The Impact of the *Plataformas de Concertación* on Technology Adoption by Gender

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The *Plataformas de Concertación* is a program of the International Potato Center (CIP) operating in select provinces of Bolivia, Ecuador, and Peru. It connects small, marginalized potato farmers to high-value markets by helping them to organize into groups and form contracts with urban restaurants and Frito Lay. This allows the groups of farmers to act as a single, large producer and supply high quality potatoes in the quantity and timeliness that the new markets demand.

The New Agricultural Economy developed as accelerating globalization has been creating greater opportunities for trade and commerce that can potentially improve the livelihoods of agriculture producers. Although this increase in marketization has raised incomes of many large-scale farmers, most small farmers in the potato-producing Andean region have not been able to access the high-value markets because of their inability to meet the quality, quantity, and timeliness requirements of potential buyers. Instead, small farmers often find themselves pushed further away from markets as the benefactors of the New Agricultural Economy gain more market share and threaten to dominate most rural agricultural transactions. The main goal of the *Plataformas* is to help the marginalized farmers organize themselves so that they can circumvent intermediaries, gain greater market access, and receive higher prices for their potatoes.

Initial impact analysis has shown that the program is effective in increasing yields, input-output seed ratios, and gross margins from the *Plataformas* participants' potato production. However, no research has been done comparing the impact of the *Plataformas* on women and men. Most, if not all, poverty alleviation programs have a gender impact (Quisumbing, 2006). Yet too few policymakers are adequately addressing gender in the design of poverty alleviation programs. As a result, the programs may not reach their full potential and pre-existing gender inequalities may be aggravated further (Quisumbing, 2003).

I received the American University Undergraduate Summer Research Grant in 2009 and traveled to Ecuador to meet and interview some of the *Plataformas* participants. During the interviews, I asked the participants about their roles within the program and their individual households as well as what they felt they gained from the FFS. I noticed that the female participants seemed to more completely and consistently follow the farming strategies encouraged by the FFS. Since I knew that adopting the appropriate technologies was a very important part of succeeding in the program, the potential for a difference in adoption rates of male and female participants seemed very interesting to explore. If further research found that the impact of the program varied by gender, if would have significant policy implications and would provide for greater success rates in future expansions of the *Plataformas*.

The Intrahousehold Bargaining Model suggests that when gender issues are not addressed, unexpected policy outcomes can occur due to households with dominant men and dominant women behaving differently. The theory claims that independent of the cultural context, income and assets that are obtained by individual members of a household are not necessarily pooled and this strongly influences the household's decision-making process. The weight that is placed on each partner's preference depends on the individual's bargaining power. An individual's earnings, access to employment and credit, asset ownership and control, human capital, presence of support systems and networks, and social and cultural institutions affect his or her bargaining power. These factors influence whether or not that individual's preferences will be expressed in the household's decisions and behavior (Blau, Ferber, & Winkler, 2010; Quisumbing, 2006).

Each household participating in the *Plataformas* selects an individual to be the household's main participant. Having this position most likely increases his or her bargaining power at least with respect to potato production decisions because it is the main participant's responsibility to represent the household's interests at group meetings and attend Farmer Field School (FFS) sessions. Therefore, the preferences of that individual are more likely to prevail when he or she is the main participant.

Development economics theory and empirical research suggests that men and women have different expenditure preferences. These preferences combined with the bargaining power associated with each decision maker affect a household's actions. Men, when given control over household resources, tend to spend money on productive inputs and luxuries while women tend to spend more money on health, education, and other child-raising expenses (Blau et al., 2010; Quisumbing, 2006; Quisumbing & Maluccio, 2000; Hallman, 2000; Smith, Ramakrishnan, Haddad, Martorell, & Ndiaye, 2003; Sharma, 2001; Ruel, de la Briere, Hallman, Quisumbing, & Coj de Salazar, 2002; Skoufias & McClafferty, 2001). Because of these preferences, development projects that try to stop the intergenerational transmission of poverty like conditional cash transfers often target women to be the recipients of aid as development practitioners know the money will most likely be spent in a predictable way, namely towards the well-being of the households' children (Winters, 2009). In fact, several studies have shown that the presence of an additional adult female in a household who has completed primary school can reduce the proportion of the population living under the poverty line by up to 34% (Datt & Jolliffe, 1998; Datt, Simler, & Mukherjee, 1999 as cited in Quisumbing, 2006). Therefore, policy makers should strongly consider how women's skills and preferences interact with the programs' benefits and requirements in order to accomplish the intended outcomes.

Since individual preferences differ across gender and main participants are likely to acquire bargaining power, households may behave differently under the program depending on the sex of the main participant. Most of the household decisions affected by participation in the *Plataformas* and captured in the survey data are influenced by what producers learn in the FFS, which is where local agronomists instruct the main participants on how to cultivate new seed varieties with contemporary farming techniques and agrochemical usage. The technologies introduced in the *Plataformas'* FFS are the following: two new commercial seed varieties, integrated pest management, traps, and new agrochemicals with non-traditional applications. All agricultural technologies covered in the FFS are designed to increase smallholders' potato yields. Therefore, households who more consistently and completely follow the advice of the FFS should receive greater returns to their potato cultivation efforts.

This paper is focused on comparing the outcomes of the *Plataformas* for households with a male participant to those with a female participant. In the literature review I discuss the potential determinants of female and male participants' decisions to follow the suggested farming strategies of the FFS. In the second section I describe background information on the Ecuadorian Andean region and the *Plataformas* program. Then I explain the general methods, data description, full methodology and results.

Literature Review:

Related studies on gender's impact on technology adoption rates show that gender alone cannot explain differences in males' and females' inclination to adopt. More information on the type of technology and welfare and personality characteristics of the adopter must also be considered. A study in Ghana found that African female farmers adopt less frequently then males (Doss & Morris, 2001). However, a separate study in Kenya testing the effectiveness of agriculture extension in raising farmers' productivity found that male and female-headed households had the same adoption rates for all of the simpler technologies introduced except fertilizer, one of the most expensive technologies to utilize. Additionally, this research showed that women in the study were more likely to adopt the more complex technologies such as top dressing, plant protection chemicals, and stalk borer control (Bindlish & Evenson, 1993). The contradictions between these two studies may imply that general statements about gender and technology adoption cannot be made cross-culturally. However, further research on the subject offers an explanation for the variation in adoption rates for Kenyans and Ghanaians as it suggests that females choose to adopt only when the technologies aid the activities that females perform (Jha, Hojjati, & Vosti, 1991; Appleton, Bevan, Burger, Collier, Gunning, Haddad, & Hoddinott, 1991). In the case of the *Plataformas*, all technologies support potato production, and in Ecuador, men do the majority of work involved in potato cultivation. Therefore, the foregoing research would imply that households with female participants might adopt fewer technologies.

Research suggests that the level of education of the adopter and the household's access to productive resources are extremely important determinants of technology adoption. Higher levels of education allow the adopter to better understand the long-term payoff and to more skillfully manage new technologies (Doss & Morris, 2001; Appleton et al., 1991; Quisumbing, 2006). Female farmers have lower levels of educational attainment than men, but this difference is smallest amongst developing countries in Latin America (Quisumbing, 2006; Doss & Morris, 2001). In the FAO data sample of Ecuadorian potato producers created to analyze the *Plataformas*, 89% of men and 94% of women have completed primary education. Women participants' higher education level should make them more likely to encourage their households to adopt the advice of FFS.

A household's wealth, usually measured by land size, and access to credit and inputs can also be a determinant of adoption decisions. If female participants are found in mainly female headed or predominantly female households, then women's limited access to key productive resources is likely to affect whether or not they choose to adopt. The influence could work in both ways, however. On one hand, the resource constraint may make them more likely to seek the advice of agronomists and follow it consistently in order to make up for their disadvantage (Bindlish & Evenson, 1997). On the other hand, having limited resources makes it much harder for households to bear risk and get access to credit, causing them to be less receptive to new technologies. Therefore, the effect of productive resource access on the adoption rates of households with a female participant is uncertain.

A person's decision to follow the advice of FFS can also be based on personality characteristics such as the propensity to trust others and comply with regulations. Research done on gender's influence on trust in asset investments shows that men are more trusting, and a stronger relationship between expected returns on investments and trusting behavior exists amongst men (Buchan, Croson, & Solnick, 2008). These gender differences in trust seem to imply that households with a male participant would adopt more technologies, especially since

the *Plataforma* technologies are recommended by skilled agronomists and therefore are likely to have relatively high returns. However, since one of the major characteristics of the *Plataformas* is the formation of and close interaction of members within groups of producers, women's greater social capital and inclination towards trusting the effectiveness of organizing and cooperation may influence them to adopt more of the technologies encouraged by FFS (Maluccio, Haddad, & May, 2000; Maluccio, Haddad, & May, 2003; Sabatini, 2008; Rankin, 2002; Grootaert & Narayan, 2004).

Research on rule compliance suggests that women are more likely to follow rules than men. On pedestrian compliance with traffic lights, research overwhelmingly shows than men cross on red more often than women (Rosenbloom, Shahar, & Perlman, 2008). This is even the case amongst preschoolers where a study found that girls' were more compliant with, had a better knowledge of, and revealed greater absorption of pedestrian rules (Granié, 2007). This might indicate that households with female participants are more likely to comply with FFS advice on adopting technologies.

Clearly, past social science research presents several different determinants of men's and women's propensity to adopt technologies, and it is difficult to tell which factors are the strongest predictors of adoption rates. Levels of trust in others and the male orientation of the *Plataformas* technologies seem to imply that men will adopt more of the technologies while tendency to comply and high educational attainment present women as more likely to adopt. The effects of access to productive inputs on adoption is unclear.

Background: Ecuador and the *Plataformas de Concertación*

The Ecuadorian Andean region experiences extreme levels of poverty and inequality with 80% of farmers impoverished (CEPAL, 2004). The majority of its inhabitants are small farmers who produce potatoes for subsistence and as a cash crop. Thirty-two percent of these farmers own less than one hectare (ha) and about half own less than two hectares (has) (Cavatassi, Gonzalez, Winters, Andrade-Piedra, Thiele, & Espinosa, 2009; OFIAGRO, 2009; INEC, 2007). Ecuador's small land size and its evenly dispersed cities allow producers to stay relatively connected to local markets when compared to farmers in Bolivia and Peru. However the producers have almost no power in setting prices in local markets and demand for potatoes varies greatly over time. Additionally, the climate permits year-round potato production and most farmers have three harvests per year. Although these advantages may seem significant, Ecuadorian potato farmers consistently experience much lower yields than their neighbors (Ecuador: 6.8 tons/ha, Peru: 12.6 tons/ha, Colombia: 17.3 tons/ha and Venezuela:18.6 tons/ha) (INEC, 2007; FAOSTAT, 2007). The vulnerability of Ecuador's market access for potato producers and their relatively low yields suggest that the region's farmers would greatly benefit from the *Plataformas* since the program provides greater and more secure access to high-value markets and agricultural extension to improve productivity through FFS.

The majority of farmers in the Andean region function on an individual level rather than in groups. Although many belong to agricultural organizations (in our sample, 19% belong to associations in the community and 7% belong to associations outside the community), few of those groups, if any, encourage cooperation in the production, marketing, and sale of the goods. As a result, most farmers suffer from the region's long supply chains with multiple intermediaries, high transaction costs, limited access to inputs, and a poor understanding of new technologies (Cavatassi et al., 2009). However, the *Plataformas*, established in Ecuador in 2003,

construct a way of managing these challenges through the use of the participatory market chain approach (PMCA), multi-stakeholder platforms, and agricultural innovation in order to connect small farmers to high-value markets and lift them out of their entrenched poverty. The PMCA is a strategy used to encourage the cooperation between smallholders, organizations, private businesses, and researchers in promoting market interactions between small farmers and large-scale suppliers. To accomplish this goal the FORTIPAPA program of the Instituto Nacional Autónomo de Investigaciones Agropecuarias (INIAP) with the help of CIP through its Papa Andina project use the following five steps (Cavatassi et al., 2009; Devaux, Horton, Velasco, Thiele, López, Bernet, Reinoso, & Ordinola, 2007):

> *(i)* Identification of producer organizations and communities of farmers. Those that are ideal for the program have had prior experience working in organizations and have built social capital intensive skills. Communities that have more potential to be connected to the market are given preference.
> *(ii)* Creation of an efficient market chain. Unnecessary intermediaries and transaction costs are identified and solutions on how to avoid them are generated. Buyers in high-value markets are determined and the negotiation between buyers and producers is facilitated. Once agreements are met, a formal contract is written up.
> *(iii)* Defining of the functional structure. Local NGOs are contacted to be responsible for linking farmers to the necessary inputs such as certified seeds, training, and overseeing the progress of the producer unions.
> *(iv)* Development of the production schedule. Clients and producers agree upon quotas and delivery dates. Producer unions map their planting and harvest times to meet demand. Methods for securing and dispersing inputs are cemented.
> *(v*) Setting producers' self-sufficiency. The producer unions, or *plataformas*, are christened the Potato Consortium, or the Consorcio de la Papa (CONPAPA) and the managerial role once assumed by the NGOs is transferred to each union. The NGOs support the farmers by maintaining their access to inputs, defending the contracts, and conducting quality control measures.

A key part of the *Plataformas* program is the agricultural extension provided by the FFS. Agronomists help the producers meet the higher requirement standards of the urban restaurants and Frito Lay. An integral way that they do this is by introducing smallholders to new technologies and suggesting more effective ways of implementing technologies that producers are already using. The policymakers of the *Plataformas* called this agricultural innovation and defined this as the use of technology to achieve positive economic outcomes (DeVaux et al., 2007). If farmers choose to use these technologies and follow the agronomists' directions carefully, they will more efficiently produce higher quality potatoes in a more timely manner. In addition to efficiency goals, the FFS aims to reduce the agrochemicals and harmful practices that farmers use in potato production by recommending certain technologies.

There are three primary pests that infect potatoes in the Andean region of Ecuador. Late blight is the most damaging followed by the Andean Potato Weevil and the Central American Tuber Moth. Past studies have found that 100% of farmers have crops that are affected by late blight, 80% are affected by the Andean Potato Weevil and 6% are affected by the tuber moth. Of the crops affected by the three pests, the Andean Potato Weevil destroys up to 80%, late blight

ruins at least 15-30% and the tuber moth causes varying amounts of harm (Lang, 2001; Muñoz & Cruz, 1984). Agronomists in the region have adapted the Integrated Pest Management (IPM) system to respond to these challenges in a way that minimizes agrochemical usage while keeping input costs low. The *Plataformas* also uses IPM which directs farmers to address late blight with preventative fungicide applications as opposed to curative fungicides due to the persistence of the pest. Most farmers in the Ecuadorian Andean region use fungicides, but most over-spray at an average of six times a crop cycle and do not focus on preventative fungicides (Barrera, Escudero, Norton, & Alwang, 2003; Crissman et al. 1998). Therefore, FFS guidance allows farmers to avoid buying so much costly chemicals that are dangerous to the farmers applying them and to consumers as well. The Andean Potato Weevil can be controlled by targeting low-toxicity insecticides during the adult stage of the population, according to IPM, and through the use of traps. Low-toxicity pesticides are suggested for the tuber moth (Mauceri 2005). For all three pests, farmers learn the life cycle and transmittal patterns in order to effectively use the technologies. Additional strategies are crop rotation, renewing of seeds, use of chemical and organic fertilizers, and earlier planting. In past experiments, the use of IPM has resulted in much lower of input costs and increased yields for almost all participants (Mauceri 2005).

The *Plataformas* also encourages the use of the Fripapa potato variety in the FFS. It is ideal for frying and processing and can easily be reproduced and disseminated by INIAP. Further, Fripapa has a degree of resistance to late blight, allowing farmers to use less agrochemicals, and matures earlier for harvest than other substitutes. Therefore, Fripapa is an ideal commercial variety for potato farmers in the region. The variety Gabriela is also encouraged in the FFS as high-value markets prefer it (Cavatassi 2009).

The database that I use for this analysis includes information about technology usage and I will discuss how I create indicator variables measuring technology adoption in the data description.

General Methods:

In order to evaluate the *Plataformas* program, a non-experimental program, researchers must account for the potential selection bias. Therefore, I must create a variable that will capture the observable differences between those who chose to participate and those who didn't. This variable will need to predict for participation in the program and be uncorrelated with outcome variables except through participation. Using this variable will allow me to capture the impact of the program on certain outcome variables. To do this, I borrow from the Cavatassi et al. initial impact analysis of the program because our final sample of households is almost identical. They use social capital variables, and I explain these and the process of propensity score matching (PSM) further in the full methodology. The non-experimental nature of the program also requires the use of PSM that corrects for the selection bias and only compares outcome variables of observations that have similar propensity scores.

Since I am conducting a gender analysis, I also need a way to distinguish between male and female influenced households. To do this, I use the sex of the main participant. This allows me to answer the question of whether or not females and males have different adoption rates. However, this variable is not readily available in the dataset, and I use several strategies of extracting this information for each participating household. The process of identifying the sex of the participant is described in the full methodology.

Before I conduct my research I also need to construct a comparison group, explore baseline characteristics of my observations, and describe my outcome variables. I do this in the following section.

Data Description:

I use a database compiled by the FAO and CIP of a survey that was administered from June to August of 2007 specifically for the evaluation of the *Plataformas*. Two local NGOs, *Fundación Marco* and *Maquita Cushunchic* (IEDECA), helped to administer the surveys to 1,007 households in the provinces Tungurahua and Chimborazo. Of the 35 communities surveyed, the program functioned in 18 communities and was not offered to 17 communities. Therefore, the members of 17 communities were not eligible for the program and I will refer to them as non-eligible. Within the 18 communities, some households, called the beneficiaries, chose to participate and some, called the non-beneficiaries, chose not to participate. Including the non-beneficiaries in the comparison group might underestimate the impact of the program if there was a spillover effect (i.e. if non-beneficiaries received an impact from the program from being in contact with the participants). However, excluding the non-beneficiaries is not ideal either because their observable characteristics are most likely very similar to the beneficiaries as they both lived in the same community. When Cavatassi et al. conducted the initial impact analysis they found no evidence for spillover effects. Therefore, I will include both the non-beneficiaries and non-eligible households as my comparison group and call them the non-participants, representing 683 households. I will rename the beneficiaries as the participants to form my treatment group, representing 324 households.

The extensive survey used to create the dataset contains information on the following: characteristics of owned, rented, and shared land, potato production, off-farm labor, use of agrochemicals, transaction costs, knowledge of potato viruses, welfare characteristics of the household and individual members, migration, credit, and social capital. The database also contains a community survey which captures information about the farmers that is constant for all members within each community such as the distance to the nearest market, altitude, soil quality, etc.

Baseline characteristics of the participants, non-participants, female participants, and male participants are shown in Table 1. On average, households own 2.58 hectares of land and have 2.97 plots. Most have soil appropriate for potato production with the average percentage of black soil being 79%. However the average household has 60% of its land located on an incline where potato production is less efficient. More than half of their land (58%) is irrigated to provide water in dry, winter months. Household variables show that 12% of households in the entire sample have a female head, 62% have an indigenous head, the average household size is 4.68 people, and the average head has 5.21 years of schooling. Welfare indicators describing housing show that 86% have exterior walls made of brick or cement, the materials considered to be the most advanced, 94% have access to public or private water, and 17% own a refrigerator. Households own on average 1.83 cows, 0.82 bulls, 0.17 oxen, and most own no pieces of valuable agriculture equipment. Social capital variables show that the sample's households are very active in non-agricultural organizations within the community with 84% participating. High levels of participation are also found in agricultural organizations as 19% of households have participated for more than one year.

A comparison of baseline characteristics of participants and non-participants also in Table 1 shows that there are few statistically significant differences between them, often with a small magnitude, and most of those characteristics should not greatly affect their production decisions. The participants and non-participants are similar across all household variables except for the head's education. Although this difference is significant at the one percent level, the magnitude is not large. The two subgroups are also very similar across land characteristics except for number of plots owned. Participants own 3.27 plots on average and non-participants own 2.83, but the difference is relatively small at only 0.44 plots. There are more variances between the two groups in welfare indicators: four percent more of non-participants have access to water, seven percent more of non-participants have concrete or brick walls, six percent more have a refrigerator, and non-participants have 0.38 more cows than participants. All of these differences seem to suggest that the non-participants are less impoverished, but the differences relative to the magnitude of the mean values are negligible. Finally, social capital variables are similar apart from participation in a women's, health, or education organization and participation in an agricultural association inside the community for more than one year. The difference in the latter is explained in the following section. The variation in women's, health, and education organization participation rates is of a large magnitude, which may suggest, upon initial observation, that these two groups are fundamentally different. However, this variable is more an indication of whether or not the household has a female with significant social capital accumulation. In fact, as I explain in the following section, it is used in my analysis to predict which non-participating households would have selected a female as the main participant had they participated. Therefore, since this variable influences the sex of the main participant rather than the household's initial decision to participate in the program, the significant and high magnitude difference between participants and non-participants should not be alarming.

A closer look at the differences between female- and male-participant households, to be referred to in this paper as FPH and MPH, along baseline characteristics is appropriate in order to set the stage for interpretation of any significant differences in their outcome variables. However, significant differences in baseline characteristics between these two groups will not result in any bias in my analysis. By hypothesis, I believe that FPH and MPH are different and am looking to explore those differences further. According to Table 2, the differences between FPH and MPH are much greater than the differences between participants and non-participants in this sample. Four out of the six household characteristics for the two groups are significantly different. The difference in female headship is understandable, as female-headed households should have more female participants. Additionally, the difference in the head's age is not surprising as many female heads are widows and therefore much older than the average head. The differences in dependency ratio and the head's education are of very small magnitude. However, variation in land and welfare characteristics are significant and large in magnitude: MPH owned 62% more land; 27% more of land owned by MPH was irrigated; 7% more of MPH had access to sewage; 19 and 13% more of MPH lived in a concrete or brick house and had concrete or brick walls, respectively; MPH had over twice as many cows and oxen on average.

All of these significant differences suggest that MPH are better off than FPH. This pattern is consistent with development theory that female-headed households tend to be more resource constrained than male-headed households and often live further below the poverty line. Finally, there are only two differences in social capital indicators between MPH and FPH. FPH are more likely to participate in agricultural associations outside of the community with a 14% participation rate compared to 4%of MPH. The other significant difference that also has a large

magnitude is in participation in a women's, health, or educational organization. 58% of FPH and 24% of MPH also participate in a women's, health, or educational organization. This large difference is intuitive as a household participating in a women's, health, or educational organization is most likely a household whose females have high levels of social capital, one of whom is likely set as the main participant. Furthermore, this difference presents a good candidate for a variable to help predict whether a non-participating household would have set a female as the main participant. As previously mentioned, this variable is explained in the next section.

For my indicator variables, I have three categories: primary program indicators, technology adopted, and FFS knowledge. The primary program indicators measure whether the program achieves its main goal of raising the farmers' wellbeing through increasing yields, productivity, and access to the market. I measure productivity with gross margins which are total potato revenues minus total variable costs and capture the returns to fixed costs of production (Cavatassi et al. 2009). Access to the market is captured by total potatoes sold and the share of harvested potatoes sold. The initial impact analysis found that all of these values were significantly different for participants and non-participants.

To answer my research question on whether FPH adopt more of the *Plataformas* technologies and follow the directions of the FFS more closely, I need to create variables for technology adoption and following the directions, the second category of outcome variables. There were five technologies that the *Plataformas* encouraged that are measured in the dataset: use of commercial seed varieties, fertilizer, insecticides, fungicides, and traps. Some of these technologies are already used by potato producers in the region, but they are often improperly adopted and their effectiveness is not fully reached (Mauceri 2005). Therefore, the FFS should encourage a greater degree of technology adoption in participants who are most eager to follow the program's directions. To measure the adoption of the technologies I use a combination of binary and continuous variables to show whether or not the technologies are used by the producers and the degree to which they are adopted. The FFS encouraged the use of all of these technologies, but preferred the Fripapa variety over Gabriela and supported preventative rather than curative fungicides.

In my last category of outcome variables I measure the retention of some of the FFS lectures on the toxicity of pesticides and the life cycle and characteristics of the three most common pests in the region. This section is meant to capture households who properly adopted technologies and paid attention to the specific directions that the agronomists mentioned. Knowing this information about the pests and toxicity levels is vital in properly using the *Plataformas* technologies. Without this dimension of my analysis, I would be giving equal weight to producers who blindly used the technologies and producers who not only decided to adopt, but also attended the FFS lectures and decided to follow the suggested directions. For the pests late blight, the Andean Potato Weevil, and the potato tuber moth, the survey asks respondents about how to tell if the virus has infected a potato plant, the cause of the virus, how to control the virus, and how the virus is transmitted. I put equal weight on all four of these questions for the three pests and aggregate them to form a single variable that measures the percentage of the questions that they answered correctly.

An initial look at differences in the outcome variables for MPH and FPH suggests that the program had a similar impact on both of them. Of all of the indicators in Table 3, only five had a statistically significant difference. The magnitude of these differences is quite large with FPH favoring the Fripapa and general commercial varieties more than MPH and MPH retaining more of the information from FFS lectures on pests. The knowledge difference suggests that

MPH more properly adopted the technologies, but there is less evidence in differences in total technologies adopted since use of the commercial varieties was just one the five *Plataforma* technologies tested in this analysis. The following section explains how I will use non-participants to control for the effect of the program.

Full Methodology:

In order to do an impact analysis of a non-experimental program researchers need to identify a variable that will capture the differences in participants and non-participants to use in their regression and control for the potential selection bias. The gender component of my analysis also requires an instrument to predict for female participation. I will explain these two key variables first and then describe how I use them in the PSM approach.

In order to control for the potential selection bias associated with choosing to participate in the *Plataformas*, Cavatassi et al. use variables that measure household participation in agricultural and non-agricultural organizations for more than one year. These variables predict for participation in the program, but are not correlated with any outcome variables except through participation. Cavatassi et al. explain that the program organizers heavily advertised the *Plataformas* to farmers who had already participated in an organization. They also set up organizations, both agricultural and non-agricultural, prior to the initiation of the program in order to prepare and qualify farmers for the transition into becoming a participant and explain the effectiveness of social organization. Therefore, major differences between percentages of participants and non-participants active in an agricultural group are most likely due to the agricultural organizations that the program formed prior to the *Plataformas'* initiation. In fact, they find that the participants participated in an agricultural organization within the community for an average of 4.01 years while the non-participants did so for an average of 9.93 years. This implies that the difference between percentages of participants and non-participants in agricultural groups is due to the participants' role in the *Plataformas*-preparation-oriented organizations. Additionally, there is no significant difference between the percentages of participants and non-participants in an agricultural organization for more than five years, the length of time that the *Plataformas* had existed since the time that the surveys were administered. These results indicate that prior to the *Plataformas*, the level of participation in agricultural organizations of the participants and non-participants was similar, and the only differences between them are due to the participation in the *Plataformas*-preparation-oriented organizations. Since these differences are observable, they can be controlled for through PSM.

In addition to the comments above, social capital variables are especially useful in determining whether or not households would have decided to participate when the structure of the *Plataformas* is considered. Participants in the program organize themselves into associations of farmers that use an intimate level of cooperation to jointly make potato production decisions and supply their harvests to buyers. Hence, prior experience in organizations is very helpful in predicting whether or not farmers will decide to join the program for two reasons: past experience in an association is likely to increase their trust in social organization and past experience in an association probably indicates households who already have a preference for participating in organizations and are therefore more likely to join the *Plataformas*.

Another characteristic that often results in selection bias is the smallholders' degree of motivation. This can be especially problematic because it is hard to measure and will likely affect outcome variables as those who are motivated enough to participate in a poverty

alleviation program are also likely to be more motivated and successful farmers. However, using variables that measure participation in organizations should capture, at least to some degree, the producers' motivation level. Choosing to participate in an agricultural or non-agricultural organization requires an input of effort, time, and motivation. Farmers who were motivated enough to participate in an organization most likely would have also had the necessary level of motivation to choose to participate in the *Plataformas*. However it is possible that a selection bias still exists even after these measures have been taken. This is something that all researchers of non-experimental programs must keep in mind. Therefore, I will use variables measuring household participation in agricultural and non-agricultural organizations to control for observable differences between participants and non-participants.

In order to test for the FPH's tendency to adopt *Plataforma* technologies and follow the FFS directions, I need to determine how I will measure the degree of female-influence within households. Female-headedness might seem logical, but I will not use it because there are too few female-headed households to do the analysis, and many development economists consider the use of self-reported headship to be unreliable. Instead, I use the sex of the main participant. This presents a challenge, of course, because this variable is not available for non-participants as they have no main participant. Therefore, I have to create an instrument to predict for female participation. Additionally, information on the sex of the main participant is not available in the survey data, and I have to cross-reference several sections of the database as well as other sources to determine it. In doing this, I make a contribution to the dataset.

The question in the survey that presented information on the main participant addressed to the interviewee was "Who in your family is the main participant of the *Plataformas*? (a) head of household (b) spouse (c) son/daughter (d) mom/dad (e) other." It is most likely that respondents assumed for choices c through e that those positions were in relation to the interviewee. For households that responded with (a), I simply crosschecked this with the sex of their household head. For households that responded (b), I used the name of the respondent and the name of their spouse to determine the sex of their main participant. Standard gender associations with certain names were used here. For options (c), (d), and (e), I used a list of the names of main participants. However, because the pool of potential spouses in rural communities is relatively small causing many people to share common names, this source was not enough to determine the sex of the main participant in many cases. I further investigated the main participant by looking within undetermined households to see whether or not a female or male of an appropriate age was present to perform the duties of a *Plataformas* participant. Using these strategies, I was able to identify the sex of the main participant for all 205 participant households that completed the agricultural cycle in the year prior to the interview. I found that there are 65 female and 140 male participants in the sample once non-harvesters had been dropped. Non-harvesters were dropped because primary indicators of the impact of the program would not be available for them. This action decreased the sample to 648 households: 443 non-participants and 205 participants.

Once the sex of the participant was determined, I realized that a large number FPHs also had a family member participating in a women's, education, health, nutrition, or family planning organization. Since the focus of these organizations, which I will now refer to as womanly organizations, is on preferences that are strongly associated with females, it is likely that it was a female family member that participated in them. Households with a female participating in a womanly organization are likely to be households that would set that female as the main participant had they participated. This is because experienced organization participants are likely

to have more trust in the act of organizing. Therefore, household participation in womanly groups is a good candidate for an instrument for the sex of the participant.

In order to test for the strength of the dummy instrument described in the above paragraph which I will refer to as Womanly, I looked at the representation of households with male and female participants within it and tested for its significance in predicting the sex of the participant for *Plataformas*-participating households. I found 192 households where Womanly equaled one and 456 households where Womanly equaled zero. Of the participants where Womanly equals zero, 15.96% of them are female participants. Of the participants where Womanly equals one, 53.48% of them are female participants. Although this percentage does not seem very high, when compared to the percentage of females whose Womanly value is zero, it seems to be appropriate for predicting for female participation. Further, Womanly is significant at the 5% level and has a very large magnitude relative to other significant variables in predicting for female participation amongst *Plataformas* participants in a probit model. Therefore, Womanly is an appropriate instrument for female participation, and I will use it to predict female participation for the entire sample.

In order to carry out my analysis, first I must group my sample into those who would and would not have set a female as the main participant, regardless of whether or not they participated in the program. These predictions of MPH and FPH are made on the basis of my PSM variables that describe baseline characteristics and the Womanly variable mentioned in the description of key variable section. In this step, each household is assigned a propensity from zero to one on their likelihood of setting a female as the main participant. Households with a propensity of less than 0.5 are called predicted MPH and those with a propensity greater than or equal to 0.5 are called predicted FPH. Then within each of these two samples, I conduct PSM on participation in the *Plataformas* and each predicted MPH and FPH is assigned a covariate that measures their propensities to participate in the program. Finally I find the average treatment effect on the treated households with kernel matching for each of my outcome variables. But first I must explain the necessity of using PSM in this analysis.

To evaluate an experimentally set up program where treatment and control groups were randomly assigned prior to the initiation of the program, researchers can reasonably assume that the only difference between the treatment and control observations is that the treatment went through the program and the control did not. This is because the determination of whether or not a household participated in the program is not correlated with any characteristic; the probability that a randomly drawn household is a participant is based on nothing but random chance. Therefore, there are no hidden characteristics about the treatment observations that are correlated with their participation in the program.

However, these assumptions cannot be made about non-experimental programs like the *Plataformas* where the treatment and control groups were formed by participants' self-selection. Standard weighted least squares models do not account for the selection bias. Furthermore, Cavatassi et al. tested other methods and found PSM to be the most robust. Therefore, I will use PSM which does not assume linearity and controls for the selection bias through the use of balancing covariates within participating and non-participating groups. Covariates are created by a vector of PSM variables that describe baseline characteristics of households and help to predict for their participation in the *Plataformas*. A probit model is used to predict for program participation based on these variables and creates the covariates or propensities to participate in the program, not conditional on whether or not households in fact did participate. This vector of

PSM variables allows researchers to compare treated households to comparison group households with similar likelihoods of participation.

As I mentioned in the data description, I will use households in non-participating communities as well as households in communities where the program was offered but who chose not to participate to form my comparison group. In order to control for the selection bias, once I have formed my predicted MPH and predicted FPH groups, I will use social capital variables and pay special attention to participation in agricultural associations for a longer period of time than the *Plataformas* was initiated to avoid endogenity.

Once I have done PSM on all of my outcome variables I can make conclusions about how the program impacted the predicted FPH, who actually participated relative to predicted FPH who did not participate, and, similarly, how it impacted the predicted MPH who did participate relative to predicted MPH who did not participate. From now on I will refer to the predicted FPH and predicted MPH who participated as female participants and male participants, and I will refer to the predicted FPH and predicted MPH who did not participate as female non-participants and male non-participants. Note that these groups still represent households and not individuals. However because the female and male participants (or predicted participants) within each household have a lot of bargaining power and control of household resources, the results of this analysis may be extended to the individual males and females, and conclusions can be made about their individual preferences.

Although it is possible through PSM to compare female and male participants to female and male non-participants in order to determine how the program affects men and women differently, due to the non-linearity of PSM, there is no test to compare the difference between male participants and male non-participants to the difference between female participants and female non-participants. It is possible, however, to note this comparison without commenting on the significance of it.

Results:

It is clear from looking at Table 4 that both male and female participants benefited from the program. However the degree of the impact varies and is different for men and women. Additionally there is no clear pattern on gender differences in technology adoption. Examining the primary program impact, female participants had no significant differences from non-participants while male participants were significantly different from non-participants for three of the four indicators. The small sample size for the female participants and non-participants most likely ensured that there would be no statistically significant differences despite large absolute differences amongst the primary program impact indicators. This is most clear in the females' yields. The reported female non-participants' yields (4,076.03 kg/ha) are only 38% of the female participants' (10,496.96 kg/ha), however the standard error was quite large (4,515.42 kg/ha) and prevented the difference from being significant. This set of outcome variables fluctuates the most, creating higher standard errors than the other two categories. Nevertheless, male participants sold 73% more potatoes, increased their share of harvested potatoes sold by 10%, and increased gross margins 12 fold compared to non-participants and all of these differences were significant. Although the increase in yields for males and females was not statistically significant, the differences were large and positive. The females had positive but insignificant increases in total potatoes sold and the share of harvested potatoes sold, but gross margins actually decreased by 60% although this change is also insignificant. Again, such

strange and non-statistically significant results are most likely due to the small female sample size.

The technology adopted indicators show many significant increases in technology usage for both males and females, but one gender did not seem to adopt more of all of the technologies than the other. Both males and females experienced positive significant increases in Fripapa usage and decreases in Gabriela usage that can be seen both in the percentage of producers using the varieties and the share of those varieties in the smallholders' total planted potatoes. However, an interesting difference is that females did not have significant differences in usage of either commercial variety nor in the share of commercial varieties in total planted potatoes. This seems to be due not to large standard errors, but to the female non-participants already high levels of commercial variety usage. Commercial varieties made up 28% more of total planted potatoes for female non-participants than for male non-participants and 28% more of female non-participants used either commercial variety than male non-participants.

Neither females nor males had significant changes the amounts of applied fungicides or insecticides, but both experienced significant increases in the percentage using insecticides, with a much larger increase for women (28%) than for men (8%). This is likely due to the fact that most male non-participants (80%) already used insecticides while only 49% of female non-participants used insecticides. Differences in male and female participants' usage of all agricultural applications were insignificant. Similarly females' 15% increase in chemical fertilizer usage was significant while males' 4% increase was not. This difference is likely due to male non-participants' high usage (93%) of chemical fertilizers relative to females' (83%).

Both females and males experienced large and significant increases in trap usage, with males' increase slightly larger than females'. Males increased their total traps used per hectare by almost 9 fold and 47% more male participants used traps than male non-participants. Females increased their total traps used per hectare by 7 fold and 33% more female participants used traps than female non-participants.

The program had positive, large, and significant differences in the FFS knowledge variables between male and female participants and male and female non-participants. The significant differences were as follows: for knowledge of pests male participants answered 14% and female participants answered 7% more of the questions correctly than the corresponding non-participants; 12% more female participants and 13% more male participants know the exact order of toxicity levels in pesticides than non-participants; 19% more female participants and 16% more male participants can identify the most toxic pesticides than non-participants; 15% more male participants can identify the least toxic pesticides. However in each one of these categories, both male participants and male non-participants have higher mean values than their female counterparts. Additionally even after attending FFS lectures, both male and female participants have a poor knowledge of agricultural pests, scoring only 40% and 29% of the questions correctly, and both have few producers who can identify toxicity levels in pesticides with accuracy.

Conclusions:

This analysis examines whether or not female and male participants of the *Plataformas de Concertación* follow the directions of the FFS and adopt the FFS technologies differently. It also looks to see if the primary impact of the program was gendered. Through the use of a probit model and PSM, I account for the non-experimental nature of the program. I use social capital

accumulation to capture the observable differences between participants and non-participants to account for the selection bias. Additionally I use household participation in a women's, health, or education organization to predict for whether households would have set a female as the main participant. First I separate the sample into predict female participants and predicted male participants. Then within each of those subgroups I run PSM on participation in the *Plataformas* and calculate the ATT on all of my outcome variables with kernel matching.

The program clearly helped males improve their welfare as most of the differences between male participants and male non-participants for the primary program impact variables are positive, large, and significant. However, the lack of significant differences between the female participants and non-participants is not a meaningful result because the predicted female sample size was very small and large standard error may have inhibited any significant differences rather than a poor program impact on females.

The results show that the program has clearly helped both males and females adopt more technologies and improve their agricultural knowledge. Simple t-tests between male and female participants on all outcome variables show that the two groups only differ in the use of the Fripapa and Gabriela varieties and in the knowledge of the region's most common pests. This suggests that most of the differences in the impact of the program on males and females is due to differences in the female and male non-participants. In other words, it is not the program that is affecting male and female producers differently and allows one group to advance further than the other, it is the differences in their technology adoption and agricultural knowledge score before entering the program that accounts for the differences between changes from non-participants to participants for both males and females. This seems to be the case for adoption of commercial varieties and the attainment of FFS knowledge.

A surprisingly high percentage of female relative to male non-participants used commercial varieties and a very high percentage of their total planted potatoes were of the commercial kind. This seems to imply that households with a social-capital-holding female[1] are more inclined to adopt commercial varieties without the encouragement from FFS than households without a socially active female.

Potential policy implications of this analysis are to continue teaching smallholders about IPM techniques, but to put more emphasis on conveying the details on how to properly use the new technologies such as by further stressing the importance of understanding agricultural pests. Although the program had a significant increase in knowledge variables for both males and females, the knowledge scores for them are still very low and could result in improper usage of technologies.

Future research should focus on gender differences in poverty alleviation programs' impacts on primary welfare indicators since the small sample size in this analysis greatly inhibits any conclusions to be drawn there. Policymakers should make sure to design more gender aware surveys that make the measure of differences in gender's bargaining power, social capital, and productive contributions more obvious. This gender component to the evaluation can be costly, but development practitioners should be encouraged to invest in it given the integral role that women play in stopping the intergenerational transmittal of poverty.

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[1] Household participation in a women's, health, or education organization was how we determined whether as household was a predicted "female participant" or not (i.e. whether or not it would have set a female as the main participant). According to development theory on women's preferences for health and education, it is most likely that these predicted "female participants" are households with a female active in a women's health, or education organization, and therefore with a social-capital-holding female.

Table 1. Testing for Differences in Baseline Characteristics: Participants vs. Non-participants at Household Level

	All	Participant	Non-participant	Difference	Significance of Difference
Household					
Household size (#)	4.68	4.72	4.67	0.05	
Female-headed household	12%	12%	12%	0%	
Indigenous head	62%	57%	64%	-7%	
Head's education (yrs)	5.21	5.63	5.01	0.62	***
Head's Age (yrs)	42.24	42.01	42.35	-0.34	
Dependency ratio	0.29	0.30	0.29	0.01	
Land					
Land owned (ha)	2.58	2.56	2.59	-0.03	
Plots owned (#)	2.97	3.27	2.83	0.44	**
Black soil	79%	77%	80%	-4%	
Flat land	40%	38%	41%	-3%	
Irrigated land	58%	54%	60%	-5%	
Welfare					
Access to Water	94%	92%	96%	-4%	**
Access to Sewage	7%	6%	7%	-1%	
Concrete/brick House	86%	84%	87%	-3%	
Concrete/brick walls	87%	82%	90%	-7%	***
Cooking Facilities	54%	58%	53%	5%	
Refrigerator	17%	13%	19%	-6%	*
Cows (#)	1.83	1.57	1.95	-0.38	*
Bulls (#)	0.82	0.88	0.79	0.09	
Oxen (#)	0.17	0.21	0.15	0.06	
Credit Constrained	21%	20%	21%	-1%	
Social Capital					
Women/Health/Education Org.	27%	35%	24%	11%	***
Non-Ag. Ass. Outside Comm.	17%	18%	17%	1%	
Non-Ag. Ass. Inside Comm.	84%	84%	84%	1%	
Ag. Ass. Outside Comm.	7%	7%	6%	1%	
Ag. Ass. Inside Comm. (>1yr)	19%	34%	12%	22%	***

Note: * = statistically significant at the 10% level; ** = significant at the 5% level; *** = significant at the 1% level

Table 2. Testing for Mean Differences in Baseline Characteristics: Female Participants vs. Male Participants at Household Level

	Female Participant	Male Participant	Difference	Significance of Difference
Household				
Household size	4.85	4.66	0.19	
Female-headed household	28%	4%	23%	***
Indigenous head	65%	54%	11%	
Head's education (yrs)	5.03	5.91	-0.88	**
Head's Age	44.89	40.68	4.21	**
Dependency ratio	0.33	0.28	0.05	*
Land				
Altitud				
Land owned (ha)	1.80	2.91	-1.11	**
Plots owned (#)	3.15	3.32	-0.17	
Black soil	74%	78%	-4%	
Flat land	39%	37%	2%	
Irrigated land	36%	63%	-27%	***
Welfare				
Access to Water	91%	92%	-1%	
Access to Sewage	11%	4%	7%	**
Concrete/brick House	71%	90%	-19%	***
Concrete/brick walls	74%	86%	-13%	**
Cooking Facilities	51%	61%	-11%	
Refrigerator	8%	16%	-8%	
Cows (#)	0.87	1.89	-1.02	***
Bulls (#)	0.49	1.06	-0.57	***
Oxen (#)	0.23	0.20	0.03	
Credit Constrained	20%	19%	1%	
Social Capital				
Women/Health/Education Org.	58%	24%	34%	***
Non-Ag. Ass. Outside Comm.	23%	15%	8%	
Non-Ag. Ass. Inside Comm.	88%	83%	5%	
Ag. Ass. Outside Comm.	14%	4%	10%	**
Ag. Ass. Inside Comm. (>1yr)	26%	37%	-11%	

Note: * = statistically significant at the 10% level; ** = significant at the 5% level; *** = significant at the 1% level

Table 3. Testing for Impact Differences between Male and Female Participants
(Mean values reported at the household level)

	All	Female Participant	Male Participant	Difference	Significance of Difference
Primary Program Impact					
Total Yields (kg/ha)	8,481.78	9,256.37	8,122.15	1,134.22	
Total Potatoes Sold (kg/ha)	4,960.33	4,354.50	5,241.61	-887.11	
Share of Harvested Potatoes Sold	50%	47%	51%	-4%	
Gross Margins ($/ha)	252.45	108.54	319.27	-210.73	
Technology Adopted					
Used Fripapa Variety	70%	83%	64%	20%	***
Used Gabriela Variety	33%	38%	31%	8%	
Used Either Commercial Variety	88%	98%	84%	14%	***
Fripapa Share of Planted Potatoes	54%	62%	50%	13%	**
Gabriela Share of Planted Potatoes	20%	22%	19%	3%	
Commercial Variety % of Planted Potatoes	73%	84%	68%	16%	***
Curative Fung. Applied (kg/ha)	3.70	4.34	3.40	0.94	
Prevent. Fung. Applied (kg/ha)	2.81	2.69	2.86	-0.17	
Used Insecticide	86%	82%	89%	-7%	
Insect. Applied (kg/ha)	3.03	2.88	3.10	-0.22	
Used Organic Fertilizer	73%	74%	73%	1%	
Used Chemical Fertilizer	97%	98%	96%	2%	
Used Traps	53%	51%	53%	-2%	
Total Traps used (#/ha)	66.79	67.54	66.45	1.09	
FFS Knowledge					
Knowledge of Pests	38%	32%	40%	-8%	***
Knows Exact Order of Toxicity Levels	19%	18%	19%	-1%	
Knows Most Toxic Pesticides	25%	28%	24%	3%	
Knows Least Toxic Pesticides	21%	23%	20%	3%	

Note: * = statistically significant at the 10% level; ** = significant at the 5% level; *** = significant at the 1% level

Table 4. Impact of Program on Females and Males
(mean values reported at the household level)

	All	Female Non-part.	Female Part.	Diff.	Signif. of Diff.	Male Non-part.	Male Part.	Diff.	Signif. of Diff.
Primary Program Impact									
Total Yields (kg/ha)	7,006.15	4,076.03	10,496.96	6,420.93		6,155.59	7,684.39	1,528.80	
Total Potatoes Sold (kg/ha)	3,554.87	1,473.99	3,686.02	2,212.03		2,963.03	5,130.71	2,167.68	**
Share of Harvested Potatoes Sold	45%	32%	34%	2%		45%	55%	10%	**
Gross Margins ($/ha)	107.77	24.18	10.57	-13.61		25.89	340.82	314.93	**
Technology Adopted									
Used Fripapa Variety	39%	32%	78%	46%	***	30%	66%	36%	***
Used Gabriela Variety	45%	72%	48%	-24%	**	36%	30%	-7%	***
Used Either Commercial Variety	75%	90%	98%	8%		62%	85%	23%	***
Fripapa % of Planted Potatoes	29%	19%	53%	34%	***	20%	52%	32%	***
Gabriela % of Planted Potatoes	30%	53%	26%	-26%	**	24%	18%	-6%	
Commercial Variety % of Planted Potatoes	59%	72%	79%	7%		44%	70%	26%	***
Curative Fung. Applied (kg/ha)	4.20	2.62	5.83	3.21		2.58	2.88	0.30	
Prevent. Fung. Applied (kg/ha)	3.17	1.79	3.35	1.56		2.90	2.74	-0.16	
Used Insecticide	80%	49%	78%	28%	**	80%	88%	8%	*
Insect. Applied (kg/ha)	2.23	1.13	3.51	2.38		1.84	2.72	0.88	
Used Organic Fertilizer	61%	77%	68%	-9%		56%	74%	18%	**
Used Chemical Fertilizer	94%	83%	98%	15%	**	93%	97%	4%	
Used Traps	23%	8%	41%	33%	***	9%	55%	47%	***
Total Traps used (#/ha)	26.37	7.45	60.97	53.52	**	6.95	69.10	62.15	***
FFS Knowledge									
Knowledge of Pests	28%	22%	29%	7%	**	26%	40%	14%	***
Knows Exact Order of Toxicity Levels	10%	3%	15%	12%	*	7%	21%	13%	**
Knows Most Toxic Pesticides	14%	4%	23%	19%	**	10%	26%	16%	***
Knows Least Toxic Pesticides	11%	6%	18%	11%		7%	22%	15%	***

Note: * = statistically significant at the 10% level; ** = significant at the 5% level; *** = significant at the 1% level

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