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Adoption of certified organic technologies:

The case of coffee farming in Colombia⁺

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Abstract

Agricultural production is an important source of income and employment for developing countries, yet it is the cause of serious environmental problems. Though ECO-labels appear as a promising alternative to control the negative effects of agriculture on the environment and to increase the income of rural poor, the proportion of agricultural land and exports certified as is quite small. We investigate the factors that affect the adoption of certified organic coffee in Colombia and in particular study the effect of economic incentives on adoption. We find that those who have lower cost of adoption are more likely to be certified as organic. Correcting for sample selection, we find that certified organic production is 40% less productive and 31% less costly than non-certified production. Given the price premium in 2007, certified organic production is 15% less profitable than non-organic production. We find that in order to make organic production attractive, the price premium of certified organic coffee should be about 5 times higher than in 2007.

Keywords: Technology adoption, Switching regression models, Organic Coffee, Colombia

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1. Introduction

Agricultural production is an important source of income and employment for developing countries. The World Bank (2008a) estimates that in agriculture-based countries 29% of GDP corresponds to agricultural production while in transforming and urbanized countries more than 30% of the GDP corresponds to agribusiness, food industry and services. From 5.5 billion people living in developing countries, about 2.5 billion are involved in agriculture and of those 1.3 billion are smallholders and landless workers. Agriculture is not only an important source of income in developing countries, but it is also responsible for serious environmental damage. For instance, agricultural activity has been associated with underground water depletion, land degradation, water and soil pollution and health problems (World Bank, 2008a). Other environmental impacts associated with agriculture are loss of biodiversity, deforestation, soil erosion, spread of livestock diseases and global climate change (Isik, 2004; Sterner, 2003, World Bank, 2008a).

The control of environmental impacts of agriculture is challenging. On one hand, the implementation of command and control regulations is difficult because of weak institutions, lack of political will, and the high transactions costs due to lots of small-scale polluters. On the other hand, poverty can cause or be the result of environmental degradation (e.g. Duraipappah, 1998). According to the World Bank (2008a), three out of four poor people living with less than one dollar a day lives in rural areas. A promising alternative to control the negative effects of agriculture on the environment and to increase the income of rural poor is ECO-labels. Awarded by a third party who controls that the production meets specific environmental criteria, ECO-labels allow consumers to compensate producers who use environmentally friendly and socially responsible practices. In the last two decades Eco-labels grew fast and more than 100 labels for food production have been created worldwide (www.Ecolabelling.org). Though the different labels privilege different environmental aspects of production, the non use of chemical fertilizers, the protection of the forest and the conservation of wildlife has been the focus of organic certificates. Certified organic cultivation generates positive impact to the community in the form of improvements in the environment. In addition, farmers benefit from improved market access and reduced health problems (e.g. intoxication due to misused of agrochemical) (IFAD, 2003; Parrot et al., 2007).

In response to the increase in demand for sustainable production, certified organic technologies have expanded rapidly and the areas certified as organic more than tripled between 2000 and 2008 (Willer and Yussefi, 2000 and 2008). Despite the high growth rates of certified organic production, its development is less salient when it is evaluated in terms of proportion of agricultural land and proportion of exports from developing countries. For instance, Colombia, the third largest producer of green coffee in the world with about 12% of the world production, has less than one percent of the area with coffee certified as organic. In 2002, from total exports of 10.3 million bags only 88 thousand were certified as organic (Giovannucci, 2002; Murgeito and Sandoval, 2004; Esguerra, 2001; Willer and Yussefi, 2008). A better understanding on the factors that motivate the adoption of certified organic technologies is needed to design instruments and policies that favor environmentally friendly technologies.

Though certified organic coffee producers receive a 5 to 10% price premium (depending whether the cooperatives commercialize the product through an intermediary or directly), it is not clear whether this premium is enough to compensate the lower productivity and the potential higher labor cost of organic production compared with non-organic production. Neither is clear the magnitudes of productivity loss due to organic cultivation or the differences in production cost between certified and non-certified production. A proper assessment of the economic performance (productivity, cost and profitability) under different technologies is required to evaluate the economic incentives of adoption of certified organic coffee. The direct comparison of performance for adopters and non adopters of certified organic coffee would be bias if the individual characteristics that determine the decision to get certified are correlated with economic performance. Hence, the estimation of productivity, production cost and net return needs to take into consideration the self-selection into different technologies.

The objective of this paper is twofold. First, we study the factors that promote and retard adoption of certified organic coffee in Colombia. In particular we consider the effect of net return of adoption in the decision to get certified. Second, we evaluate the economic incentive of organic cultivation estimating the productivity, production cost and net return for organic and non-organic coffee cultivation. Though, there is a considerable large tradition in the study of adoption of new technologies (see Feder, Just and Zilberman, 1985; Feder and Umali, 1993; Mercer, 2004 and reviews on adoption studies), the effect of net return of adoption has been largely disregarded. One of the exceptions are Pitt et al. (1991) and Fuglie and Bosch (1995).

However, unlike those authors, in the case of organic production is important to consider also yields and cost of different technologies. This paper contributes to existing literature studying simultaneously the yield, production cost and return of certified organic and non-certified producers. Based on this analysis we do some recommendations on the minimum price premium for certified coffee.

The adoption of organic coffee in Colombia was studied previously by Muñoz and Moreno (2001), Ospina and Farfal (2003) however one limitation of these studies is that the criteria used to evaluate the potential for organic coffee is assumed rather than derived from farmer's behavior. This limitation is partly overcome in Otero (2004) and Tudela (2006) who used survey data to explain the adoption organic coffee in Colombia and Peru, respectively. However, these studies suffer from multiple endogeneity problems. We use retrospective questions to build a panel data and use information on behavior in 1997 as an instrument.

The return and production cost of certified and non certified organic coffee was previously studied by Ospina et al. (2003), however, the small number of observations used in the analysis (14 farms) and the lack of correction for sample selection limit the significance of their results.

The rest of the paper is organized as follows. In the next section we present a background of organic coffee cultivation in Colombia. In the third section we present the econometric model and suggest an estimation mechanism. In the fourth and fifth sections we present the data and discuss the results, respectively. We conclude with some discussion.

2. Coffee cultivation in Colombia

Coffee is the most important agricultural product in Colombia employing 29.5% of the rural population and generating 12.4% of the agricultural GDP (FNC, 2008). About 18% of rural households directly depend on coffee for income either through coffee harvesting or through wage labor (Giovanocci, 2002). Historically, coffee has been cultivated by small farmland holders. 55% of the farms with coffee have less than 5 hectares and the average size of a coffee field is 1.4 hectares.

As other agricultural products, under the green revolution, coffee cultivation transformed and the proportion of technically planted coffee increased from 0.22% to 70% between 1970 and 1997 (Guhl, 2004). The intensification in coffee cultivation was possible, as new varieties were developed so traditional plantations under shadow were replaced by varieties that could be

cultivated under full sun exposure. According to the National Coffee Farmers Association – (FNC, 2008) 47% coffee is grown under full sun exposure and in some regions this percentage reaches up to 78%. The modernization of coffee cultivation has allowed increase in production as it is estimated that yields per hectare year in full sun exposed plantations are between 2500 to 4000 kg compared with 500 to 1000 kg for shadow plantations (FNC, 2008). However, the modernization of coffee cultivation has generated various environmental concerns. First, the reduction in forest coverage is associated with lost in biodiversity. Greenberg, R., et al. (1997) found that full sun coffee plantations support 90% fewer bird species than shade-grown coffee. Second, various studies have found the erosion is higher in sun exposed plantations compared with shade coffee (e.g. Ataroff and Monasterio, 1997, Sancho, 1991, Bermudez, 1980). Another drawback of sun exposed coffee plantations is the dependence on fertilizers and pesticides. The sun exposure makes coffee areas more susceptible to weeds and pest and the reduction in organic material from trees increases the requirements of chemical fertilizers. For example, according to WWF (2008), in Costa Rica, the government recommends that sun coffee producers apply 30 kilograms of nitrogen per hectare per year compared with shade coffee producers who use little or none. However, the use of nitrates and agrochemicals can contaminate groundwater affecting microorganism and causing health problems.

Further, coffee procession generates additional environmental impacts. The removal of the mucilaginous pulp using the wet method¹ is water intensive and contaminates the water. It is estimated that 40 to 60 liters of water are needed to process 1 kg of dry pergamine coffee. The processing of coffee beans besides being water intensive generates water contamination as the residuals from coffee processing are freely disposed into rivers and fields (Zambrano and Isaza, 1998).

Consumers' concerns about the environmental and social impact of coffee cultivation (and also their health) led to the emergence of Eco-Labels. Some of the most popular of such labels are Organic, Rainforest Alliance, Fair-trade and Utz Kapeh. The emphasis that these labels give to environmental protection varies but it is the organic label the one that is the most demanding. Organic cultivation goes beyond prohibiting the use of agrochemicals and promotes a systemic view of the farmland. Hence besides compelling the use of organic fertilizers as compost and

¹ Under this method, the coffee beans are first fermented in water tanks to remove the mucilaginous pulp and are later washed to remove the residuals.

organic matter it requires the use of traditional techniques as crop rotation, grass coverage and integrated pest management.

The first experiences of certified organic coffee cultivation in Colombia started in the 1980 when NGO promoted organic cultivation in different regions in the country. Since then, many more independent firms have worked all over the territory in promotion and commercialization of organic coffee. Esguerra (2004) estimated that in 2004 the potential exports of certified organic coffee were around 76 thousand sacs of 70 kg. In the last years, the production of certified organic coffee has grown and by 2007, the Agriculture Ministry had 76 producers or associations registered.

Organic technologies seem to be viable alternative for small farms that are already close to organic technologies and who belong to an association. Farms that are relatively big and have used agrochemicals are not suitable for organic agriculture due to the high labor demand (especially in the fertilization and weed control) and the drop in productivity that the transformation of the system causes in the first three years. Small farms can compensate for the higher labor demand of certified coffee employing family members and interchanging labor force with neighbors.

Even the possibilities of higher return, certified organic coffee faces many obstacles. First, producers do not have the discipline and education needed to maintain a system of registers as is required by the certifying authority. Second, producers have uncertainty about the profitability of the certification compared with the conventional technology and incomplete knowledge about the organic technology. Third, to reach the minimum production volume that makes commercialization profitable and to reduce the cost of certification small farmers need to associate which imposes additional coordination cost. Furthermore, the expansion of organic coffee might be limited by the existence of other certificates which offer a price premium with less demanding conditions on the environmental management (Fair Trade (FLO), Rain Forest, Starbuck, etc). In addition, the increase in the cost of organic material, posts a challenge to organic farms since only 40% to 60% of the needed organic fertilizers are produced in the same farm. The increase in the world supply of certified organic coffee threatens the further development of certified organic production as the price premium is expected to fall.

3. Econometric Model

The problem of the individual farmer is to decide whether to opt for certified organic production or not. Farmers are assumed to be utility maximizers and adopt certified organic coffee if the net utility from certification is positive. The net utility from certification, D^* , is a function of net incentive from certification ($y_{i1}-y_{i0}$) and a vector of observed (Z_i) and unobserved characteristics ε_i . D^* is non observable and we only observe if producers got certificated or not,

$$D_i = 1 \quad \text{if } D_i^* = (y_{i1}-y_{i0})' \delta_1 + Z_i' \delta_2 + \varepsilon_i > 0 \text{ and } D = 0, \text{ otherwise.} \quad (1)$$

The decision to get certified depends on the net incentive from certification ($y_{i1}-y_{i0}$). However, for each producer we only observe the outcome (yield, production cost or profit) either from being certified (y_{i1}) or from not being certified (y_{i0}). The observed outcome is a function of a vector of observed characteristics of the farm and the producer (X_i) and unobserved characteristics (u_i).

$$\begin{aligned} y_{i1} &= X_i' \beta_1 + u_{i1} \quad \text{if } D_i = 1 \\ y_{i0} &= X_i' \beta_0 + u_{i0} \quad \text{if } D_i = 0 \end{aligned} \quad (2)$$

A OLS estimation of (2) would lead to inconsistent estimators if the decision to be certified as organic is not random and the unobserved characteristics that affect adoption (ε_i) are correlated with the unobserved characteristics that affect outcome (u_{ik}). For example more motivated producers are likely to try new technologies and in turn realize higher profit. An alternative method is to use the two stage procedure suggested by Lee (1978). In this model the error terms are assumed to have a joint-normal distribution with zero mean and a non-singular covariance matrix. Hence the expected values of the truncated error terms ($u_{i1} | I=1$) and ($u_{i0} | I=0$) are:

$$\begin{aligned} E(u_{i1} | D=1) &= \sigma_{u1\varepsilon} \frac{\phi(\alpha)}{\Phi(\alpha)} = \sigma_{u1\varepsilon} \lambda_{i1} \\ E(u_{i0} | D=0) &= \sigma_{u0\varepsilon} \frac{-\phi(\alpha)}{1-\Phi(\alpha)} = \sigma_{u0\varepsilon} \lambda_{i0} \end{aligned} \quad (3)$$

Where $\alpha = X_i' \beta_1 + Z_i' \delta_2$, ϕ and Φ are the probability density and the cumulative distribution function, respectively. The ratios $\phi(\alpha)/\Phi(\alpha)$ and $-\phi(\alpha)/(1-\Phi(\alpha))$ are the inversed Mills ratios.

Previous studies have applied the switching regression model to study the effect of technology adoption on yields, costs or returns (Fuglie and Bosch, 1995; Shrestha and Gopalakrishnan,

1993; Blackman and Bannister, 1998; Solis et al., 2007, Rahman et al., 2009). In the first stage a reduced form of the probit model is estimated and the inversed Mills ratios are computed. ($D_i=1$ if $D_i^* = X_i'\beta + Z_i'\delta + \varepsilon_i > 0$ and $D_i=0$, otherwise). In the second stage the predicted Mills ratios are included in equation (2) so the new system of equations is:

$$\begin{aligned} y_{i1} &= X_{i1}'\beta_1 + \sigma_{u1\varepsilon}\lambda_{i1} + u_{i1} & \text{if } D_i = 1 \\ y_{i0} &= X_{i0}'\beta_0 + \sigma_{u0\varepsilon}\lambda_{i0} + u_{i0} & \text{if } D_i = 0 \end{aligned} \quad (4)$$

To account for heteroscedasticity in the errors terms u_1 and u_0 , Freeman et al. (1998) suggested the use of weighted least squares. However, to apply this procedure it is required to know the exact form of heteroscedasticity. An alternative approach to obtain an consistent estimation of the model is to estimate (4) using a maximum likelihood estimation or to estimate (1) and (2) simultaneously using the full information maximum likelihood (FIML) (Pitt and Sumodiningrat, 1991 and Alene and Manyong, 2007, Rahman et al. 2009). In this paper we use a two stage procedure. In the first stage a probit model is estimated in the second stage a generalized least squares model that includes the estimated mills ratios is estimated.

The significance and magnitude of the estimated correlation coefficients ($\sigma_{u1\varepsilon}$ and $\sigma_{u0\varepsilon}$) has an economic interpretation (Fuglie and Bosch; 1995). If the estimated coefficients are different from zero, then there is sample selectivity. In addition, if the correlation coefficients have different sign, individuals adopt on the basis of their comparative advantage (i.e. those who adopt have above average returns from adoption than those who did not adopt). On the other hand if the correlation coefficients have the same sign, it indicates hierarchical sorting (i.e. adopters have above average returns whether they adopt or not, but they are better off adopting than not adopting. Those who did not adopt have below average returns in either case but are better off not adopting).

Using the estimated parameters in the model, it is possible to predict the net outcome from adoption for each farmer correcting for selectivity bias. The expected net outcome for adopters is: $E(y_{i1}| D=1) - E(y_{i0}| D=1) = X'(\beta_1-\beta_0) + (\sigma_{u1\varepsilon} - \sigma_{u0\varepsilon}) \lambda_{i1}$ while the expected net return for non adopters is $E(y_{i1}| D=0) - E(y_{i0}| D=0) = X'(\beta_1-\beta_0) + (\sigma_{u1\varepsilon} - \sigma_{u0\varepsilon}) \lambda_{i0}$.

Finally, the estimated net return functions are used to estimate the net incentive to be certified ($(\Pi_{i1}-\Pi_{i0})$) and to estimate the structural probit model as equation (1).

4. Data and Variables

4.1. Data

We design and conducted a survey with 377 farmers living in Cauca.² The interviews were conducted in Inza, Cajibío, Tambo, Timbio and La Sierra. Cauca is one of the most important regions with certified organic coffee in Colombia. In 2007 there were 331 farmers and 587 hectares of coffee certified in the area of our study. In addition, 162 farmers and 211 hectares were in transition towards certification. Farmers were randomly selected from the list of organic coffee cultivators and from the general register of coffee farmers. The interviews were carried out individually and lasted 40 min in average.

Besides asking standard questions on socioeconomic characteristics of the household, we explained participants that one of the objectives of the study was to learn more about the evolution of agricultural practices during the last 10 years and asked them about farmland characteristics and coffee cultivation in 2007 and 1997³. We also asked about production of certified coffee where three different certificates were considered: organic coffee, fair-trade and rainforest alliance. Finally, we asked about the income from coffee cultivation and production cost. We valued family work in own farm according to the market price of labor. Net return was estimated as revenue minus production cost.

4.2. Variables and empirical model.

We used a two-stage procedure to estimate equations (1) and (5). In the first stage we used a probit model to explain the decision to get certified. The estimated coefficients are used to compute the inversed mill ratios as in equation (3). In the second stage we estimated separate equations for yields, production cost and net return and for certified organic and non-certified

² Previous the survey we conducted a pilot study in Riosucio Caldas where 54 producers were interviewed.

³ It is important to notice that coffee prices in 1997 were the highest in the last two decades reaching 1.31 US per lb. This might have induced to changes in the agricultural practices, though in general we expect that transformation of productive system is slow.

coffee farmers. In this regression we included the mill ratios estimated in the first stage to correct for self-selection. We used generalized least squares model to obtain consistent estimators of the parameters.

Yields, cost and net return are measured by hectare and are normalized using natural logarithms. Yields, cost and net return are modeled by a trans-log function as follows:

$$\ln(y_i) = \beta_0 + \sum_k \beta_k \ln(x_{ik}) + \sum_k \sum_j \beta_{jk} \ln(x_{ik}) \ln(x_{ij}) + \sum_d \delta_d X_{id} + \sigma_{id} \lambda_d + \mu_i \quad (6)$$

Where y represents the output variable and x represents the price vector of variable factors and other fix factors. We considered three output variables: yields, production cost and profit. Yields are measured as arrobas of green coffee per hectare. Production costs include the cost of labor and inputs per hectare planted with coffee and net return is defined as revenue minus productive cost. In the price vector we considered the wages and fertilizer. Wage is measured as average daily wage in all cultural activities except collection and proceession. Price of fertilizers is measured as the average price per kilogram of fertilizer. Profits, wages and price of fertilizer are relative to the price of one arroba of coffee. In the fix factors we considered area planted with coffee (in hectares) and capital measured as the value of the productive capital (machinery for coffee processing and other equipment). Among the socioeconomic characteristics (X) we considered family size and number of years of education. The effect of institutional programs that support coffee cultivation is captured by the number of workshops or courses in which the household have participated during the last year. Finally, we include a dummy variable for fertilization and pest control during the last year. The Mills ratios estimated in the first stage (probit model) are represented by λ .

We expect that a higher net return from certified coffee vs. conventional coffee increases the likelihood to get certified. It is expected that farms that were closer to organic production previous to the certification will be more likely to be certified as the transformation cost is lower. For instance maintaining a system of registers previous to the adoption is expected to increase the likelihood to adopt. On the other hand, having used agro-chemicals previously is expected to reduce the likelihood to adopt due to the productivity shock that production suffers when the new technology is adopted. Farms that have higher operation cost, for example that are bigger, or

have less availability of family labor are expected to be less likely to be certified. Other socioeconomic characteristics are expected to affect adoption. Being more educated is expected to increase the likelihood of adoption as it makes easier to learn the new technology and comply with the requirements of the certifying agency. Having had a good disposition towards associations (belonging to productive associations) is likely to increase the likelihood to switch to an organic technology as it makes easier to work cooperatively. Finally we expect to find a positive learning effect given by participation in courses and workshops about coffee cultivation as it would denote a positive attitude towards change.

5. Results

5.1. Descriptive statistics

The descriptive statistics of the variables included in the analysis are presented in Table 1. Our sample of producers is composed by people who were relatively poor. Sixty seven percent of the respondents have a farm with two or less hectares and own productive assets with a value of 1,800 thousand COL (\$900 dollars). The education level of the participants is also quite low and 90% of the participants have at most primary education. The average size of the household is 5 people. The participation in associations is relatively high and about forty percent of the respondents belong to the Coffee Growers Cooperative. All the farmers included in our sample cultivated coffee in 2007, though only 88% of cultivated coffee in 1997. Coffee is the most important agricultural product and 71% of the participants cultivate all their farmland with coffee. Other products cultivated in the farmland are sugar cane, plantain and fruit trees.

The average yield of coffee for our sample is 8.8 sacs of 60 kilos of c.p.s (dry pergamín coffee) per hectare year which is relatively smaller than the national average of 14 sacs per hectare. We observe that yields from organic technology are significantly lower at 1% level than those from non-organic technologies (Mann-Whitney test). The average production cost per hectare is 1,084 thousand COL, value that is close to the estimated from CRECE (Giovanucci et al. 2002). Even though, organic technologies are labor intensive, we find that the production cost per hectare is significantly lower at 5% level than non-certified technologies using the Mann-Whitney test. Surprisingly, we find that for 20% of the farmers the revenue is not enough to compensate the productive cost so the net return from coffee cultivation is negative. In other

words, farmer's labor is under paid comparative to the market price of labor, or farmers work to buy agricultural inputs that do not pay-off in terms of higher yields. The average net return per hectare is 1,015 thousand COL. We find no significant differences at 5% level in profits between certified and non-certified coffee farmers using Mann-Whitney test.

We find that between 1997 and 2007 the use of natural resources improved. Though wood is still the main source of energy to prepare food, its use decreased and was replaced by gas and gasoline. Similarly, the practice of disposing liquids and solid residuals in the open field has decreased in favor of septic tanks and burial of garbage. The agricultural practices of coffee cultivation have also evolved towards a more sustainable use of the resources. First, we find that a larger proportion of farmers fertilize and do pest control which has probably increased households income. Second, the agricultural techniques have become friendlier to the environment: The proportion of farmers who use of organic fertilizers, do cultural and biological pest control and use of pulp to prepare fertilizers has increased at the time that the use of pickaxe to control weeds has decreased. Another positive trend is the increase in the use of a system of registers. The changes in agricultural practices of coffee cultivation could be related with the increase in participation in courses on coffee production.

Table 2 presents the proportion of farmers who self-reported to be cultivating certified coffee, the average number of hectares and the average number of years that they have been certified. Almost 40% of the participants self-declared to have at least one certificate: 26% of the participants are certified as organic, 9% as rainforest and 4% as fair trade. The average number of hectares certified varied between 1.4 and 2.1, being larger for farmers certified as rainforest alliance. The experience with certified coffees is relatively new. On average farmers have been certified for no more than 6 years. One of the most common critiques to organic production is that the productivity decreases after adopting the new technology. We asked participants to report their production before and after certification and found that there the production before and after certification and found that the production before and after certification was not significantly different at 10% level using the Wilcoxon sign-rank test.

5.2. *Econometric model*

The estimations of the reduced form probit model on being certified as organic coffee producer are presented in Table 3. We report the estimated marginal effects evaluated at the sample mean. The marginal effects indicate the change in probability for a one unit change in the independent variable while for the dummy variables it refers to the change in probability for a discrete change from zero to one in the corresponding variable.

We find that those who used technologies that were relatively closed to organic production are more likely to get certified as organic. For instance, keeping a system of registers in 1997 and having not used chemical fertilizers increases the likelihood to get certified. Interestingly, we find that adoption of certified coffee is not equivalent to have the farms abandoned. Those who did pest control in 1997 are more likely to be certified as organic. We also find that belonging to an indigenous group increases the likelihood to be certified as organic. The positive effect of belonging to an indigenous group could be associated with more concern towards the environment due to the special relation that these groups have with their surroundings. Contrary to what we expected, we find that the likelihood to be certified decreases with participation in courses on coffee cultivation in 1997 and participation in communitarian associations. The negative effect of course participation could be related with an emphasis in non-organic technologies during those workshops. We have no clear explanation on why, contrary to our expectations, participation in communitarian organizations reduces the likelihood to be certified as organic.

The estimations of the second stage switching model are presented Table 4. We present the results separately for yields, production cost and net return and for certified and non-certified coffee farmers. The model is estimated using a generalized linear model to account for heteroscedasticity in the errors. The last row in Table 4 presents the estimated correlation coefficients (σ_{i1} and σ_{i0}). The positive and significant estimated correlation coefficient for non-adopters indicates that there was self-selection. Had non-adopters switched to certified production, the yields, production cost and net return would have been different from those who were certified. Since the correlation coefficient of certified organic producers is not significant, this indicates that prior to adoption there were no significant differences in average yields, cost and net return of the two groups due to unobserved factors.

We find that yields increases significantly with pest control both for certified and non-certified producers. Similarly, fertilization has a positive effect on yields but only for those who are certified while education has a positive effect for non-certified producers. For certified producers, the cost of production increases significantly with wages, number of hectares with coffee and use of fertilizer. On the other hand, for non-certified producers, the producer cost increases significantly with education level, and with squared capital while it decreases with squared fertilizer use. Pest control has a significant effect on net return for non-certified producers.

5.3. *Economic incentives of certified organic coffee*

An important question for institutions that promote organic coffee cultivation is how good certified organic producers perform compared with non-certified producers. We used the estimated coefficients from the second stage to estimate yields, productive cost and net return for certified organic and non-certified producers after correcting for self-selection. The results are presented in Table 5. Using the Whitney sign-rank test we find that certified organic producers are significantly less productive, less costly and less profitable at 1% level than non-certified producers. The low adoption rate of certified organic coffee could then be explained by the lack of economic incentives to switch to the new technology. Hence we expect that certified organic coffee will continue being marginal unless a higher price premium is offered or unless the international prices drop.

Given that certified organic coffee is not profitable, the question that emerges is: what is the price premium that would need to be offered to make certified organic coffee as attractive as non-certified coffee? Or in other words, how much should the price premium (a) be so as the net return of certified organic coffee, $E(\pi | d=1)$, equals the net return of non-certified coffee, $E(\pi | d=0)$ or:

$$(E\pi | d=0) = E(y | d=0) * p - E(c | d=0) = E(y | d=1) * (p + a) - E(c | d=1) = (E\pi | d=1)$$

Where $E(y | d=k)$ and $E(c | d=k)$ are the yield and production cost of certified ($d=1$) and non-certified coffee ($d=0$). p and a , represent the market price and the price premium respectively.

Using estimated yields and cost presented in Table 5 we find that the price premium that would equal the net return from certified and non-certified coffee is $a = 0.58 p - 9,180$. Considered that in 2007, the price per arroba of coffee was 47 thousand COL, the minimum price premium should be 17 thousand COL per arroba. Hence, to make certified coffee cultivation profitable, the price premium would be to need 36% the price of coffee in 2007. This is almost 5 times higher than in the 3,400 COL per arroba observed in 2007. Only for prices as low as 26 thousand per arroba, would the actual price premium be attractive.

6. Discussion and Conclusions

Organic technologies appear as an attractive alternative to reduce the environmental impact of agriculture and improve the income of rural population. The incipient adoption of certified organic technologies opens the question on how institutions could promote these technologies and which type of farmers should be targeted. Our results suggest that those farmers who are closer to organic technologies before being certified are more likely to be certified as organic. We also find that workshops and educational programs have the potential to promote organic technologies. However, workshops should correct the bias towards the use of agricultural inputs and promote technologies that are friendlier to the environment. We find a positive effect of belonging to an indigenous group on the likelihood to be certified as organic. This could be related with environmental conscience, but could also be due to cohesion of the group that make easier to be certified as organic.

We find that the major obstacle in the promotion of certified organic technologies is the low economic incentives to switch to the new technology. Even if the production cost for organic technologies is lower than for non-certified technologies, we find that the reduction in yields from organic technologies is less than compensated by the price premium. Given the actual context of high prices of coffee, the price premium should be 36% the price of coffee.

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Table 1. Descriptive Statistics

Variable	All population		Non-Certified Producers		Certified Organic		Rank Sum Test Ho: Cert=Non- Cert
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	
Coffee Cultivation							
Profit per hectare (COL)	1,030,245.00	1,772,335	1,130,088.00	1,904,612.00	653,058.70	1,072,289.00	
Arrobas per hectare	42.87	47.0	47.26	50.67	26.32	22.44	***
Production Cost per hectare (COL)	1,097,463.00	951,121	1,171,823.00	1,010,231.00	816,544.10	612,074.60	**
Price per arroba including price premim (COL)	49,199.93	6,851	48,273.51	6,250.62	52,699.75	7,873.85	***
Daily wage (COL)	7,065.28	3,614	6,925.00	3,697.45	7,595.24	3,253.23	*
Fertilizer price per Kg (COL)	118.01	75	116.71	76.64	122.92	67.78	
Days of work per hectare	38.85	30	38.84	31.71	38.87	23.04	
Kg of fertiliyer used	676.98	1,182	746.84	1,299.75	413.08	467.53	
Farm Characteristics							
Farm size (hectares)	2.29	1.94	2.21	1.82	2.61	2.31	
Area with coffee (hectares)	1.81	1.50	1.80	1.46	1.85	1.66	
Value of Capital (COL)	1,826,290.00	3,057,912	1,928,517.00	3,354,975.00	1,440,098.00	1,424,021.00	
Socioeconomic characteristics							
Age	50.91	13.03	50.45	13.50	52.67	11.00	
Years of education	3.87	2.361274	3.87	2.34	3.86	2.44	
Family size	4.85	2.12679	4.78	2.14	5.10	2.06	
Dummy for indigenous group	0.29	0.4525062	0.22	0.42	0.52	0.50	***

Table 2. Producers Certified by certificate

Certificate	Househods certified	Number of hectares		Number of years since adoption	
		Mean	Std. Dev.	Mean	Std. Dev.
Organic	77	1.41	0.90	3.77	2.88
Fair Trade	11	1.56	0.80	5.64	3.14
Rain Forest	29	2.10	1.65	1.96	1.73

Table 3. First-stage probit model and Structural Model

Variable	First Stage Probit		Structural Model	
	Marginal Effect	t-value	Marginal Effect	t-value
Expected net return certified coffee			0.582 ***	3.04
Expected net return non-certified coffee			-0.352	-1.32
ln coffee price	0.329 *	1.87		
ln wage	1.254	1		
ln fertilizer price	0.400	0.43		
lnwage*lnwage	-0.050	-0.81		
lnwage*lnfertilizer	-0.065	-0.89		
lnfertilizer* lnfertilizer	0.024	0.41		
ln area with coffee in 2007	0.018	0.6	-0.020	-0.49
ln capital in 2007	0.016	0.94	0.013	0.61
Dummy for chemical fertilizer use in 1997	-0.221 ***	-4.56	-0.174 ***	-3.52
Dummy for pest control in 1997	0.167 ***	4.25	0.147 ***	3.59
Number for course participation in 1997	-0.040 **	-2.45	-0.033 **	-2.04
Dummy for Coffee farmers Comite in 1997	-0.043	-1	-0.056	-1.31
Dummy for maintaining a registers in 1997	0.056	0.59	0.072	0.72
Dummy for belonging to a indigenous resguardo	0.198 ***	3.22	0.146 **	2.38
Dummy for cooking with wood in 1997	0.027	0.35	0.032	0.39
Dummy for growing coffee under shadow	-0.105	-1.12	-0.069	-0.77
Dummy for use of pulp to prepare fertilizers	-0.016	-0.35	-0.019	-0.41
Availability of organic fertilizer in 1997	0.000	0.65	0.000	0.48
Proportion of borbon variety in 1997	0.241 **	2.19	0.164	1.36
Proportion of tipica variety in 1997	0.003	0.06	0.023	0.38
Proportion of colombian variety in 1997	0.100	1.32	0.124	1.63
Proportion of castillo variety in 1997	-0.045	-0.16	-0.026	-0.09
Proportion of other varieties in 1997	-0.350 *	-1.67	-0.234	-1.18
Number of adults	0.001	0.04	-0.011	-0.72

Table 4. Second-stage estimations

Variable	Production Function				Cost Function				Net return function			
	Certified Organic		Non certified		Certified Organic		Non certified		Certified Organic		Non certified	
	n=63		n=238		n=63		n=238		n=63		n=238	
	Coef.	t-value	Coef.	t-value	Coef.	t-value	Coef.	t-value	Coef.	t-value	Coef.	t-value
ln coffee price									0.3641 *	1.93	0.3467 **	2.44
ln yields					0.194 **	2.25	0.469 ***	11.32				
ln labor/ ln wage	-1.042	-0.55	0.108	0.28	0.271 *	1.77	0.268 ***	3.4	-0.060	-0.92	0.003	0.07
ln fertilizer kg / price	-0.548 *	-1.94	-0.082	-1.53	-0.125	-1.21	-0.124 **	-2.16	-0.023	-0.54	-0.026	-0.76
ln wage*ln wage	0.065	0.26	0.015	0.25								
ln wage*ln fertilizer	0.147 **	2.15	0.012	0.76								
ln fertilizer* ln fertilizer	0.006	0.36	0.025 ***	3.66								
ln area with coffee in 2007	-0.472 **	-2.13	-0.855 ***	-10.81	-0.479 ***	-3.77	-0.360 ***	-6.14	0.015	0.38	-0.108 ***	-3.82
ln capital in 2007	-0.964	-0.77	-0.100	-0.24	0.237	0.33	-0.590 **	-2.13	0.033	1.22	0.043 ***	2.77
ln area*ln area with coffee in 2007	-0.226	-1.47	0.093	1.44	-0.220 ***	-2.57	-0.020	-0.48				
ln capital in 2007*ln area in 2007	0.052	1.09	0.009	0.55	-0.004	-0.15	0.024 **	2.24				
Dummy for book keeping	0.645 **	2.42	0.296 **	2.4	0.343 **	2.28	-0.165 **	-2	-0.017	-0.27	0.081	1.64
Dummy for chemical fertilization in 2007	-0.264	-0.61	0.473 ***	4.16	-0.063	-0.26	0.172 **	2.22	0.138	1.09	0.133 ***	2.94
Dummy for pest control in 2007	0.579 *	1.92	0.294 **	2.46	0.144	0.81	-0.178 **	-2.22	0.125 *	1.75	0.162 ***	3.34
Number of courses in coffee cultivation in 2007	-0.023	-0.57	-0.012	-1.01	0.009	0.50	0.021 ***	2.78	-0.003	-0.36	0.001	0.27
Number of years of education	-0.018	-0.44	0.026	1.15	-0.050 **	-2.09	0.023	1.52	0.006	0.58	0.008	0.84
Family size	0.031	0.6	-0.013	-0.53	0.004	0.14	0.024	1.55	0.018	1.42	-0.012	-1.22
Proportion of borbon variety in 2007	0.580	1.21	-0.963 *	-1.9								
Proportion of tipica variety in 2007	-0.177	-0.37	-0.295	-1.1								
Proportion of colombia variety in 2007	-0.657	-1.5	-0.152	-0.77								
Proportion of castillo variety in 2007	0.993	0.68	0.869 **	2.26								
Dummy for selling coffe to an intermediary									-0.262	-1.02	-0.067	-1.3
Dummy for selling coffee to an association									0.085	1.17	0.002	0.03
Dummy for sellind coffee to the exporter									0.666 ***	5.08	0.338 **	2.09
Inversed Mills Ratio (s1 / s2)	-0.057	-0.21	0.104	0.51	0.186	1.33	-0.007	-0.05	-0.025	-0.42	0.107	1.29
Constant	8.633	1.01	1.530	0.55	8.358	1.60	13.744 ***	6.94	11.113 ***	5.42	10.877 ***	6.94
Log likelihood	-55.98		-258.1		-28.54		-168.40		25.069		49.301	

Table 5. Expected mean output for certified producers by state of certification

Output	Certified Organic	Non-certified	Sign Rank Test Ho: Cert=Non-Cert	Price Premium
Expected Yield (@ per hectare)	22.1 13.44	29.0 23.73	***	35-39%
Expected Cost per hectare (COL)	771,982 470,247	709,125 566,860	***	
Expected Net Return per hectare (COL)	599,443 800,905	869,455 714,150	***	

Standard deviation in parenthesis

*** Denote statistical significance at 1% level.