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Organic coffee certification in Peru as an alternative development-oriented drug control policy

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Abstract

Purpose – This article aims to evaluate the effect of organic coffee certification on coca cultivation, based on a survey of 496 members from coffee cooperatives located in the upper Tambopata valley in Peru. Coca is a bush from the leaves of which cocaine is extracted.

Design/methodology/approach – The results were estimated using the propensity score matching methodology.

Findings – The results suggest that participation in organic coffee certification statistically significantly reduces the scale of coca cultivation.

Originality/value – This paper analyses a unique primary data set from a coca-growing region in Peru. The value of this paper is that the results suggest that under specific conditions, such as reasonable high and stable coffee prices, organic coffee certification can be an effective element of drug control policy in Latin America.

Keywords Peru, Propensity score matching, Coca, Cocaine, Coffee, Organic certification

Paper type Research paper

1. Introduction

Coca is a native bush from the Amazon rainforest in South America. In Peru and Bolivia, the leaves of this native bush have been subject of different traditional uses since 3000 BC (Rivera *et al.*, 2005) those traditional uses mainly include coca chewing and coca tea drinking (Rospigliosi, 2004). Since the 1970s, however, coca cultivation has skyrocketed as raw material for the production of cocaine, an illegal drug, first in Peru and Bolivia, and later in Colombia (Caulkins *et al.*, 2005; Dietz *et al.*, 2001). Currently, Colombia's coca areas represent around 40 percent, Peru's 40 percent, and Bolivia's 20 percent of the total extent under coca cultivation worldwide, amounting to 154,100 hectares (United Nations Office on Drugs and Crime (UNODC), 2011).

Drug control policies are oriented on eradication efforts and alternative development (AD) in coca producing countries. Eradication treats coca cultivation as an international law enforcement issue that provides immediate results. On the other hand, the application of AD strategies treats coca cultivation as a socio-economic issue and emphasizes poverty reduction and typically requires longer periods for benefits to

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manifest (Commission on Narcotic Drugs, 2005). One AD policy in Peru is the replacement of coca cultivation with coffee production, which is the primary alternative cash crop in terms of economic importance (UNODC Office in Peru, 2009). The environmental tolerance of coffee and coca overlap in many coca producing regions, which makes coffee a suitable candidate crop for coca substitution programs. In the mid-1990s, when coca prices collapsed and coffee prices were high, coffee was perceived by many farmers as an attractive alternative cash crop. This perception was reinforced by the fact that many coca growers wished to avoid the violence and extortion associated with the criminal nature of the coca economy for narcotics traffic in Peru (Crabtree, 2002).

On the other hand, organic certification can increase the value of coffee at the producer-level, which may enhance the attractiveness of coffee cultivation as an alternative for coca growers. Accordingly, international cooperation organizations have promoted the participation in organic certification as drug control policy in Andean countries (Dietz *et al.*, 2001). There is evidence that this support will continue in the future. INCB (2009, p. 10) indicates that organic certification "offer(s) encouragement to efforts to extend the scope and sustainability of alternative development projects". At present, Peru is the leading exporter of organic certified coffee in the world, with an estimated volume of 27,000 metric tons exported per year (ICO, 2008).

Nevertheless, the effectiveness of the AD strategies, including organic coffee certification, as drug control policies is still subject to controversy. The effects of AD on the reduction of coca production areas are not well known (Alvarez, 2005). In practice, AD initiatives operate on the assumption that reductions in coca cultivation will result from social and economic development in coca producing regions. As such, the reduction of coca cultivation may be perceived only as a positive externality of the process of increasing farmer income and the improvement of producer livelihoods (Mansfield, 1999).

This article contributes to the available research by evaluating the effects of farmer participation in the organic coffee certification program on coca cultivation, using a unique data set obtained through a survey of the members of a coffee cooperative located in a coca-growing region in Peru. The article is organized as follows: the literature review is presented in Section 2. Section 3 describes the study area, data collection and statistical methods. Section 4 presents the results and discussions; and Section 5 summarizes and presents conclusions.

2. Literature review[1]

This literature review the historical trend on coca cultivation in Andean countries, types of drug control policies and their corresponding evaluation, and the implementation of organic coffee certification as drug control policy in Peru, although the available data about this latter topic is limited. The review continues with a description of research findings relevant to individual-level motivations for participation in organic certification schemes.

2.1 Coca cultivation in Andean countries

Coca is cultivated almost exclusively in three Andean countries: Colombia, Peru and Bolivia (UNODC, 2011). Coca cultivation is a recurrent problem in those three countries. Several large-scale drug control policies have been implemented in the region (e.g. Plan Dignidad in Bolivia, Plan Colombia); however, the total amount of cocaine production has remained around the same. Only the distribution of coca areas has shifted from one country to another (Figure 1). For example, from the 1970s until the mid-1990s, Peru was the main coca-leaf producing country, ahead of Colombia and Bolivia. Afterwards, coca areas dropped dramatically in this country due to a combined effect of local eradication efforts, lower coca-leaf yields from the natural dissemination of a fungus (*Fusarium oxysporum*), and changes in the coca market structure (Cabieses, 2001; Rojas, 2005). Unfortunately, this mid-1990s plunge did not correspond to the reduction in coca supply in the Andean region. By mid-1990s, Colombian coca production had risen considerably. At that time narcotics traffic started, the initial coca market was mostly composed of Peruvian and Bolivian farmers who sold their coca leaf to Colombian narcotic traffickers. Those narcotic traffickers processed the coca leaf and smuggled cocaine to the USA but through the years, Colombians increasingly cultivated their own coca crops to avoid dependency on those two countries (Rojas, 2005).

Between 2000 and 2009, coca areas in Colombia decreased by 58 percent, mainly due to strong local eradication efforts, but increased by 38 percent in Peru and more than doubled in Bolivia (up to 112 percent), while traffickers in both countries increased their own capacity to produce cocaine (UNODC, 2010). Currently, Peru is once again the coca producer leader worldwide, slightly ahead of Colombia (*The Economist*, 2013). In addition, coca yields have increased due to technological advances, leading to a reduction of the total area required to produce similar harvests.

2.2 Drug control policies

Drug control policies to reduce coca cultivation focus either on eradication or AD programs. In relation to eradication efforts, there are two main types of programs:

(1) manual eradication often with the consent of the producers, but also without their consent; and

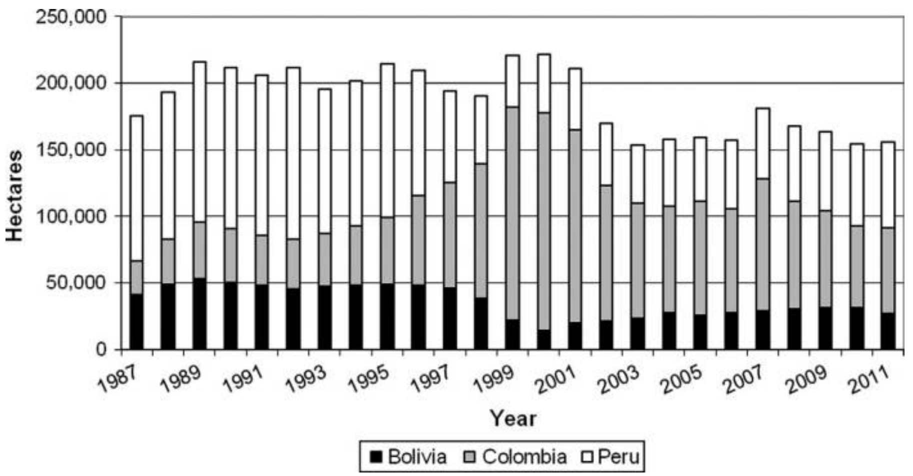


Figure 1.
Comparison of coca cultivation trends in Bolivia, Colombia and Peru (1987-2011)

Source: UNODC (2012a, b, c) and US Office of National Drug Control Policy (2009); Own elaboration

(2) chemical control that involves dispersing glyphosate, a herbicide, and administered from low-flying aircraft over cultivation areas to kill or inhibit the growth of targeted illicit crops (Veillete and Navarrete-Frias, 2005).

The Peruvian law, Prohibition on the Eradication Using Pesticides of 2000 (Supreme Decree No. 004-2000-AG), prohibits the use of pesticides or related substances to eradicate coca plantations, in response to objections to chemical control from coca producers. The government justified the prohibition of aerially administered herbicides based on environmental and public health criteria (Veillete and Navarrete-Frias, 2005).

Thus, only manual eradication is permitted in Peru. Manual eradication employs agricultural workers to physically uproot individual coca bushes. Thirty men working by hand can eradicate 1-2 hectares of coca per day. Obando (2006) indicates that at this rate it would require 69 years to eradicate the 200,000 hectares of coca that existed during the 1980s, provided not one more hectare was planted in Peru. In addition, it was reported that some coca plantations eradicated manually were only cut down not uprooted and exhibited invigorated growth afterwards (Office of Technology Assessment, 1993).

Manual eradication of coca can be also dangerous. For example, the Special Project for Control and Eradication of Coca in the Alto Huallaga (Projecto de Control y Reducción de los Cultivos de Coca en el Alto Huallaga (CORAH)), implemented in the mid-1980s, conducted manual coca eradication in Peru. CORAH workers destroyed 5,000 hectares of coca in 1985 with "weed whackers" and machetes. Between 1986 and 1988, 34 CORAH workers were killed by insurgent groups (Office of Technology Assessment, 1993).

Most of the efforts to deal with the coca cultivation problem centered on eradication until about 1990, when focus shifted to AD. Major funders of AD projects have been the UN, the US Government, and in lesser amounts the German Technical Agency (GTZ), Italy and other European Union counterparts, Switzerland, and Canada (Jones and Amler, 1997). On a global basis, farmers receiving AD assistance have been relatively few due to budget constraints. AD projects have worked with only 23 percent of families in illicit-crop production areas in the Andes, and with only 5 percent of families in poppy-cultivation areas in other countries worldwide (Commission on Narcotic Drugs, 2005; INCB, 2009).

There is not universally accepted definition of AD. The UN defines AD as the "process to prevent and eliminate the illicit cultivation of crops through rural development measures within the context of sustained national economic growth". The ultimate goal of AD is:

> [. . .] to help shape a set of conditions which, given sufficient time and growth of the licit economy, could lead to permanent behavioral change in drug producing areas. AD aims at creating conditions for those who give up growing illicit drug crops to participate in licit economic activities and hence permanently give up growing drugs (UNODC, 2005, p. viii).

In general, over the course of 30 years AD has evolved as various approaches to coca supply reduction have been attempted. Those approaches include (UNODC, 2001, 2005):

- *Crop and income substitution.* The idea behind those projects was to directly replace illicit crops with alternative legal crops. This approach includes the implementation of different alternatives such as promoting non-agricultural opportunities and enhancing alternative crop profits with certification schemes, among others.

- *Integrated rural development (IRD).* The IRD approach was first adopted in the 1980s. IRD addressed a broad range of local social, economic, and environmental problems simultaneously. The approach is expensive, generally requiring large international staff and a large complement of local counterparts.
- *Mainstream development.* The best alternatives from a list of possible interventions obtained from a holistic evaluation of the local situation are chosen in order to limit funding requirements and to use available skills most effectively. This approach also seeks to embed drug control activities within regional and national level development programs. The UNODC has nominally endorsed this approach for its AD interventions but in practice many of their efforts mostly continue to resemble crop and income substitute approaches.

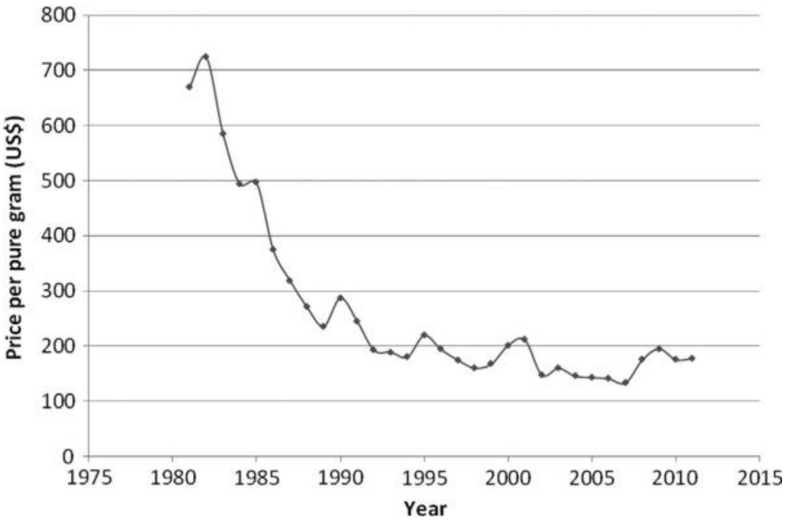
Experts emphasize the importance of combined eradication and AD strategies. Eradication only works in reducing coca areas when preceded by comprehensive development programs to promote alternative, licit livelihoods. Where such alternatives exist, farmers who persist with coca cultivation can be pushed by eradication towards legal livelihoods. Where alternatives do not exist, eradication can fuel violence and insecurity, hostility to national authorities, displace cultivation to less accessible locations, and ultimately undermine long-term efforts to change the conditions that promote drug crop cultivation (Mansfield, 2006).

2.3 Evaluation of drug control policies

The evaluation of drug control policies is complicated for many reasons. According to Caulkins *et al.* (2005), spending on drug control increased rapidly in the late 1980s and early 1990s, but relatively little was invested in evaluation and monitoring of the effect of those expensive strategies. A significant limitation for the assessment of policy effectiveness is the lack or poor quality of farmers' relevant data (EU, 2009).

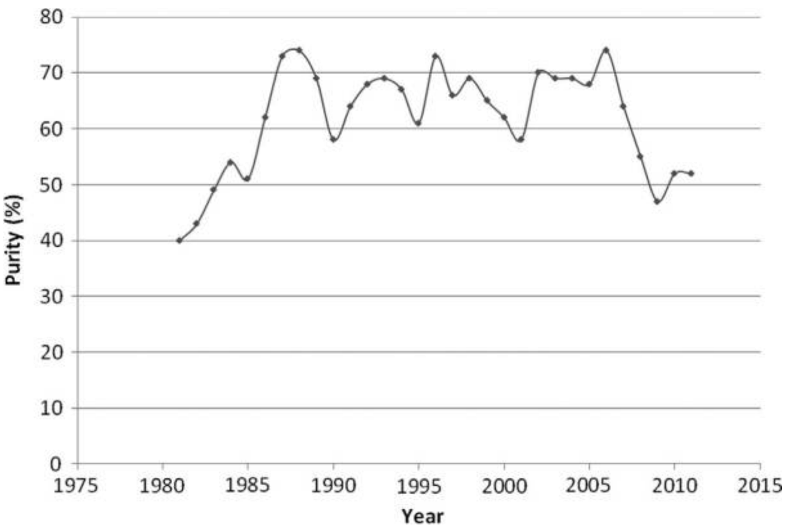
Nevertheless, some efforts have been implemented to evaluate drug control policies using aggregate or macro-level data. From the point of view of international donors, the objective of supply-side drug control policies is to reduce drug availability. If farmers eliminate their coca crops, the supply of cocaine should become reduced and cocaine prices would rise in demand countries. According to economic theory, the direct consequence of prices going up would be a reduction in cocaine demand (Walsh, 2009). Following Caulkins *et al.* (2005), one evaluation method of the drug control policies would be to analyze the trends in cocaine prices in demand countries. A reduction in cocaine availability could be inferred from large increases in retail prices. In the case of the USA, analysis of prices over a 27-year period (1981-2007) indicates that despite aggressive and costly activities aimed to reduce cocaine supply; the prices of cocaine have decreased and the quality (purity) has remained relatively stable (Figures 2 and 3).

In addition, Caulkins *et al.* (2005) indicate that coca is currently grown on less than 1 percent of the potential area suitable for cultivation in Bolivia and Peru alone. Indeed, it seems that there is plenty of land suitable for growing the quantity of coca required to produce the 400 metric tons of cocaine that is shipped each year to the USA.



Source: Garcia-Yi (2014)

Figure 2.
Price per pure gram of cocaine at retail level in the USA (1981-2011)



Source: Garcia-Yi (2014)

Figure 3.
Purity of cocaine at retail level in the USA (1981-2011)

This fact, coupled with the highly skewed cocaine equivalent prices in the distribution system (Table I) creates a situation in which consumer prices might increase only 0.5 percent (from US$120,000 to US$120,650 per pure kilogram equivalent) even if eradication activities were successful and farm-gate prices were doubled (from US$650 to US$1,300 per pure kilogram equivalent).

Therefore, Kennedy *et al.* (1994, p. xii) indicate that the justification for US funded eradication efforts "[…] has to be found in claims other than (to) reduce US cocaine consumption in the long run". On the other hand, while eradication policies do not seem to have a significant effect in demand countries, they do have side effects in supply countries. Supply countries are left to cope with the side effects of current drug control policies. Eradication causes four types of unintended effects:

(1) *Balloon effect*. Coca reduction in one area is offset by increases in other areas (like a balloon that when it is squeezed in one area increases its volume in other area).
(2) *Mercury effect*. Intercropping of coca cultivation is increased to avoid detection and eradication.
(3) *Membrane effect*. Coca cultivation shifts to the neighboring region or country.

Thus, most of the current eradication interventions seem to only affect where drugs are produced, such as the shifting location of coca cultivation within the Andean region (EU, 2009). Rouse and Arce (2006) assessed the empirical effects of US military assistance on coca cultivation in the Andes region, while controlling for other explanatory variables that influence coca cultivation. Using data from 1980 to 2001 for Colombia, Bolivia, and Peru, they performed a pooled cross-sectional time-series analysis. Eradication operations were only relatively successful in "squeezing out" coca production in Bolivia and Peru, but the drug industry gravitated towards Colombia. Continued eradication pressure may succeed in shifting production to other countries, such as Ecuador, Venezuela and/or Brazil. Concerning this issue, coordinating drug control policies with other governments may help to prevent the further expansion of coca production to other countries (Alvarez, 1995).

On the contrary to eradication policies, AD seems to have actually contributed to the reduction and containment of coca cultivation in supply countries; however, its precise contribution to those achievements is unknown (Commission on Narcotic Drugs, 2005). Importantly, in contrast to eradication policies AD projects have also achieved socio-economic improvements in specific coca-growing areas where conventional development agencies are often not active, despite the prevailing levels of poverty (Mansfield, 2006).

The main criticisms to AD are that it has failed to deliver reductions in coca cultivation over a short-term time frame and over a sufficiently significant geographic area (Lupu, 2004). Even taking into account those criticisms, AD could be more effective than eradication at reducing coca production. Tabares and Rosales (2005) studied the effects of AD and eradication simultaneously, using municipal data for the period of 1998-2002 in Colombia. The results show that the investment in AD has a small effect, although statistically significant in the reduction of coca areas.

Table I.
Prices of cocaine through the distribution system (per pure kg equivalent)

Stage	Price (US$)	Place
Farm-gate	650	Leaf in Colombia
Export	1,000	Colombia
Import	15,000-20,000	Miami
Wholesale (kg)	33,000	Chicago
Retail (100 mg pure)	120,000	Chicago

Source: Adapted from EU (2009); own elaboration

According to their calculations an increase of US$1,000 in AD project funding reduces coca cultivation areas by 0.169 hectares of coca. In contrast, an increase of US$ 1,000 in the funding of eradication efforts reduces coca cultivation areas by 0.128 hectares. This later result was no statistically significant.

2.4 Organic coffee production and certification as drug control policy in Peru

The main substitute crop promoted by AD in Peru in terms of economic importance is coffee. The commercial activity of coffee cooperatives and associations financed by the UN drug control programs reached US$64 millions in 2008. In second place is cacao and derivatives, with sales of US$15 millions during the same year (UNODC Office in Peru, 2009). Peru is also among the top ten coffee exporters in the world, although with a relatively small market share of 3.3 percent, well below Brazil and Vietnam with market shares of 36.4 percent and 12.7 percent, respectively, (ICO, 2013). Nevertheless, coffee production is a relevant contributor to the Peruvian economy. This crop is among the top ten exported products with a share of 2.1 percent of the total FOB value. The remaining nine products are minerals and crude oil (INEI, 2009). Moreover, Peru is the leading exporter of certified organic coffee in the world. According to ICO (2008), Peruvian organic coffee exports were estimated in 27,000 metric tons in 2007.

A direct comparison between the price of a kilogram of dried coca leaf (US$3-3.3; UNODC, 2012c) and the average price of organic coffee (US$1.55-2.64; Van der Vossen, 2005) indicates that the former is consistently higher. So, in most of the cases, organic certified coffee may not offer economic returns that are as remunerative as coca; but there is empirical evidence that some farmers are willing to reduce coca cultivation in exchange for substitute crops when provided with appropriate technical and financial support in order to avoid repressive measures by the government and criminal activities of narcotics traffickers (Mansfield, 1999). Consequently, international cooperation promotes organic certification as drug control policy in the Andean region. For example, the German society for technical cooperation, GTZ, operated an organic coffee certification AD project in the region. The Promotion of Organic Coffee Cultivation and Marketing in Coca Regions Project (1994-2001) aimed to:

> [. . .] help small coffee farmers in coca cultivation regions gradually to switch their coffee crops to organic coffee. It also advised them on processing and marketing the organic coffee, thus helping them to sustainably increase their income, and create a stable economic alternative to coca cultivation.

The project operated in the Sierra Nevada de Santa Marta and the Cauca regions of Colombia; in the Selva Central of Peru, and in the northern Yungas are of Bolivia (Dietz *et al.*, 2001, p. 41).

In the particular case of Peru, the replacement of coca cultivation with alternative crops such as coffee is a key element of the government's anti-narcotics plan (Likins, 2012). Farmers in selected coca areas receive support from UN AD project, which trains farmers on how to cultivate high-quality coffee in a sustainable and environmentally friendly way, avoiding the use of chemicals. This project has also strengthened farmer coffee cooperatives by providing guidance in business management. As a result, the members of such cooperatives have become successful coffee producers and have obtained organic coffee certifications (UNODC, 2013).

2.5 Motivations for the decision to adopt organic coffee certification

Knowler and Bradshaw (2007) reviewed the results of 31 research analyses including nearly 170 variables in order to identify factors that influence the adoption of conservation agriculture, including organic certification. They concluded that there are few if any universal motivations that help to explain the adoption of conservation agriculture across the scope of research efforts they reviewed. Thus, farmers' decisions are expected to depend on local conditions. In general, farmers' attitude related to the adoption of conservation agriculture can be influenced by socio-economic characteristics, agricultural plot conditions, and agricultural management decisions (Abd-Ella *et al.*, 1981).

2.5.1 Socio-economic characteristics. The adoption of organic agriculture practices requires specialized knowledge and management skills (Abd-Ella *et al.*, 1981). Thus, older, more experienced and educated farmers would be more likely to adopt organic certification than their counterparts. Related studies have found dissimilar results with respect to these characteristics. Atari *et al.* (2009) did not find statistical evidence that farmers' age or education influenced participation in environmental farm programs, and found that farmers with moderate level of experience were more likely to participate than more experienced farmers in Nova Scotia. Hattam and Holloway (2005) found that age and education were not significant, and that less experienced farmers were more likely to adopt organic agriculture in Mexico. Conversely, Amsalu and De Graaff (2007) found a significant positive influence of age on the likelihood of adopting soil and water conservation measures in Ethiopia, and Abd-Ella *et al.* (1981) found that education was correlated with the adoption of agricultural practices in Iowa.

Another variable important socio-economic characteristic is gender. Amsalu and De Graaff (2007) did not find gender to be significant in the adoption of soil and water conservation practices in Ethiopia. Findings from Peru are ambiguous: Novella and Salcedo (2005) found that women were significantly more likely to adopt organic agricultural practices and Posthumus (2005) found that men were significantly more likely to adopt soil and water conservation practices. In addition, social capital, e.g. connections between and within social networks based on trust and security feelings, could also influence organic certification adoption. People with extensive social networks are more likely to hear about new agricultural interventions, including organic certification. As such, Oelofse *et al.* (2010) indicate that the development of social capital at the local level is a pre-requisite for the development of organic agriculture, especially in developing countries.

Another factor that could affect farmers' participation in organic certification is risk aversion, which is defined as the probability that the farmers will avoid opportunities associated with risk. More risk adverse farmers would be less likely to adopt new agricultural practices (Clearfield and Osgood, 1986). Novella and Salcedo (2005) found that less risk adverse farmers were more likely to adopt organic certification practices. Erwin and Erwin (1982) found similar results; less risk adverse farmers adopted more soil conservations practices in the state of Missouri, in the USA. On the contrary, Posthumus (2005) found that risk adverse farmers were more likely to participate in soil and water conservation programs in Peru.

2.5.2 Agricultural plot conditions. The agricultural plot constitutes the basic resource for determining a farmer's income. Thus, decisions to adopt organic certification are likely to be influenced by plot characteristics. Variables reflecting agricultural plot characteristics include total production and coffee production area sizes, slope, and altitude. Coffee quality is directly related to altitude. In general terms, coffee quality improves with increases in the altitude at which it is produced (Wintgens, 2004). Hattam and Holloway (2005) did not find statistical evidence that the size of agricultural plots influenced farmers' adoption of organic agriculture in Mexico. Conversely, Abd-Ella *et al.* (1981) found that the size of agricultural plots was correlated with the adoption of agricultural practices in Iowa. Amsalu and De Graaff (2007) also found a significant positive influence of agricultural plot size on the likelihood of adopting soil and water conservation measures in Ethiopia; and Posthumus (2005) found similar results in Peru. In addition, several studies have found significant positive influence of steeper slopes on the likelihood of adopting soil and water conservation measures in Ethiopia (Amsalu and De Graaff, 2007), Bolivia (Kessler, 2006), and Peru (Posthumus, 2005).

2.5.3 Farm management characteristics. Organic agriculture is often labor intensive. It is expected that the availability of family labor could influence participation in organic agriculture. Greater availability of family labor equates to greater ability to adopt organic agricultural practices (Abd-Ella *et al.*, 1981). Hattam and Holloway (2005) did not find statistical evidence that labor availability influenced participation organic agriculture in Mexico. Bewket (2007) found that farm households with lesser labor constraints were more able to adopt soil and water conservation measures in Ethiopia.

In some cases part-time farming facilitates environmentally friendly management because income from external activities may be used to support the farmers' preferred farming system (Battershill and Gilg, 1997). In the research area, external employment opportunities are still limited, but some farmers have additional agricultural plots in the highlands (Altiplano), which they attend on a part-time basis. De Graaff *et al.* (2008) found that part-time income positively influenced soil and water conservation program participation in Peru. On the other hand, Amsalu and De Graaff (2007), Kessler (2006) and Posthumus (2005) found that off-farm activities did not significantly influence the adoption of soil and water conservation programs in Ethiopia, Bolivia, and Peru, respectively.

3. Methods[2]

3.1 Study area

The research area is located in the upper Tambopata valley, one of the most remote and difficult to access Amazon rainforest areas in Peru (UNODC Office in Peru, 1999). The entire population of the upper Tambopata valley is composed of immigrants, especially descendants from the Aymara indigenous population. Aymara is a native ethnic group originally from the Andes and Altiplano regions of South America.

Before 1989, coca cultivation in the upper Tambopata valley was very limited. Small-scale coca production was aimed at self consumption or was restricted to minor sales for traditional uses to Andean farmers and miners. After 1989, coca cultivation was intensified, but mostly in the neighboring upper Inambari valley, which did not respond to any changes in demand by own or external traditional users (UNODC Office in Peru, 1999). Coca from those valleys has lower acceptance for traditional chewing than coca from Cuzco region due to its bitterness (Caballero *et al.*, 1998). During the last years, large increases in coca cultivation in the upper Tambopata valley have been consistently reported by the UN, as observed in Table II. The percentage variation per year in the upper Tambopata valley is above the annual change of around 4 percent at national level in 2008 (UNODC, 2009).

It is believed that the coca provided by the upper Tambopata valley and upper Inambari valley supplies cross boarding trade associations between Peruvian and Bolivian narcotics traffickers. Bolivia remains the world's third largest producer of cocaine, and it is a significant transit zone for Peruvian-origin cocaine (US Department of State, 2009). In this sense, those valleys constitute a strategic coca production area for both Peruvian and Bolivian narcotics traffickers due to their proximity to an external exit route (UNODC Office in Peru, 1999). Coca leaves are not transformed into cocaine in the agricultural plots. Narcotics traffickers take advantage of the fact that large quantity of coca leaves are transported to major cities apparently to be sold to traditional users by informal marketers. So, they buy part of this coca and process it in hidden places in major cities near the border to Bolivia. In this way, they diversify their risk of being caught. From Bolivia, cocaine is dispatched to Brazil and Europe (Garcia and Antezana, 2009).

In relation to organic certification, this program started in 1997 with 159 registered farmers in the study region (BPA-Peru, 2013). Unfortunately, there is no open access historic data related to the rate of adoption of organic certification in the upper Tambopata valley. However, local farmers indicated that organic coffee production increased significantly during the first decade after the initial adoption. Currently, organic certified coffee constitutes around of 67 percent of the total production of coffee in the study area.

3.2 Data collection

The pilot survey for the designed questionnaire and the final survey were conducted in 2008 in San Pedro de Putina Punco (SPPP), the district inside the upper Tambopata valley which is located in the deepest mountainous Amazon rainforest. All the farmers in the research area produce coffee as cash crop and some supplement their income with coca cultivation. Farmers have to become a member in one of those co-operatives in order to be able to sell their coffee, because restrictions to coffee intermediaries are in place. The number of valid questionnaires was 496, which represents around 15 percent of the population under study. A convenience sampling method was applied. However, in order to test for representativeness of the sample, the distribution of the co-operative registration numbers of the respondents was compared with the distribution of the co-operative registration numbers from a simulated simple random

Year	Area (ha)	Change to previous year (%)
2005	253	–
2006	377	49.0
2007	863	128.9
2008	940	8.9

Notes: Since 2009 coca areas from the upper Tambopata valley are aggregated with coca areas from Inambari valley in UNODC reports; therefore, it is not possible to estimate the percentage of variation in relation to the previous year only for Tambopata valley during later years
Source: Garcia-Yi and Grote (2012)

Table II.
Coca cultivation in the upper Tambopata valley (2005-2008)

sample without replacement obtained from co-operative lists. The results of the test of equality of distribution functions (Mann-Whitney) suggest that the survey sample is equivalent to a simple random sample, and therefore representative of the population under study. In addition, data collection related to coca cultivation is a sensitive topic. The questionnaire design and survey conduction for this research were based on sensitive question principles as described in Garcia-Yi and Grote (2012).

3.3 Statistical methods

The main question of this article is whether the outcome variable of interest (number of coca bushes) for individual farmers is affected by participation in the treatment (organic coffee program). Unfortunately it is impossible to observe both states (participation and non-participation) for the same farmer during a single period because one of the states is counterfactual. However, it is possible to compare the outcomes of participants in organic coffee certification program with the outcomes of a control group of producers that do not participate in organic coffee certification, if certain conditions are met.

The basic idea of the propensity score matching method is that the outcome (number of coca bushes) is independent of the farmers' voluntary participation on the treatment when a previous matching between participants and non-participants is conducted based on observed characteristics ("selection on observables assumption"). Those observed characteristics account for pre-adoption variables that could have affected farmers' decisions to participate in the organic certification program. Specifically, propensity score matching balances observable variables by reweighting the treated and non-treated individuals based on their conditional probability of participating in the organic coffee certification program, or "propensity score". The propensity score is usually estimated by binary probability models such as logit or probit models. The effect of the treatment is estimated by contrasting the propensity score of the treated observation with a weighted average of the corresponding control group observations (Caliendo, 2006; Schmidl, 2008).

Different matching algorithms may be used to assign weights. Frequently used matching algorithms include single nearest neighbor, caliper and kernel. The nearest neighbor method uses a distance metric. The non-participant with the propensity score value closest to the participant is selected as the match. There is a risk that this algorithm will make bad matches, for instance if the closest neighbor is far away. This can be avoided by imposing a tolerance level on the maximum distance. This form of matching is known as caliper matching. One of the critical issues with this last algorithm is to choose a reasonable tolerance level. In general, different tolerance levels are calculated for comparison purposes (Caliendo, 2006). On the other hand, kernel matching uses all units in the control group to construct a match for each program participant. This is done in such a way that it takes more information from those who are closer matches and down weights more distal observations (Guo and Fraser, 2010).

4. Results and discussions

4.1 Descriptive statistics

The main descriptive statistics of the variables used in the organic certification model are presented in Table III. Organic certified coffee growers represent 57 percent and coca growers 64 percent of the sample. On average coca growers have 3,100 coca bushes,

	Mean all	Mean uncertified	Mean certified
Age	42.3	41.8	42.7
	(12.4)	(12.6)	(12.3)
Male (dummy)	0.9	0.9**	1.0**
	(0.2)	(0.3)	(0.2)
Years of education	8.3	8.4	8.3
	(3.3)	(3.1)	(3.5)
Years of experience as farmer	17.2	16.3*	17.9*
	(10.9)	(11.1)	(10.7)
Aymara (dummy)	0.8	0.8	0.8
	(0.4)	(0.4)	(0.4)
Coffee area (hectares)	2.1	1.7***	2.3***
	(1.1)	(1.1)	(1.1)
Total area (hectares)	6.7	5.7***	7.5***
	(4.7)	(4.7)	(4.6)
Number of children	2.9	2.9	3.0
	(2.0)	(2.1)	(1.9)
Number of other economic activities	0.7	0.8	0.7
	(0.9)	(0.9)	(0.8)
Location in high altitude (dummy)	0.4	0.4	0.4
	(0.5)	(0.5)	(0.5)
Risk aversion (from 1 – low to 3 – high risk aversion)	2.1	2.2	2.1
	(0.7)	(0.7)	(0.7)
Trust (from 1 – low to 3 – high trust in neighbors five years ago)	2.4	2.3**	2.5**
	(0.7)	(0.8)	(0.8)
Security (from 1 – low to 3 – high sense of security inside the neighborhood five years ago)	2.7	2.7***	2.8***
	(0.6)	(0.7)	(0.5)
Having a plot/house in the Altiplano (dummy)	0.5	0.6***	0.4***
	(0.5)	(0.5)	(0.5)
Slope (from 1 – flat to 3 – sharp slope)	2.2	2.3***	2.1***
	(0.5)	(0.5)	(0.5)
Number of observations	508	217	291

Notes: *t*-test statistically significant at: *0.1, **0.05 and ***0.01; standard deviation in parentheses

Table III.
Mean values of variables

which would be the equivalent of 0.1 hectares, considering a conventional coca-growing density of around 35,000 bushes per hectare (UNODC, 2001). This average coca area is within the range found in VRAE, one of the main coca-growing regions in Peru, where most of the farmers self-reported to have coca areas between 0.1 and 0.5 hectares (Rodriguez, 2003). SPPP is a relatively new coca-growing area for narcotics-trafficking business (UNODC Office in Peru, 1999), and it could be expected that some farmers are only growing coca for traditional self-consumption.

There were no statistically significant differences in main socio-economic characteristics (age, years of education, Aymara ethnicity, and number of children) between organic and non-organic farmers. Farmers averaged 42 years old, had three children, and 82 percent identified themselves as Aymara. The average years of schooling were 8.3 although the quality of education is very low. There were statistically significant differences with respect to gender and farming experience between organic and non-organic farmers. Most respondents were male in the case of both organic and non-organic farmers, but the percentage of males within organic farmers was higher than within non-organic farmers (96 percent versus 92 percent within non-organic farmers). The reason why most respondents were males is because only the heads of households were surveyed. Organic farmers had an average of 17.9 years while non-organic farmers an average of 16.3 years of farming experience.

There were statistically significant differences between organic and non-organic farmers in the size of total agricultural areas, coffee production areas, and slope of the terrain. Organic farmers had an average of 7.5 hectares of land, of which 2.3 hectares were used for coffee cultivation. In contrast, non-organic farmers had an average of 5.7 hectares of land, of which 1.7 hectares were used for coffee cultivation. Organic farmers indicated that their plots have an average slope of 2.1 (from 1 – flat to 3 – sharp slope), while non-organic farmers have an average slope of 2.3. Significantly fewer organic farmers (43 percent) had other agricultural plots in the highlands (Altiplano) than non-organic farmers (57 percent).

With respect to social capital, organic farmers showed higher feelings of trust in their neighbors (2.5, on the scale from 1 – low level to 3 – high level) than non-organic farmers (2.3). In addition, organic farmers indicated higher feelings of security inside their neighborhood (2.8, on the scale from 1 – low level to 3 – high level) than non-organic farmers (2.7). In the case of both variables, farmers were asked for the situation five years ago to obtain lagged responses and avoid endogeneity problems, which may occur when the direction of causality is not clear. Finally, there were no statistically significant differences with respect to number of other economic activities, risk aversion, and altitude between organic and non-organic farmers.

4.2 Propensity score matching

A probit model was used to calculate the propensity scores. The probit model results are reported in Table IV. For the continuous variables in the probit model the marginal effect is the marginal increment in the likelihood to participate in the organic program associated with a marginal increment in the corresponding explanatory variable. For the dummy variables in the probit model the marginal effect is the increment in the likelihood to participate in the organic program associated with a discrete change from zero to one of the explanatory variable.

The results suggest that less educated farmers with more experience are significantly more likely to participate in the organic certification program. However, this likelihood increases at increasing rate for education and at decreasing rate for experience. In addition, larger coffee areas and location in high altitude have significant positive influence on the likelihood of participation in the organic certification program. On the contrary, having a plot in the highlands (Altiplano), higher number of other economic activities, and steeper slopes has significant negative effect on the likelihood of participation in the organic program. Overall, the results suggest that farmers with comparative advantages in coffee cultivation, as indicated by their larger coffee areas, higher altitude plots, more farming experience, and with level terrain, are the ones who are more likely to participate in the organic program.

The results of propensity score matching are reported in Table V. They indicate the change on the number of coca bushes among the farmers who participate in the organic certification program (average treatment effect on the treated). Different matching

Variable	Marginal effect
Age	−0.0049
	(0.0033)
Male (dummy)	0.1606
	(0.1096)
Education	−0.0814***
	(0.0318)
Education squared	0.0046***
	(0.0017)
Experience	0.0180**
	(0.0081)
Experience squared	−0.0003*
	(0.0001)
Aymara (dummy)	−0.0384
	(0.0577)
Coffee area	0.0931***
	(0.0219)
Total area	0.0060
	(0.0052)
Number of children	0.0103
	(0.0148)
Other economic activities	−0.0423*
	(0.0249)
Location in high altitude (dummy)	0.0870**
	(0.0438)
Risk aversion	−0.0242
	(0.0324)
Trust	0.0395
	(0.0286)
Security	0.0521
	(0.0366)
Altiplano (dummy)	−0.1622***
	(0.0433)
Slope	−0.1288***
	(0.0412)
Constant	–
Log likelihood	−272.7372
McFadden pseudo R^2	0.1332
Number of observations	460

Notes: Statistically significant at: *0.1, **0.05 and ***0.01; standard error in parentheses

Table IV.
Probit model results for organic certification decision

algorithms were used to calculate this average treatment effect (nearest neighbor, caliper, and kernel). The results of two of the matching algorithms (nearest neighbor and caliper) suggest a statistically significant reduction on coca cultivation. The results of the kernel matching algorithms, although not statistically significant, suggest also a reduction of coca cultivation due to organic farming.

The results were calculated based on bootstrap estimates of standard errors after 1,000 repetitions with enforced common support and allowing for matching with replacement. Poor balance between treated and non-treated observations could bias the results under this methodology. In this study, each of the covariates achieved balance at 0.01. So, the distribution of each of the variables included in the propensity score for organic and non-organic farmers was similar after matching. The median standardized biases after matching for all covariates were also estimated and reported in the last column of Table V. The standardized bias is the difference of the sample mean in the organic and non-organic sub-samples, calculated as percentage of the square root of the average of sample variance in both groups. The median standardized bias before matching for all covariates was 13. Empirical studies show that a bias reduction of 3-5 percent is sufficient to assure balance of measured covariates (Caliendo and Kopeining, 2008).

I also evaluated the assumption that observable variables influence the decision whether to participate or not in the organic certification program and there are no unobserved variables that significantly undermine the results (ignorability assumption). No empirical test of this assumption exists; however, I calculated the Rosenbaum bounds to check the sensibility of the results to the failure of this assumption (Guo and Fraser, 2010). Those bounds estimate a probability value for different values of Γ, which is an index of the strength of the influence that unobserved factors could have on the selection process. I calculated Γ^*, a critical value of Γ at which the estimated effect (average treatment on the treated) is no longer significant at the 10 percent level for matching estimator (single nearest neighbour, caliper and kernel). In all the cases I obtained a $\Gamma^* = 1.3$. This means that the effect would still be significant even if matched organic and non-organic farmers differed in their odds of certification by a factor of 1.3 because of unobserved factors. In general, this test provides evidence that unobserved factors may not drive the statistically significant effects, and it compares favourably with findings from other studies, such as Ali and Abdulai (2010), who obtained a value of $\Gamma^* = 1.45$ for the effect of genetically modified crops on farmers' income in Pakistan.

Overall, the propensity score matching results suggest that there is a negative effect of organic certification in coca growing. In general, this reduction on the scale of coca cultivation is likely to be related to the increase on the relative profitability of coffee due to organic coffee certification. In the research area, farmers receive 16 percent price premiums for organic coffee in comparison to conventional coffee. Moreover, most of the coffee farmers in the research area are organic by default, as they do not use pesticides due to their high costs. Ibanez and Carlsson (2010) also found that increases in the relative profitability of alternative crops significantly reduced the likelihood of coca cultivation and the number of hectares of coca cultivated in Colombia. Nevertheless, the present study is still unable to provide the long-term experimental

	Average treatment effect on the treated	Probability	Median standardized bias after matching
Single nearest neighbor	−1,839.9090 (1,122.6780)	0.1	5.1
Caliper (0.05 and 0.25)	−1,839.9090 (1,139.6830)	0.1	5.1
Kernel (0.05 and 0.25)	−771.2083 (708.7078)	0.2	3.7

Note: Standard error in parentheses

Table V. Propensity score matching results

results that are necessary to truly test the effect of AD on coca growing. On the other hand, these propensity score matching results bring research one step closer towards a test of causal-effect, which could be a determinant to obtain more support for this type of drug control policy.

5. Conclusions

The lack of research at the micro-level in coca cultivation has limited the knowledge as due whether AD policies, such as the promotion of participation in organic coffee certification, influence farmers' decisions related to coca cultivation. This article evaluated the effects of organic coffee certification on the number of coca bushes cultivated by individual farmers using propensity score matching.

A survey of 496 farmers was conducted among the member of a coffee cooperative located in the upper Tambopata valley, which is a coca-growing region, located deep in the mountainous Amazon rainforest of Peru. First, the determinants of participation on the organic certification program were evaluated. The results suggest that farmers with comparative advantages in coffee cultivation, in particular farmers with larger coffee areas, higher altitude plots, more farming experience, and with level terrain, are more likely to participate in the organic program. Then, the effect of organic coffee certification on coca growing was calculated. Overall, the propensity score matching results showed a significant negative effect of organic coffee certification on the scale of coca cultivation. Those results were consistent under different matching algorithms and robustness tests.

The reduction of the scale of coca growing is likely to be related to income changes. The price premiums of organic certified coffee are around 16 percent above the normal coffee price, and almost all the farmers in the study area are organic by default due to the lack of affordable pesticides in this remote, rural area. However, these results could be temporary in nature, as there is a lack of relevant time series data to conduct more integral assessments in the study region.

Notes

1. The sub-sections of the Literature review: "2.2 Drug control policies", and "2.3 Evaluation of drug control policies" are repeated with the permission of Garcia-Yi (2014) (a paper that deals with a review of literature on coca growing and policies, including historic perspectives, in Latin America).
2. The sub-sections of the Methods: "3.1 (Description of the) study area", and "3.2 Data collection" are repeated with the permission of Garcia-Yi and Grote (2012) (a paper that focuses on the survey conducted and lessons learned asking sensitive questions in coca-growing areas in Peru).

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