	(1.239)	**(446.3)**	**(1,559)**	**(4,074)**	**(0.0737)**	**(7,629)**	**(777.9)**	**(227.2)**	**(96.59)**
Dirt floor (0,1)	-0.0827	159.2	850.4	-1,414	-0.0248	6,215*	113.0	90.26	-122.1*
	(0.224)	(218.1)	(893.6)	(1,144)	(0.0281)	(3,576)	(251.9)	(87.33)	(67.91)
Assets index	-0.0967	323.2**	2,198*	-1,180*	-0.0169	11,194*	-194.5	-47.17	160.8***
	(0.0677)	(140.1)	(1,173)	(627.7)	(0.0182)	(5,819)	(126.4)	(53.94)	(47.41)
Female head of hh (0,1)	0.285**	-427.6*	660.1	-2,201	-0.0333	1,522	-431.5	-104.8	-15.13
	(0.115)	(218.1)	(882.0)	(1,797)	(0.0280)	(2,885)	(386.6)	(83.53)	(55.95)
Age (years)	0.0143	-79.28	77.93	78.51	-0.00459	648.6	-5.367	42.97***	26.64***
	(0.0193)	(49.47)	(123.9)	(143.2)	(0.00453)	(522.9)	(46.19)	(15.37)	(8.370)
Age squared	-0.000170	0.907*	-1.255	-1.450	1.80e-05	-6.933	-0.0803	-0.413***	-0.301***
	(0.000203)	(0.545)	(1.261)	(1.477)	(4.71e-05)	(5.460)	(0.485)	(0.155)	(0.0859)
Primary education, incomplete	-0.0974	-15.99	476.3	386.4	-0.00367	1,149	103.4	3.508	-16.38
	(0.136)	(175.6)	(753.4)	(1,153)	(0.0218)	(3,312)	(272.4)	(91.91)	(48.03)
Primary education, complete	-0.0140	369.7	-1,890	1,028	0.0248	-12,309	-47.22	-109.1	13.11

	(0.190)	(275.5)	(1,715)	(1,287)	(0.0339)	(7,834)	(264.3)	(118.4)	(78.82)
Secondary education, incomplete	0.185	29.77	-44.91	-221.4	0.00308	-733.8	-479.4	-109.1	50.30
	(0.208)	(328.3)	(1,512)	(1,726)	(0.0402)	(9,451)	(329.1)	(149.0)	(98.18)
Secondary education, complete	-0.423**	-223.0	1,515	853.5	-0.0212	5,283	-845.9	-238.5	-47.02
	(0.176)	(460.0)	(2,105)	(3,194)	(0.0955)	(6,087)	(566.3)	(181.6)	(144.5)
Terciary education	-0.449**	-397.8	-9,035***	-5,980	0.0379	-21,248***	-1,292	-648.7**	18.33
	(0.198)	(456.4)	(1,583)	(3,711)	(0.214)	(8,084)	(947.3)	(263.4)	(220.3)
Distance to road (km,ln)	0.000602	-136.2	217.3	-601.0	-0.0336***	2,997	-258.0**	21.31	24.68
	(0.0601)	(99.77)	(780.1)	(453.6)	(0.0111)	(3,981)	(119.4)	(40.29)	(24.98)
Distance to market (km,ln)	-0.0749	87.80	919.9*	233.1	0.0107	3,587	-77.51	41.28	-76.63**
	(0.0774)	(127.8)	(537.3)	(506.5)	(0.0134)	(2,338)	(132.7)	(50.67)	(30.82)
Distance to head city (km,ln)	0.0448	-147.7	-401.2	-301.3	-0.00948	-1,392	-95.02	-35.75	56.68**
	(0.0679)	(113.7)	(375.8)	(531.7)	(0.0130)	(1,466)	(128.6)	(42.84)	(27.91)
Owned land area (mz, ln)	0.379***	69.51	480.6	2,038***	0.0391***	4,242*	306.7**	93.40	0.113
	(0.112)	(113.4)	(513.0)	(619.0)	(0.0139)	(2,386)	(121.9)	(59.36)	(37.27)
Cultivated land area (mz, ln)	-0.0450	220.5	-1,122*	-1,090	-0.160***	17,939***	-403.3**	463.4***	70.46
	(0.0950)	(157.5)	(606.1)	(853.7)	(0.0240)	(2,257)	(165.7)	(67.73)	(46.59)
Participation in other project (0,1)	0.0623	172.0	2,118	1,451	0.00391	6,865	42.05	128.7	56.48
	(0.139)	(216.4)	(1,575)	(1,176)	(0.0267)	(7,173)	(255.4)	(90.86)	(60.36)
Participation in local group (0,1)	0.131	-16.55	635.2	1,604	0.0667***	715.1	740.9**	-45.59	-32.34
	(0.148)	(197.5)	(694.7)	(1,217)	(0.0239)	(3,282)	(309.1)	(94.96)	(54.83)
Contract farming (0,1)	0.210	100.7	5,740**	447.3	-0.0369	41,131**	13.61	559.7**	86.92
	(0.192)	(271.1)	(2,861)	(1,950)	(0.0249)	(15,955)	(306.9)	(229.8)	(96.18)
Access to credit service (0,1)	-0.0708	229.1	1,332	426.8	-0.0169	14,808***	199.8	244.8**	80.83
	(0.120)	(184.8)	(879.7)	(1,134)	(0.0217)	(4,252)	(321.5)	(96.23)	(59.88)
Migration (0,1)	0.438	-1,092**	16,019	5,781	0.149	64,562	-186.2	-229.3	-255.3
	(0.376)	(482.2)	(13,420)	(6,409)	(0.0938)	(68,193)	(370.8)	(288.4)	(163.2)
Quantity of remittance (cord)	-3.97e-06	0.107	-0.661	-0.107	-3.03e-06	-2.735	0.00746	0.00805	0.0174**
	(1.93e-05)	(0.0752)	(0.459)	(0.197)	(4.43e-06)	(2.310)	(0.0246)	(0.0152)	(0.00794)
Esteli	0.0773	1,188***	1,055	2,128**	0.0788**	-3,637	352.0	-21.97	29.16
	(0.136)	(246.2)	(1,045)	(1,080)	(0.0333)	(4,622)	(316.8)	(104.0)	(77.13)
Jinotega	-0.190	94.09	3,421***	3,874***	0.104***	20,508***	357.8	498.9***	-24.81
	(0.156)	(231.0)	(1,008)	(1,262)	(0.0287)	(5,316)	(296.1)	(128.0)	(66.12)
Matagalpa	0.140	32.21	1,101	4,249***	0.145***	1,046	517.9	123.0	-85.74
	(0.141)	(202.2)	(1,031)	(1,273)	(0.0319)	(4,782)	(366.7)	(109.7)	(72.16)
Constant	-0.311	1,682	745.1	2,151	0.465***	-46,620**	1,517	-696.2*	43.05
	(0.503)	(1,120)	(4,606)	(3,965)	(0.120)	(22,890)	(1,139)	(419.8)	(216.9)
Observations	562	562	562	562	562	562	562	562	562
R-squared	0.361	0.315	0.157	0.231	0.342	0.347	0.141	0.355	0.189

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Appendix 3. Disaggregated analysis of the empowerment index for women

For this analysis, we are only using the information for the women in the household, and comparing treated and control women. Table 15 displays the 4DE index for women in the baseline and the follow-up. Few things are worth noticing. First, the descriptive statistics show that women's disempowerment has decreased overtime for women in the treated and control groups. Second, women in the treated households started in a more disadvantageous position with 94% of the women being disempowered compared to 91.5% in the control group. Third, after treatment, less women in the treatment group were disempowered compared to the control group (80.7% vs 86.3%). Then, considering the 4DE index, women in the treated group were more empowered than the control group after the intervention (4DE of 0.57 vs. 4DE of 0.46); reversing the situation of the baseline, where the women in the treatment group were less empowered than those in the control group (4DE of 0.37 vs. 4DE of 0.41).

Table 3A. 4DE Index for Women

	Baseline		**Follow - up**	
Indexes	**Treated**	**Control**	**Treated**	**Control**
Disempowered Headcount (H)	**93.94%**	**91.47%**	**80.74%**	**86.29%**
Average Inadequacy Score (A)	66.61%	64.92%	53.83%	63.04%
Disempowerment Index (M0)	0.63	0.59	0.43	0.54
4DE Index (1-M0)	**0.37**	**0.41**	**0.57**	**0.46**
No. of observations	429	387	431	372
% of Data used	79.70%	75.70%	80.10%	72.80%

When decomposing the 4DE index in the four available domains (i.e. production, resources, income and leadership), it is clear that, in the baseline, the contribution of each dimension to disempowerment was very similar between the beneficiaries and non-beneficiaries (Figure 3A). But there is a clear change in the follow-up, where the women in the control group are more disempowered than the beneficiary women in the different domains, especially on the leadership dimension (Figure 3B).

Figure 3.A. Contribution of each indicator to disempowerment in Baseline sample

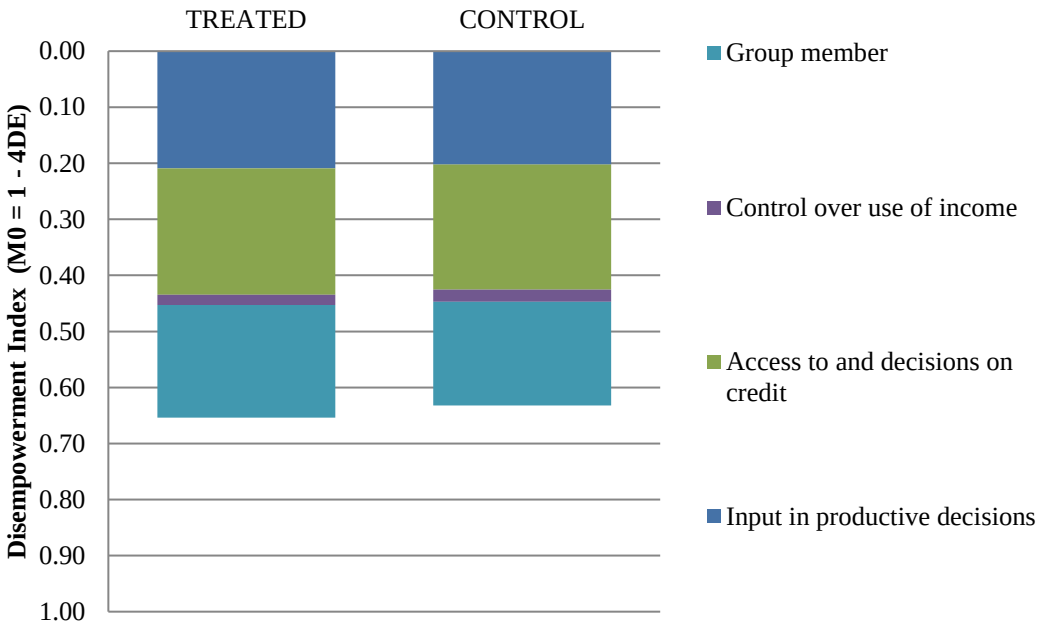
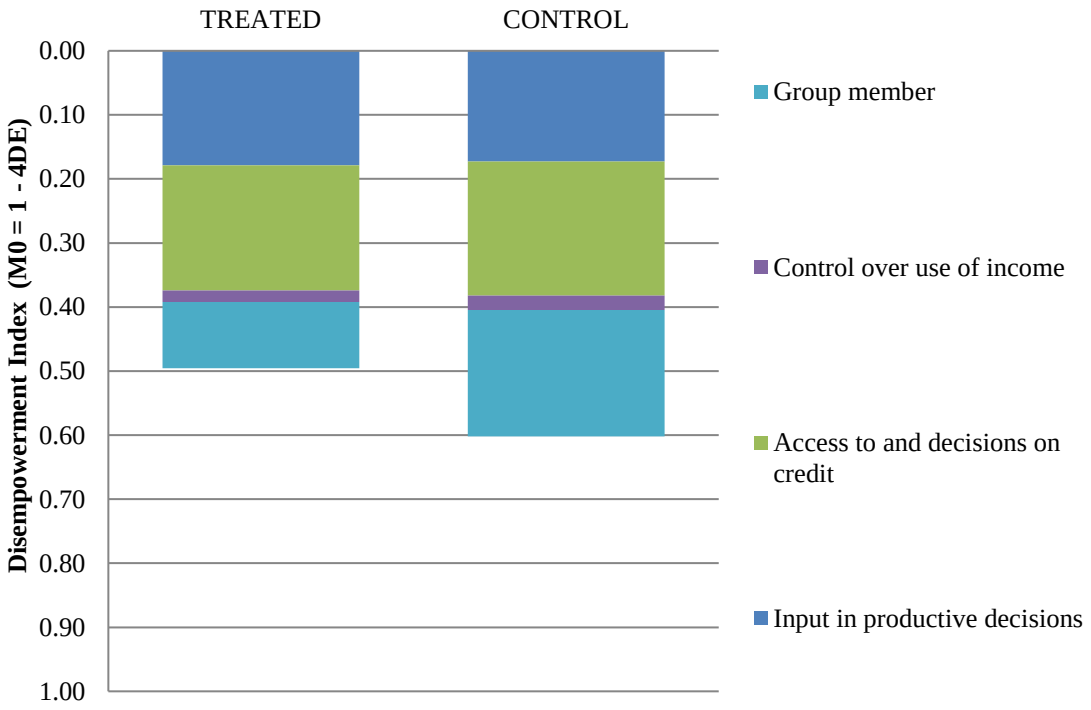


Figure 3.B. Contribution of each indicator to disempowerment in Follow-Up sample



Appendix 4. Impacts on the Disempowerment Indicators following the original construction

Table 4A. Pooled Sample – Basic Model and Technical Assistance Model

Model	Basic	Technical Assistance	
	I	II	III
		Time*Treat1	Time*Treat2
Variable	Time*Treatment	(Only Livestock)	(Livestock + TA)
Female Disempowerment Account	-0.019	0.043	-0.047
	(0.030)	(0.037)	(0.035)
Female Disempowerment Score	-0.051***	-0.050**	-0.056***
	(0.015)	(0.022)	(0.016)
Gender Disparity	-0.181***	-0.134**	-0.204***
	(0.045)	(0.063)	(0.050)
Empowerment Gap	-0.014	-0.021	-0.018
	(0.023)	(0.036)	(0.024)
Controls	yes	yes	yes

***p<0.01, **p<0.05, *p<0.1
*Robust standard errors
*Controls included: dirt floor, assets index, female head of household, age, education level, distance to locations, participation in groups, contract farming, credit access, migration, remittances, department, type of beneficiary group (1 if pilot)

Table 4B. Pooled Sample – Exposure to Treatment Model

Model	Exposure to Technical Assistance				
	I	II	III	IV	V
	Time*NoTA	Time*1yearTA	Time*2yearsTA	Time*3yearsTA	Time*4yearsTA
Variable					
Female Disempowerment Account	0.043	-0.152**	-0.074	-0.012	0.050
	(0.037)	(0.076)	(0.046)	(0.049)	(0.077)
Female Disempowerment Score	-0.050**	-0.084***	-0.036*	-0.063***	-0.091***
	(0.022)	(0.030)	(0.020)	(0.022)	(0.026)
Gender Disparity	-0.134**	-0.353***	-0.138**	-0.227***	-0.269***
	(0.063)	(0.105)	(0.064)	(0.069)	(0.104)
Empowerment Gap	-0.021	-0.044	-0.001	-0.011	-0.098**
	(0.036)	(0.049)	(0.030)	(0.036)	(0.044)
Controls	yes	yes	yes	yes	yes

***p<0.01, **p<0.05, *p<0.1
*Robust standard errors
*Controls included: dirt floor, assets index, female head of household, age, education level, distance to locations, participation in groups, contract farming, credit access, migration, remittances, department, type of beneficiary group (1 if pilot)

Appendix 5. Different Models for the Empowerment Outcomes

Table 5A. Model I, Basic Difference in Difference

Variables	Female Disempowerment Account	Female Disempowerment Score	Gender Disparity	Empowerment Gap
Period	0.00527	-0.00922	-0.0279	-0.0193
	(0.0193)	(0.0130)	(0.0332)	(0.0216)
Treatment	0.00968	0.00170	0.0179	0.000943
	(0.0170)	(0.0106)	(0.0282)	(0.0187)
Period*Treatment	**-0.0492***	**-0.0473*****	**-0.181*****	**-0.102*****
	(0.0287)	**(0.0180)**	**(0.0450)**	**(0.0294)**
Dirt floor (0,1)	-0.00583	-0.00108	-0.0364	-0.0147
	(0.0177)	(0.0103)	(0.0267)	(0.0167)
Assets index	0.0137	0.00687	0.00622	0.00366
	(0.0113)	(0.00656)	(0.0172)	(0.0107)
Female head of hh (0,1)	0.255***	0.153***	0.364***	0.194***
	(0.0198)	(0.0138)	(0.0324)	(0.0208)
Age (years)	0.00137	0.000437	-0.000553	0.00179
	(0.00300)	(0.00171)	(0.00461)	(0.00288)
Age squared	-2.02e-05	-4.98e-06	2.74e-06	-1.51e-05
	(3.10e-05)	(1.80e-05)	(4.87e-05)	(3.03e-05)
Primary education, incomplete	-0.00131	-0.000715	0.00754	0.0134
	(0.0162)	(0.00963)	(0.0256)	(0.0166)
Primary education, complete	-0.0206	0.00175	-0.00495	0.0129
	(0.0217)	(0.0131)	(0.0341)	(0.0218)
Secondary education, incomplete	-0.0457	-0.0181	-0.0263	-0.00374
	(0.0319)	(0.0196)	(0.0473)	(0.0304)
Secondary education, complete	-0.0318	0.00887	0.0833	0.0554
	(0.0482)	(0.0289)	(0.0701)	(0.0441)
Terciary education	-0.0768	-0.0143	-0.121	-0.0321
	(0.0698)	(0.0489)	(0.110)	(0.0796)
Distance to road (km,ln)	0.00570	0.0128**	0.0319**	0.0237***
	(0.00854)	(0.00517)	(0.0135)	(0.00859)
Distance to market (km,ln)	0.00392	0.00978	0.0136	0.0108
	(0.0106)	(0.00637)	(0.0157)	(0.0104)
Distance to head city (km,ln)	0.00217	-0.00793	-0.0135	-0.0124
	(0.00993)	(0.00603)	(0.0150)	(0.00979)
Owned land area (mz, ln)	0.000343	0.00349	0.0253	0.0107
	(0.0100)	(0.00610)	(0.0158)	(0.00992)
Cultivated land area (mz, ln)	0.0457***	0.00271	0.00714	0.0117
	(0.0129)	(0.00866)	(0.0220)	(0.0137)
Participation in other project (0,1)	-0.192***	-0.133***	-0.200***	-0.132***
	(0.0209)	(0.0116)	(0.0285)	(0.0185)
Participation in local group (0,1)	-0.168***	-0.108***	-0.0628**	-0.0734***
	(0.0199)	(0.0104)	(0.0269)	(0.0163)
Contract farming (0,1)	0.0227	0.0419**	0.0689*	0.0549**
	(0.0269)	(0.0173)	(0.0386)	(0.0277)
Access to credit service (0,1)	-0.190***	-0.0775***	0.0374	0.0417**
	(0.0205)	(0.0119)	(0.0271)	(0.0178)
Migration (0,1)	0.0475	-0.0115	0.0106	-0.0250
	(0.0545)	(0.0269)	(0.0734)	(0.0418)
Quantity of remittance (cord)	-5.84e-06	1.93e-06	1.55e-06	4.18e-07
	(5.13e-06)	(1.34e-06)	(5.31e-06)	(3.07e-06)
Esteli	-0.0197	-0.0860***	-0.187***	-0.140***
	(0.0265)	(0.0178)	(0.0438)	(0.0288)
Jinotega	0.0109	-0.0158	-0.0684	-0.0325
	(0.0241)	(0.0175)	(0.0419)	(0.0299)

Matagalpa	-0.0125	-0.0564***	-0.128***	-0.0983***
	(0.0245)	(0.0176)	(0.0424)	(0.0295)
Pilot (0,1)	0.00916	0.00360	0.0173	-0.00664
	(0.0173)	(0.0109)	(0.0286)	(0.0189)
Constant	0.696***	0.603***	0.531***	0.277***
	(0.0796)	(0.0453)	(0.124)	(0.0774)
Observations	2,098	1,619	1,619	1,604
R-squared	0.301	0.378	0.212	0.211

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 5B. Model II, Difference in Difference with Technical Assistance

Variables	Female Disempowerment Account	Female Disempowerment Score	Gender Disparity	Empowerment Gap
Period	0.00557	-0.00892	-0.0275	-0.0190
	(0.0193)	(0.0130)	(0.0332)	(0.0216)
Treatment1	-0.000113	0.0243	0.0238	0.0442
	(0.0238)	(0.0170)	(0.0400)	(0.0303)
Treatment2	0.0138	-0.00563	0.0168	-0.0136
	(0.0187)	(0.0112)	(0.0307)	(0.0195)
Period*Treatment1	**0.00796**	**-0.0284**	**-0.134****	**-0.0910****
	(0.0368)	**(0.0255)**	**(0.0626)**	**(0.0442)**
Period*Treatment2	**-0.0776****	**-0.0582*****	**-0.204*****	**-0.111*****
	(0.0337)	**(0.0196)**	**(0.0500)**	**(0.0314)**
Dirt floor (0,1)	-0.00545	-0.00133	-0.0362	-0.0153
	(0.0177)	(0.0103)	(0.0268)	(0.0167)
Assets index	0.0133	0.00637	0.00593	0.00290
	(0.0112)	(0.00656)	(0.0172)	(0.0107)
Female head of hh (0,1)	0.257***	0.153***	0.364***	0.194***
	(0.0198)	(0.0138)	(0.0324)	(0.0208)
Age (years)	0.00147	0.000612	-0.000453	0.00216
	(0.00300)	(0.00170)	(0.00462)	(0.00288)
Age squared	-2.11e-05	-6.56e-06	2.01e-06	-1.86e-05
	(3.09e-05)	(1.79e-05)	(4.87e-05)	(3.03e-05)
Primary education, incomplete	-0.000793	6.81e-05	0.00873	0.0143
	(0.0162)	(0.00960)	(0.0256)	(0.0165)
Primary education, complete	-0.0204	0.00181	-0.00435	0.0126
	(0.0217)	(0.0131)	(0.0341)	(0.0219)
Secondary education, incomplete	-0.0449	-0.0180	-0.0261	-0.00392
	(0.0320)	(0.0197)	(0.0474)	(0.0304)
Secondary education, complete	-0.0324	0.00999	0.0834	0.0576
	(0.0483)	(0.0283)	(0.0701)	(0.0432)
Terciary education	-0.0750	-0.0110	-0.116	-0.0282
	(0.0699)	(0.0479)	(0.110)	(0.0779)
Distance to road (km,ln)	0.00498	0.0123**	0.0311**	0.0233***
	(0.00852)	(0.00516)	(0.0135)	(0.00858)
Distance to market (km,ln)	0.00472	0.0104	0.0145	0.0114
	(0.0105)	(0.00632)	(0.0156)	(0.0103)
Distance to head city (km,ln)	0.00114	-0.00880	-0.0145	-0.0135
	(0.00986)	(0.00600)	(0.0149)	(0.00977)
Owned land area (mz, ln)	0.000184	0.00207	0.0241	0.00835
	(0.0100)	(0.00610)	(0.0158)	(0.00993)
Cultivated land area (mz, ln)	0.0452***	0.00264	0.00663	0.0117
	(0.0129)	(0.00862)	(0.0220)	(0.0136)
Participation in other project (0,1)	-0.184***	-0.126***	-0.190***	-0.123***

	(0.0216)	(0.0119)	(0.0294)	(0.0188)
Participation in local group (0,1)	-0.167***	-0.108***	-0.0625**	-0.0728***
	(0.0199)	(0.0104)	(0.0270)	(0.0163)
Contract farming (0,1)	0.0236	0.0432**	0.0705*	0.0567**
	(0.0270)	(0.0170)	(0.0385)	(0.0272)
Access to credit service (0,1)	-0.192***	-0.0787***	0.0353	0.0406**
	(0.0205)	(0.0119)	(0.0272)	(0.0178)
Migration (0,1)	0.0462	-0.0129	0.00848	-0.0266
	(0.0544)	(0.0270)	(0.0732)	(0.0417)
Quantity of remittance (cord)	-5.81e-06	2.14e-06	1.69e-06	7.76e-07
	(5.10e-06)	(1.32e-06)	(5.28e-06)	(2.96e-06)
Esteli	-0.0146	-0.0749***	-0.178***	-0.123***
	(0.0268)	(0.0183)	(0.0449)	(0.0294)
Jinotega	0.0146	-0.00697	-0.0606	-0.0192
	(0.0241)	(0.0176)	(0.0422)	(0.0301)
Matagalpa	-0.00607	-0.0433**	-0.116***	-0.0783***
	(0.0249)	(0.0181)	(0.0434)	(0.0300)
Pilot (0,1)	0.00784	0.000545	0.0140	-0.0112
	(0.0173)	(0.0109)	(0.0286)	(0.0188)
Constant	0.689***	0.592***	0.521***	0.259***
	(0.0797)	(0.0451)	(0.124)	(0.0774)
Observations	2,098	1,619	1,619	1,604
R-squared	0.303	0.383	0.213	0.215

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 5C. Model III, Difference in Difference with exposure to Treatment

Variables	Female Disempowerment Account	Female Disempowerment Score	Gender Disparity	Empowerment Gap
Period	0.00542	-0.00891	-0.0272	-0.0188
	(0.0193)	(0.0130)	(0.0333)	(0.0216)
less than 1 year of exposure	6.85e-05	0.0241	0.0229	0.0438
	(0.0238)	(0.0170)	(0.0401)	(0.0303)
1 year of exposure	0.0753*	0.0293	0.130**	0.0278
	(0.0446)	(0.0179)	(0.0642)	(0.0372)
2 years of exposure	0.00388	-0.00860	-0.0243	-0.0324
	(0.0245)	(0.0144)	(0.0420)	(0.0258)
3 years of exposure	0.0215	-0.00678	0.0324	0.00462
	(0.0260)	(0.0169)	(0.0426)	(0.0283)
4 years of exposure	-0.0291	-0.0196	0.0372	-0.0303
	(0.0492)	(0.0223)	(0.0661)	(0.0392)
Time*less than 1 year	**0.00849**	**-0.0284**	**-0.134****	**-0.0910****
	(0.0368)	**(0.0256)**	**(0.0627)**	**(0.0442)**
Time*1 year	**-0.150****	**-0.115*****	**-0.353*****	**-0.185*****
	(0.0753)	**(0.0354)**	**(0.105)**	**(0.0584)**
Time*2 years	**-0.0940****	**-0.0517****	**-0.138****	**-0.0740***
	(0.0444)	**(0.0245)**	**(0.0640)**	**(0.0393)**
Time*3 years	**-0.0428**	**-0.0498***	**-0.227*****	**-0.122*****
	(0.0467)	**(0.0263)**	**(0.0688)**	**(0.0436)**
Time*4 years	**-0.0450**	**-0.0605***	**-0.269*****	**-0.160*****
	(0.0828)	**(0.0337)**	**(0.104)**	**(0.0544)**
Dirt floor (0,1)	-0.00389	-0.00109	-0.0354	-0.0150
	(0.0178)	(0.0104)	(0.0268)	(0.0167)

Assets index	0.0137	0.00644	0.00703	0.00298
	(0.0113)	(0.00659)	(0.0172)	(0.0108)
Female head of hh (0,1)	0.256***	0.153***	0.366***	0.194***
	(0.0199)	(0.0139)	(0.0325)	(0.0209)
Age (years)	0.00154	0.000598	-0.000756	0.00217
	(0.00299)	(0.00171)	(0.00465)	(0.00290)
Age squared	-2.20e-05	-6.31e-06	5.06e-06	-1.87e-05
	(3.08e-05)	(1.80e-05)	(4.91e-05)	(3.05e-05)
Primary education, incomplete	-0.000260	0.000612	0.00728	0.0153
	(0.0162)	(0.00967)	(0.0258)	(0.0166)
Primary education, complete	-0.0208	0.00236	-0.00436	0.0135
	(0.0218)	(0.0131)	(0.0342)	(0.0219)
Secondary education, incomplete	-0.0437	-0.0167	-0.0225	-0.000754
	(0.0321)	(0.0198)	(0.0474)	(0.0305)
Secondary education, complete	-0.0361	0.00994	0.0788	0.0568
	(0.0480)	(0.0284)	(0.0704)	(0.0432)
Terciary education	-0.0788	-0.0113	-0.118	-0.0319
	(0.0706)	(0.0483)	(0.111)	(0.0785)
Distance to road (km,ln)	0.00476	0.0123**	0.0306**	0.0234***
	(0.00850)	(0.00516)	(0.0135)	(0.00859)
Distance to market (km,ln)	0.00488	0.0103	0.0150	0.0114
	(0.0106)	(0.00633)	(0.0157)	(0.0103)
Distance to head city (km,ln)	0.00125	-0.00844	-0.0132	-0.0130
	(0.00992)	(0.00601)	(0.0150)	(0.00976)
Owned land area (mz, ln)	-0.000550	0.00217	0.0251	0.00856
	(0.0100)	(0.00612)	(0.0159)	(0.00997)
Cultivated land area (mz, ln)	0.0455***	0.00277	0.00731	0.0117
	(0.0129)	(0.00863)	(0.0221)	(0.0137)
Participation in other project (0,1)	-0.186***	-0.127***	-0.192***	-0.125***
	(0.0217)	(0.0119)	(0.0295)	(0.0188)
Participation in local group (0,1)	-0.168***	-0.109***	-0.0627**	-0.0723***
	(0.0200)	(0.0105)	(0.0269)	(0.0163)
Contract farming (0,1)	0.0229	0.0430**	0.0704*	0.0564**
	(0.0270)	(0.0170)	(0.0384)	(0.0272)
Access to credit service (0,1)	-0.190***	-0.0784***	0.0354	0.0404**
	(0.0205)	(0.0119)	(0.0272)	(0.0178)
Migration (0,1)	0.0459	-0.0129	0.0102	-0.0260
	(0.0553)	(0.0272)	(0.0730)	(0.0419)
Quantity of remittance (cord)	-6.01e-06	2.22e-06*	1.94e-06	9.66e-07
	(5.35e-06)	(1.32e-06)	(5.22e-06)	(2.92e-06)
Esteli	-0.0116	-0.0754***	-0.180***	-0.125***
	(0.0268)	(0.0184)	(0.0454)	(0.0298)
Jinotega	0.0207	-0.00655	-0.0581	-0.0180
	(0.0242)	(0.0177)	(0.0426)	(0.0304)
Matagalpa	-0.00165	-0.0429**	-0.115***	-0.0778**
	(0.0249)	(0.0182)	(0.0437)	(0.0302)
Pilot (0,1)	0.00117	0.000116	0.0115	-0.0134
	(0.0175)	(0.0113)	(0.0296)	(0.0197)
Constant	0.685***	0.591***	0.519***	0.256***
	(0.0797)	(0.0453)	(0.125)	(0.0778)
Observations	2,098	1,619	1,619	1,604
R-squared	0.305	0.384	0.216	0.218

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Appendix 6. Diff in diff Models: Impact on disaggregated dimensions

As previously mentioned, for the construction of the Women's Empowerment in Agriculture Index (WEAI) there are five dimensions of interest: production, resources, income, leadership and distribution of time. In order to understand the main drivers of the women's empowerment, we analyze these dimensions separately for the women in the sample.

Tables 6A and 6B present the results of the three differences in difference models: the basic difference in differences, the technical assistance model and the model of exposure to treatment. The analyzed variables, which represent five different dimensions, are the following: women's decisions over production, access to credit, whether the women in the household receive income or not, women's decisions over use of income, participation in community groups and type of work developed by the women of the household.

The first model does not find significant effects on the production decisions, access to credit, income or distribution of labor hours. The only significant effect is in the leadership dimension, where it is found that participating in APAGRO increases the probability of being part of a community group or project in approximately 44%, which is expectable due to the project guidelines that emphasize the social capital formation and create nucleus of women in the communities. Indeed, this hypothesis is confirmed by the results of the second model, which shows an additional effect of receiving the technical assistance; those households who only received the livestock package increase their likelihood of participating in a group in 24% while those who also received the training raise their probability in 52%. On the other hand, the model 2, shows that receiving the complete treatment (i.e. livestock package plus technical assistance) reduces the non-agricultural work of the women in 4%.

The exposure to treatment model finds that the program increases the likelihood of the women to participate in decisions over the agricultural production after the first year of treatment, while it finds a negative effect for those who receive the program for four years. This model confirms the impact of the

program in the women's associativity. In fact, it presents perpetuate and increasing effects, showing that the probability of participating in a community group is higher as the number of years in the program increase, leading to a 77% increase for those women who are already four years in the program. On the dimension of time distribution, it is found that the treatment increases the probability of dedicating to agricultural work (13%) while it reduces the dedication to non-agricultural activities (6%).

According to the disaggregated analysis, the impacts on women's empowerment are mainly driven by the higher participation in groups or associations (leadership dimension). Even though this dimension is directly related to the program implementation, it is worth mentioning that being part of a group was not a requirement of the program. In fact, some women organized themselves in groups after the program was implemented in order to continue receiving technical assistance. And the results over time show that the participation in community groups has been increasing over time, reaching the peak after four years of program participation, which would suggest this is not an immediate consequence of the program implementation process.

Table 6A. Impacts on Women Empowerment (Production, Resources and Income)

	D1: Production			D2: Resources			D3: Income					
Variable	**Decisions over Production**			**Access to Credit**			**Income**			**Decisions over use of income**		
	Basic	**Tech Assit**	**Exposure**	**Basic**	**Tech Assit**	**Exposure**	**Basic**	**Tech Assit**	**Exposure**	**Basic**	**Tech Assit**	**Exposure**
Time(1 if 2014)	0.0261	0.0259	0.0268	0.0410	0.0407	0.0388	-0.0481	-0.0482	-0.0481	-0.00177	-0.00213	-0.00215
	(0.0269)	(0.0269)	(0.0270)	(0.0600)	(0.0601)	(0.0605)	(0.0312)	(0.0312)	(0.0313)	(0.0186)	(0.0187)	(0.0187)
Treatment	0.00392			0.00231			0.0264			0.0247		
	(0.0212)			(0.0562)			(0.0297)			(0.0176)		
Time*Treatment	-0.0138			0.0695			0.0145			-0.0267		
	(0.0364)			(0.0808)			(0.0430)			(0.0262)		
Treat1 (Only Packcage)		0.0392			-0.0204			-0.00445			-0.0684*	
		(0.0319)			(0.0816)			(0.0449)			(0.0371)	
Treat2 (Package+TA)		-0.0101			0.0105			0.0365			0.0564***	
		(0.0230)			(0.0611)			(0.0322)			(0.0161)	
Time*Treat1		-0.0685			0.106			-0.0122			-0.0104	
		(0.0508)			(0.121)			(0.0619)			(0.0518)	
Time*Treat2		0.00996			0.0558			0.0309			-0.0241	
		(0.0399)			(0.0885)			(0.0473)			(0.0235)	
No TA			0.0393			-0.0217			-0.00424			-0.0685*
			(0.0320)			(0.0820)			(0.0450)			(0.0371)
1 year of exposure			-0.130***			-0.0855			0.0626			0.0787***
			(0.0352)			(0.110)			(0.0781)			(0.0182)
2 years of exposure			-0.0385			0.0908			0.0191			0.0491**
			(0.0301)			(0.0836)			(0.0427)			(0.0215)
3 years of exposure			0.0215			-0.117			0.0515			0.0522**
			(0.0336)			(0.0764)			(0.0447)			(0.0210)
4 years of exposure			0.0984*			0.176			0.0337			0.0793***
			(0.0545)			(0.160)			(0.0728)			(0.0187)
Time* No TA			-0.0691			0.102			-0.0124			-0.0107
			(0.0509)			(0.121)			(0.0620)			(0.0519)
Time* 1 year			0.230***			0.211			0.0458			-0.00928
			(0.0850)			(0.177)			(0.108)			(0.0250)
Time* 2 years			0.0548			-0.0421			0.0361			-0.0220
			(0.0503)			(0.118)			(0.0601)			(0.0300)
Time* 3 years			-0.0474			0.163			0.0284			-0.0330
			(0.0525)			(0.121)			(0.0644)			(0.0297)
Time* 4 years			-0.193**			-0.0663			0.00601			-0.0210
			(0.0901)			(0.221)			(0.105)			(0.0257)
Controls	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Obs in Baseline	928	928	928	260	260	260	897	897	897	884	884	884
Obs in Follow Up	912	912	912	271	271	271	897	897	897	884	884	884

***p<0.01, **p<0.05, *p<0.1
*Robust standard errors

Table 6B. Impacts on Women Empowerment (Leadership and Time Distribution)

	D4: Leadership			D5: Time								
Variable	**Associativity**			**Agricultural Work**			**Non-Agricultural Work**			**Domestic Work**		
	Basic	**Tech Assit**	**Exposure**	**Basic**	**Tech Assit**	**Exposure**	**Basic**	**Tech Assit**	**Exposure**	**Basic**	**Tech Assit**	**Exposure**
Time(1 if 2014)	-0.0441*	-0.0454*	-0.0450*	-0.0208	-0.0209	-0.0208	0.0324**	0.0325**	0.0326**	-0.00657	-0.00665	-0.00662
	(0.0259)	(0.0258)	(0.0258)	(0.0144)	(0.0144)	(0.0145)	(0.0160)	(0.0160)	(0.0160)	(0.0239)	(0.0240)	(0.0240)
Treatment	-0.0220			-0.0159			0.0162			0.0159		
	(0.0246)			(0.0127)			(0.0133)			(0.0210)		
Time*Treatment	0.437***			0.0148			-0.0349			0.00610		
	(0.0359)			(0.0186)			(0.0216)			(0.0324)		
Treat1 (Only Packcage)		-0.0277			-0.00273			0.0139			0.0131	
		(0.0334)			(0.0187)			(0.0192)			(0.0308)	
Treat2 (Package+TA)		-0.0206			-0.0211			0.0171			0.0169	
		(0.0275)			(0.0134)			(0.0144)			(0.0226)	
Time*Treat1		0.239***			-0.0155			-0.0156			-0.00209	
		(0.0521)			(0.0232)			(0.0305)			(0.0445)	
Time*Treat2		0.516***			0.0290			-0.0446*			0.0106	
		(0.0397)			(0.0211)			(0.0230)			(0.0355)	
No TA			-0.0266			-0.00287			0.0140			0.0135
			(0.0334)			(0.0187)			(0.0192)			(0.0308)
1 year of exposure			0.0281			-0.0444*			-0.00816			-0.0236
			(0.0692)			(0.0264)			(0.0284)			(0.0620)
2 years of exposure			-0.0157			-0.0146			0.0308			-0.00357
			(0.0371)			(0.0185)			(0.0201)			(0.0309)
3 years of exposure			-0.0172			-0.0118			0.0167			0.0401
			(0.0400)			(0.0186)			(0.0208)			(0.0283)
4 years of exposure			-0.0886*			-0.0548***			-0.00981			0.0639
			(0.0529)			(0.0134)			(0.0210)			(0.0393)
Time* No TA			0.239***			-0.0163			-0.0156			-0.000537
			(0.0523)			(0.0232)			(0.0306)			(0.0445)
Time* 1 year			0.302***			0.134**			-0.0119			-0.0748
			(0.103)			(0.0617)			(0.0478)			(0.0962)
Time* 2 years			0.458***			0.0230			-0.0577**			0.0455
			(0.0546)			(0.0283)			(0.0289)			(0.0445)
Time* 3 years			0.566***			-0.00329			-0.0618**			0.0239
			(0.0574)			(0.0255)			(0.0282)			(0.0428)
Time* 4 years			0.776***			0.0405			0.0261			-0.0608
			(0.0759)			(0.0300)			(0.0456)			(0.0680)
Controls	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Obs in Baseline	1049	1049	1049	1049	1049	1049	1049	1049	1049	1049	1049	1049
Obs in Follow Up	1049	1049	1049	1049	1049	1049	1049	1049	1049	1049	1049	1049

***p<0.01, **p<0.05, *p<0.1

*Robust standard errors

*Controls included: dirt floor, assets index, female head of household, age, education level, distance to locations, participation in groups, contract farming, credit access, migration, remittances, department, type of beneficiary group (1 if pilot)