JICA Research Institute

JICA-RI Working Paper

Impact Evaluation Analyses for the JICA Projects

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Ryo Takahashi and and Yasuyuki Todo

No. 55

March 2013

JICA Research Institute

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JICA Research Institute
10-5 Ichigaya Honmura-cho
Shinjuku-ku
Tokyo 162-8433, JAPAN
TEL: +81-3-3269-3374
FAX: +81-3-3269-2054

Impact of a Shade Coffee Certification Program on Forest Conservation:

A Case Study from a Wild Coffee Forest in Ethiopia

Ryo Takahashi* and Yasuyuki Todo†

Abstract

In recent years, shade coffee certification programs have attracted increased attention from conservation and development organizations. The certification programs offer an opportunity to link environmental and economic goals by providing a premium price to producers and thereby contribute to forest conservation. However, the significance of the certification program's conservation efforts is still unclear because of the lack of empirical evidence. The purpose of this study is to examine the impact of the shade coffee certification program on forest conservation. The study was carried out at the Belete-Gera Regional Forest Priority Area in Ethiopia, and remote sensing data from 2005 and 2010 was used to gauge the change of the forest area. Employing the propensity score matching estimation, we found that forests under the coffee certification were less likely to be deforested than forests without forest coffee. By contrast, the difference in the degree of deforestation between forests with forest coffee but not under the certification program and forests with no forest coffee is statistically insignificant. These results suggest that the certification program had a large impact on forest protection, decreasing the probability of deforestation by 1.7 percentage points.

Keywords: shade coffee, coffee certification, forest conservation, impact evaluation, remote sensing, Ethiopia

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* Corresponding author. Department of International Studies, University of Tokyo (ggt000@hotmail.com)

†. Department of International Studies, University of Tokyo / Visiting Fellow, JICA Research Institute (yastodo@k.u-tokyo.ac.jp)

This study was conducted as part of the research project "Impact Evaluation of Aid Projects of the Japan International Cooperation Agency" in the JICA Research Institute. The authors would like to thank Yasuyuki Sawada (the project leader) and Keiichi Tsunekawa (the former Director of the JICA Research Institute) for providing us with the opportunity to perform this research. The authors would also like to thank Naoki Ando, Megumi Masui, Koji Noda, Shinji Ogawa, Yasuo Takahashi, and, in particular, Toru Inada, Tsutomu Nishimura, and Fumiaki Saso for their great help in data collection. The opinions expressed and the arguments employed in this paper are the sole responsibility of the authors and do not necessarily reflect those of the JICA, the JICA Research Institute, or any institution to which the authors are associated.

1. Introduction

Deforestation in less developed countries, mostly in sub-Saharan Africa and Latin America, is a widespread problem. Tilman et al. (2001) estimated that 1 billion hectares of forestland will be converted to agricultural land by 2050. Because deforestation is proceeding most rapidly in areas that are rich in biodiversity (Balmford 1994), a loss of forest area leads directly to a loss of biodiversity.

Many of the numerous studies on forest management have pointed to the importance of traditional coffee production for forest conservation and biodiversity protection. This coffee is traditionally grown in the understory of shade trees, and the agroecosystems of shaded coffee preserve the forest and provide an important refuge for biodiversity (Perfecto and Snelling 1995; Perfecto et al. 1996; Wunderle Jr. and Latta 1996; Greenberg et al. 1997; Moguel and Toledo 1999; Mas and Dietsch 2004). In addition, Toledo and Moguel (2012) showed the potential values of a traditional shaded coffee system in terms of the sustainability of livelihoods and landscapes. However, the forest areas currently operating under the shaded coffee system are rapidly being converted into plantations, which offer few or no shade trees, for modern industrial coffee production (Perfecto et al. 1996; Moguel and Toledo 1999). One of the major reasons for the rapid transformation is the low yield of the shaded coffee system (Rappole et al. 2003b). Although the coffee yield has been improved by the modern coffee system, the modern system also has a higher environmental cost. The modern coffee system triggers forest reduction, increased erosion, chemical runoff, and consolidation, the combined effects of which threaten the long-term sustainability of the ecosystem (Perfecto et al. 1996; Staver et al. 2001; Rappole et al. 2003b). Hence, conserving the forest area under the shaded coffee system and preventing the movement to the modern industrial system are essential from an environmental perspective.

Particularly in recent years, shade coffee certification programs have attracted increased attention from conservation and development organizations aiming to reduce producers' incentives to convert the shaded coffee forest area into plantations for industrial production (Fleischer and Varangis 2002; Philpott and Dietsch 2003; Perfecto et al. 2005; Taylor 2005). The certification programs offer an opportunity to link environmental and economic goals by providing a premium price to producers who maintain shade trees and thereby contribute to the protection of forest cover and biodiversity.

The relationship between the shaded coffee system and biodiversity (i.e., an environment rich in orchids, birds, ants, butterflies, and hymenopterans) has been the subject of many studies (Nir 1988; Nestel and Dickschen 1990; Nestel et al. 1993; Moguel and Toledo 1999; Perfecto et al. 2003). Moreover, many other studies focused on the impact of certification system on the producers' livelihoods (Arnould et al. 2009; Bolwig et al. 2009; Barham et al. 2011; Barham and Weber 2011; Ruben and Fort 2012). However, few empirical studies have examined the significance of the certification program's conservation efforts. The first ecological evaluation was conducted by Mas and Dietsch (2004) in Mexico, attempting to evaluate the effect of coffee certification on biodiversity conservation. Unfortunately, because they studied an area that was likely to meet the criteria used by the major certification programs, the results may not confirm that the certification program was the cause of the conservation effects.

The study in Mexico by Philpott et al. (2007) evaluated the ecological benefits of coffee certification programs (Fair-trade Labeling Organizations and Certimex Producer Lists) by examining the area's vegetation and the richness of the area's species, such as ants and birds. Their results revealed that there were no significant differences between certified and uncertified areas in terms of shade management or the diversity of ants and birds. However, the coffee certification programs in their study issued only organic and/or fair trade certifications, and shade coffee certification was not part of their research simply because no farms in the area under study had obtained shade coffee certification. Although other certification programs, such as the fair trade certification and organic certification, include environmental criteria, the main goal of each certification program is different (Ponte 2004). For example, the purpose of fair trade certification is to guarantee a price floor to marginal producers in less developed countries (Basu and Hicks 2008). Hence, it is less clear whether other certification programs can be expected to offer conservation of the forests or not (Philpott et al. 2007).

Moreover, these previous studies used regressive procedures to examine the differences in the mean outcomes of the target areas and the control areas. The results of this method are most likely biased by the endogeneity of the criteria used to select certificated areas (Imbens and Wooldridge 2008; Blackman and Rivera 2011). Therefore, although a large number of theoretical studies have focused on shade coffee certification, whether a shade coffee certification program provides a disincentive for shade coffee producers to convert to the modern system is still unclear, and there remains a need for empirical studies that use detailed analysis to evaluate the impact of shade coffee certification on forest conservation.

Therefore, this study aims to evaluate the impact of the shade coffee certification program on forest conservation. More precisely, we will evaluate the impact of the certification program on the probability of deforestation. We chose to analyze the certification program by the Rainforest Alliance, a major international NGO based in the US, and we selected Ethiopia as a case study because there is a lack of empirical evidence in the African context (Donald 2004).

Ethiopia is the first African country to obtain coffee certification from the Rainforest Alliance. In 2007, the NGO certified a group of 555 households that produce shade coffee in the Belete-Gera Regional Forest Priority Area (RFPA). This effort was supported by the Japan International Cooperation Agency (JICA), a Japanese foreign aid agency. JICA implemented a Participatory Forest Management Project (hereafter, “the project”) in the Belete-Gera RFPA and established forest management associations to protect forest areas (Takahashi and Todo [2012] conducted the impact evaluation of establishing the forest management associations in this area). In addition, the project provided a channel for the members of the associations who produced shade coffee within the forest area to obtain certification (hereafter, “forest coffee certification”).

In this study, we focus on those association members who obtained forest coffee certification from the NGO in 2007 and 2009. To evaluate the impact of coffee certification on the probability of deforestation, we employed a propensity score matching (PSM) method to control for possible biases.

2. Description of the Study Area

2.1 Description of the Belete-Gera RFPA and the project

The Belete-Gera RFPA is 150,000 ha in size and is located in the Gera District and the Shabe Sombo District in the Oromiya Region (Figure 1). As part of the highland rain forest, the natural vegetation in the Belete-Gera RFPA is subject to annual precipitation of 1,500 mm and an annual average air temperature of approximately 20 degrees Celsius. The topography of the Belete-Gera RFPA is complicated and consists of undulating hills in the 1,200 to 2,900 m range, with steep mountainous terrain in some places. The forest cover in the RFPA has declined significantly despite the government's prohibition of wood extraction in the forest area; more precisely, 40 percent of the forest area in the Gera and Shabe Sombo districts was cleared during the 1985-2010 period (Todo and Takahashi 2011). The average annual deforestation rate in the Belete-Gera RFPA is approximately 1.7 percent (Takahashi and Todo 2012).

2.2 Wild coffee production and coffee certification

Coffee (*Coffea Arabica*) is a native species and grows wild in the Belete-Gera RFPA. Because coffee production is not economically practical at high elevations (above 2,300 meters), wild coffee is typically found in the forest at an altitude of approximately 2,000 m (shown in the dark green areas in Figure 1). Each wild coffee area is managed by an individual producer, and the right to harvest wild coffee is given to the producer according to the traditional agreement among villagers. Producers commonly dry the wild coffee after harvesting and sell it as sun-dried, shade-grown coffee to local markets, but the selling price has been fairly low (i.e., approximately one US dollar per one kg in 2007 and 2008).

To provide a channel of income for the members of the associations, the project supported the forest associations in their efforts to obtain forest coffee certification from the Rainforest Alliance. Although the Rainforest Alliance originally worked mostly with producers of larger plantations (Méndez et al. 2010), the Rainforest Alliance also provided the certification program, which excludes modern industrial coffee producers, in an effort to encourage the shaded coffee system to move toward greater sustainability (Mas and Dietsch 2004). A group of 555 coffee-producing households was certified by the Rainforest Alliance in 2007, and they obtained a price 15-20 percent higher than the regular price in 2008 (Table 1). According to the official report by the project, such premium price successfully enhanced the incentive of conserving forest areas among producers (JICA 2010). In 2010, 58 associations took part in the certification program. Thus, the total number of participating coffee producers was 3,050. Approximately 60 tons of the certified coffee were collected from the all members and sold to the international market in 2010.

Certification was extended to the forest coffee areas within the registered forest and the areas under the natural forest coffee system but not to those under the modern coffee system. Moreover, since the certification was given to each association, all the villagers, including poor producers, were able to participate in the certification program. Once a year, an auditor from the NGO visits and checks the condition of the certified areas and the surrounding forest areas. If an expansion of the modern coffee system areas or a degradation of the forest (e.g., the logging of shade trees) is observed in the certified areas, the certification will be withdrawn.

3. Data

3.1 Remote sensing data

To calculate the probability of deforestation, we considered only the forest-covered area in 2005 and sought to determine whether that area was deforested in 2010. We used the satellite images of Landsat 7 from path/row 170/55 for January 2005 and January 2010 for our analysis.

To distinguish the forest areas from the non-forest areas, we utilized the Normalized Difference Vegetation Index (NDVI), a measure of vegetation commonly used in remote sensing studies (e.g., Tucker et al. [1985], Davenport and Nicholson [1993], and Tucker et al. [2001]). The NDVI records a value ranging from −1.0 to 1.0 that increases with the degree of vegetation biomass (Jensen 1996). Following Southworth et al. (2004), we determined a threshold value of the NDVI for the forest areas based on the information from the satellite images and our fieldwork. We conducted ground-truthing to collect the locational data of 17 points at the boundaries delineating the forest from the non-forest areas that existed during the period of our study (according to interviews with several local residents), and we chose the area with the highest NDVI value for each year as the threshold value for the forest areas. Forest areas are defined as areas that function as forests either physically or socially for local communities (Southworth and Tucker 2001). Non-forest areas include agricultural lands, young fallow, rangelands, cleared areas, bare soil areas, and urban areas.

Although this methodology has been used in previous studies (e.g., Southworth et al. [2004], White and Nemani [2006], and Takahashi and Todo [2012]), there may be errors in estimating the NDVI threshold value, and these errors can lead to errors in the forest transformation. However, because the same error would affect any locational unit within the same year, the forest change for sub-villages with and without forest certification is over- or underestimated to the same extent. Therefore, the possible errors in the estimation of a forest area from the satellite images do not lead to a bias in the estimation of the impact of forest certification on the probability of deforestation.

3.2 Certified forest coffee area and observation grids

The producers who were certified by the NGO usually had the rights to manage and harvest one or two forest coffee areas in the registered forest area. To obtain the locational data of a forest coffee area, we used a global positioning system (GPS) device to map all of the forest coffee areas managed by the certified producers. We selected four sub-villages in the study areas marked with the red diagonal line in Figure 1 and studied 240 forest coffee areas managed by 205 producers in total. In this study, we defined these areas as certified forest coffee areas, whereas the rest of the areas in the registered forest area were defined as forest areas without forest coffee.

The general characteristics of the certified forest coffee areas in the sample are given in Table 2. Columns 1 and 2 provide information on the forest coffee areas certified in 2007 and 2009, respectively. There is no statistically significant difference between the average size of the forest coffee areas certified in 2007 (56.4 *are*) and 2009 (40.3 *are*). Table 3 shows the general characteristics of the certified producers who manage 240 plots. Although most of certified producers produced not only the forest coffee but also modern coffee using the improved seeds, the total area of the modern coffee is less than the size of the certified forest coffee area. The average size is 56.6 *are* for the modern coffee and 21.5 *are* for certified forest coffee, which indicates that the modern coffee system in this area is not quite like an industrialized system or plantation.

The target forest areas were divided into square-shaped cells (30 m by 30 m). In this study, we used each grid as an observation for the analysis. The total number of observation grids was 85,323, which were divided into 4 categories: forest areas certified by the program in

2007, those certified in 2009, forest areas without forest coffee where forest certification was granted in 2007, and those where certification was granted in 2009 (Table 4). All characteristics of the certified forest coffee area and the forest area without forest coffee were significantly different ($p<0.01$).

4. Method

In this study, we evaluated the impact of forest coffee certification on forest conservation by using a PSM method to reduce possible bias, such as selection bias (detailed explanation is in the Appendix). The PSM method is commonly used in the study of the impact evaluation. For example, Ruben and Fort (2012) used the PSM method to evaluate the impact of fair trade certification on production and livelihood in Peru.

To quantify the impact of the forest coffee certification program, we first compare the probability of deforestation between the certified forest coffee area issued in 2007 and the forest area without forest coffee. The difference between the two groups reflects the effect of forest coffee certification on forest protection. However, the difference may also incorporate the effect of having coffee in the forest, regardless of whether the forest coffee is certified or not. For example, keeping forest near coffee trees may lead to a larger yield of coffee, because coffee needs some shade to grow. To highlight the effect of forest coffee without certification, our additional estimation compares between the certified forest coffee area issued in 2009 and forest area without forest coffee. In this analysis, the forest coffee area certified in 2009 is treated as the forest coffee area without certification. This treatment is justified by the fact that the certification was made in November 2009 and the remote sensing data on the forest is available only up to January 2010. Two months are too short for the certification to have any effect. Therefore, by looking at the difference between the forest coffee area certified in 2009 and the forest area without coffee, we can examine the effect of forest coffee without certification.

The two estimations – differed probabilities of deforestation between the forest coffee area certified in 2007 and the area without coffee on the one hand and differed probabilities of deforestation between the forest coffee area certified in 2009 and the area without coffee on the other – will help us to more accurately evaluate the effect of the forest coffee certification.

To obtain the PSM estimator of the effect of the treatment (i.e., the forest coffee certification), we first used a probit model to examine how forest coffee areas were selected for the certification program. Since forest coffee is wild coffee, the selection should have been made by geographic and ecological factors, rather than socioeconomic factors. Following the studies by Takahashi and Todo (2012), Cropper et al. (1999), and Chomitz and Gray (1996), our geographic and ecological covariates in the probit estimations include: the distance to the closest project office (the project has two offices located in the Belete-Gera RFPA); the distance to the village; the distance to the main road; average elevation; average slope; the dummy variable for acrisol; and the dummy variable for Gera District. Acrisol is a soil with subsurface accumulation of low activity clays and low base saturation; in other words, acrisol is unfertile.

In the benchmark (additional) case, the dependent variable of our probit estimation is a dummy variable which takes a value of 1 if the observation grid is in a forest coffee area where the certification was issued in 2007 (2009) and 0 if the grid is in a forest area without coffee where the certification was made in 2007 (2009).

5. Estimation Results

5.1 Matching procedure

The results of the probit estimation are presented in Table 5. We found that almost all of the variables had a significant effect. The goodness-of-fit can be measured by the pseudo R-squared, and both probit estimations showed a fairly large pseudo R-squared, such as 0.24 and 0.42.

Based on the propensity score from the probit estimation, we created a new control observation group such that the treatment group and the new control group would have similar characteristics. In this study, we employed the one-to-one matching with a caliper of 0.001. A common support condition has to be implemented to satisfy the overlap assumption. In other words, in the treatment group, we dropped the observations whose propensity scores were higher than the maximum score or lower than the minimum score of the observations in the control group. Each treatment observation was compared with the weighted average of all of the control observations in the common support region.

To check the characteristics of the treatment group and the control group after the matching, we conducted two types of balancing tests. First, a *t*-test was used to compare the mean of each covariate between the treatment group and the control group after the matching. The results of the *t*-test for the PSM estimation are presented in Table 6. The first column in each estimation (i.e., columns 1 and 3) shows the mean difference between the treatment group and the control group for each covariate before the matching, and the second column (i.e., columns 2 and 4) represents the difference after the matching with the *t*-values in parentheses. The results showed that the difference in all of the covariates before the matching turned to be insignificant after the matching, indicating that the characteristics of the control group are sufficiently similar after matching. Next, we ran the probit estimation using the sample after the matching and compared the pseudo R-squared with that obtained from the probit estimation using the sample before the matching. If the matching were successful, the pseudo R-squared after the matching would have a lower value than that before the matching, which would indicate that the after-matching probit has no explanatory power. The results shown in the lower rows of Table 6 indicated that the pseudo R-squared values of both estimations drastically decreased to 0.00. The second balancing test confirms that there is no systematic difference between the treatment and after-matching control groups.

5.2 Impact of the forest coffee certification program

After the matching procedure, we computed the PSM estimation given by equation (5) based on the treatment and control groups. In most studies, the standard error is obtained by bootstrapping (Caliendo and Kopeinig 2008). In this study, we also used the bootstrapping standard error based on 100 replications, following Smith and Todd (2005).

The results of the benchmark PSM estimation, which are given in the first column of Table 7, show that the probability of deforestation in the certified forest area (2.8 percent) is lower than that of the forest area without forest coffee (4.5 percent), and the difference, 1.7 percentage points, is statistically significant at the 5-percent level. As we argued in Section 4, the difference reflects the effect of the forest coffee certification and forest coffee itself. On the other hand, the results of the additional PSM estimation, given in the second column of Table 7, indicate that the mean difference between uncertified forest coffee areas and forest areas without coffee is fairly small (i.e., 0.6 percentage points) and, most importantly, the difference is statistically insignificant at any reasonable level of significance. This implies that uncertified forest coffee is not helpful to forest protection. Combining the results from the two PSM estimations, we conclude that the forest coffee certification program reduced the probability of deforestation by 1.7 percentage points.

6. Discussion and Conclusion

We ran two PSM estimations to evaluate the impact of the certification program. We found that the probability of deforestation in the certified forest coffee area was smaller than the forest area without forest coffee by 1.7 percentage points, while there was no significant difference between the non-certified forest coffee area and forest area without forest coffee. Therefore, our empirical results indicated that the forest coffee certification program had a positive effect on forest conservation, which supports the previous theoretical studies on certification systems (Fleischer and Varangis 2002; Philpott and Dietsch 2003; Perfecto et al. 2005; Taylor 2005).

The exploration of the reasons for this result is not the subject of this paper. We can just mention a few possible reasons raised by former studies. For instance, Philpott and Dietsch (2003) and Perfecto et al. (2005) clearly stated that a financial incentive is the most important aspect; the idea of the certification system would collapse if the return to producers were insufficient, which would consequently trigger the temptation to convert forest land into an industrial area. In the area under study, the certified producers sold the certified coffee at a price that was 15 to 20 percent higher than that of regular coffee. Some of the certified producers complained about the delay of payment caused by the project, but all of them were satisfied by the return (JICA 2010).

Another important aspect is the auditing system and regulation. Philpott and Dietsch (2003) pointed out the importance of regulation by certifiers to prohibit the extraction of wood and the conversion of primary forest areas; certifiers should prohibit certification if a regulation is violated. The certifier of this study area, such as the Rainforest Alliance, audits the condition of forest area once a year. Such auditing system encourages the certified producers to keep to the regulation, resulting in the conservation effort in the study area.

These results could provide useful information to the fields of forest conservation and forest management. The project decided to obtain the certification from the NGO for coffee because coffee was a valuable natural resource in the area under study. However, other natural resources, such as honey and herbs, also have the potential to be certified. There is a good possibility that the forest management system and the system for certifying natural resources will be adapted by regions outside of Ethiopia or Africa.

However, this study only examined the impact on forest conservation, not on forest degradation. As Rappole et al. (2003b) noted, one potential problem with the certification program is that it could create an incentive for the producers to convert an existing primary forest area into an area that produces shade coffee. Although a shaded coffee system represents an important refuge for biodiversity (Estrada et al. 1993), it cannot provide an ecosystem that is comparable with that of the native forest (Perfecto et al. 2003). Therefore, a certification program may encourage forest degradation instead. Conversely, Philpott and Dietsch (2003) dispute the claims of Rappole et al. (2003b) and argue that such degradation can be prevented. However, the discussion between Philpott and Dietsch (2003) and Rappole et al. (2003a) has not yet reached a consensus. Therefore, future researchers must further study the impact of the certification program on forest degradation. Furthermore, although we observed the overall conservation impact of the certification, the conservation efforts may differ according to the producers' characteristics. Further study is needed to determine how socioeconomic factors of the producer affect the forest transition and certification effort.

Appendix: Empirical Framework

This paper specifically examines the average effect of treatment on the treated (ATT), which is specified as follows:

$$ATT = E(Y_i(1) - Y_i(0) | D_i = 1, X_i), \tag{1}$$

where D_i is a dummy variable indicating that grid i is a certified forest coffee area or a forest area without coffee. Y_i is a dummy variable that takes a value of 1 if grid i were deforested in 2010. X_i denotes the environmental characteristics of grid i. ATT is the average difference between the probability of deforestation in certified forest coffee areas and the counter-factual probability that would exist if these areas had not been certified by the NGO.

To identify ATT, we must satisfy the following two assumptions (i.e., conditional independence and overlap) (Rosenbaum and Rubin 1983):

$$Y(1), Y(0) \coprod D | X, \tag{2}$$

and

$$0 < \Pr(D = 1 | X) \equiv P(X) < 1). \tag{3}$$

The first assumption given by equation (2) implies that given a set of observable characteristics X that are not affected by treatment; the outcomes are independent of the treatment assignment. The second assumption given by (3) ensures that the grids with the same X values have a positive probability of obtaining the certification and the control observation. Rosenbaum and Rubin (1983) designated these two assumptions as 'strong ignorability'.

To estimate ATT, this study made use of the PSM method developed by Rosenbaum and Rubin (1983). The PSM estimator is simply the mean difference in outcomes over the common support, which is appropriately weighted by the propensity score (i.e., the probability of obtaining certification). Hence, ATT in equation (1) becomes:

$$ATT = E(Y_i(1) \mid D_i = 1, P(X_i)) - E(Y_i(0) \mid D_i = 0, P(X_i)). \qquad (4)$$

One advantage of using remote sensing data is that we can build panel data for the analysis. If panel data are available, a difference-in-differences (DID) PSM estimation of the ATT can be employed, as proposed by Heckman et al. (1997, 1998). Thus, we can eliminate time-invariant effects on the outcome variable. The DID-PSM estimation used in this study is defined as:

$$DID - ATT = \frac{1}{N}\sum_{i \in I_1}\left(\Delta Y_i(1) - \sum_{j \in I_0} W\big(P(X_i), P(X_j)\big)\Delta Y_j(0)\right), \qquad (5)$$

where $\Delta Y_i \equiv Y_{it} - Y_{is}$ and t and s are the post- and pre-program periods, respectively. I_1 and I_0 are the treatment and matched control groups, respectively. N denotes the number of observations in the treatment group. Finally, W is a weight determined by the distance between the propensity scores of the treated and matched control observations.

References

Arnould, E. J., A. Plastina, and D. Ball. 2009. Does fair trade deliver on its core value proposition? Effects on income, educational attainment, and health in three countries. *Journal of Public Policy & Marketing* 28 (2): 186-201.

Balmford, A. 1994. Avian endemism and forest loss. *Nature* 372 (6507): 623-24.

Barham, B. L., M. Callenes, S. Gitter, J. Lewis, and J. Weber. 2011. Fair trade/organic coffee, rural livelihoods, and the "agrarian question": Southern Mexican coffee families in transition. *World Development* 39 (1): 134-45.

Barham, B. L., and J. G. Weber. 2011. The economic sustainability of certified coffee: Recent evidence from Mexico and Peru. *World Development* 40 (6): 1269-79.

Basu, A. K., and R. L. Hicks. 2008. Label performance and the willingness to pay for fair trade coffee: A cross-national perspective. *International Journal of Consumer Studies* 32 (5): 470-78.

Blackman, A., and J. Rivera. 2011. Producer-level benefits of sustainability certification. *Conservation Biology* 25 (6): 1176-85.

Bolwig, S., P. Gibbon, and S. Jones. 2009. The economics of smallholder organic contract farming in tropical Africa. *World Development* 37 (6): 1094-1104.

Caliendo, M., and S. Kopeinig. 2008. Some practical guidance for the implementation of propensity score matching. *Journal of Economic Surveys* 22 (1): 31-72.

Chomitz, K. M., and D. A. Gray. 1996. Roads, land use, and deforestation: A spatial model applied to Belize. *World Bank Economic Review* 10 (3): 487-512.

Cropper, M. L., C. Griffiths, and M. Mani. 1999. Roads, population pressures and deforestation in Thailand, 1976-1989. *Land Economics* 75 (1): 58-73.

Davenport, M. L., and S. E. Nicholson. 1993. On the relation between rainfall and the normalized difference vegetation index for diverse vegetation types in East Africa. *International Journal of Remote Sensing* 14 (12): 2369-89.

Donald, P. F. 2004. Biodiversity impacts of some agricultural commodity production systems. *Conservation Biology* 18 (1): 17-38.

Estrada, A., R. Coates-Estrada, and D. Meritt Jr. 1993. Bat species richness and abundance in tropical rain forest fragments and in agricultural habitats at Los Tuxtlas, Mexico. *Ecography* 16 (4): 309-18.

Fleischer, G., and P. Varangis. 2002. Toward more sustainable coffee: Consumers fuel demand for more sustainable agriculture. *Agriculture Technology Notes* 23.

Greenberg, R., P. Bichier, A. C. Angon, and R. Reitsma. 1997. Bird populations in shade and sun coffee plantations in central Guatemala. *Conservation Biology* 11 (2): 448-59.

Heckman, J. J., H. Ichimura, and P. Todd. 1998. Matching as an econometric evaluation estimator. *Review of Economic Studies* 65 (2): 261-94.

Heckman, J. J., H. Ichimura, and P. E. Todd. 1997. Matching as an econometric evaluation estimator: Evidence from evaluating a job training programme. Review of Economic Studies 64 (4): 605-54.

Imbens, G. M., and J. M. Wooldridge. 2008. *Recent developments in the econometrics of program evaluation*. National Bureau of Economic Research,

Jensen, J. R. 1996. *Introductory digital image processing: A remote sensing perspective*. Englewood Cliffs, NJ, USA: Prentice-Hall Inc.

JICA. 2010. Report of the terminal evaluation on the Japanese technical cooperation for the participatory forest management project in Belete-Gera regional forest priority area, phase 2 in the Federal Democratic Republic of Ethiopia. Japan International Cooperation Agency (JICA). http://lvzopac.jica.go.jp/library/indexeng.html.

Méndez, V. E., C. M. Bacon, M. Olson, K. S. Morris, and A. Shattuck. 2010. Agrobiodiversity and shade coffee smallholder livelihoods: A review and synthesis of ten years of research in Central America. *Professional Geographer* 62 (3): 357-76.

Mas, A. H., and T. V. Dietsch. 2004. Linking shade coffee certification to biodiversity conservation: Butterflies and birds in Chiapas, Mexico. *Ecological Applications* 14 (3): 642-54.
Moguel, P., and V. M. Toledo. 1999. Biodiversity conservation in traditional coffee systems of Mexico. *Conservation Biology* 13 (1): 11-21.
Nestel, D., and F. Dickschen. 1990. The foraging kinetics of ground ant communities in different Mexican coffee agroecosystems. *Oecologia* 84 (1): 58-63.
Nestel, D., F. Dickschen, and M. A. Altieri. 1993. Diversity patterns of soil macro-Coleoptera in Mexican shaded and unshaded coffee agroecosystems: An indication of habitat perturbation. *Biodiversity and Conservation* 2 (1): 70-78.
Nir, M. A. 1988. The survivors: Orchids on a Puerto Rican coffee finca. *American Orchid Society Bulletin* 57.
Perfecto, I., A. Mas, T. Dietsch, and J. Vandermeer. 2003. Conservation of biodiversity in coffee agroecosystems: A tri-taxa comparison in southern Mexico. *Biodiversity and Conservation* 12 (6): 1239-52.
Perfecto, I., R. A. Rice, R. Greenberg, and M. E. Van der Voort. 1996. Shade coffee: A disappearing refuge for biodiversity. *BioScience* 46 (8): 598-608.
Perfecto, I., and R. Snelling. 1995. Biodiversity and the transformation of a tropical agroecosystem: Ants in coffee plantations. *Ecological Applications* 5 (4): 1084-97.
Perfecto, I., J. Vandermeer, A. Mas, and L. S. Pinto. 2005. Biodiversity, yield, and shade coffee certification. *Ecological Economics* 54 (4): 435-46.
Philpott, S. M., P. Bichier, R. Rice, and R. Greenberg. 2007. Field-testing ecological and economic benefits of coffee certification programs. *Conservation Biology* 21 (4): 975-85.
Philpott, S. M., and T. Dietsch. 2003. Coffee and conservation: A global context and the value of farmer involvement. *Conservation Biology* 17 (6): 1844-46.
Ponte, S. 2004. *Standards and sustainability in the coffee sector: A global value chain approach.* Winnipeg, Manitoba, Canada: International Institute for Sustainable Development.
Rappole, J. H., D. I. King, and J. H. Rivera. 2003a. Coffee and conservation III: Reply to Philpott and Dietsch. Conservation Biology 17 (6): 1847-49.
Rappole, J. H., D. I. King, and J. H. V. Rivera. 2003b. Coffee and conservation. *Conservation Biology* 17 (1): 334-36.
Rosenbaum, P. R., and D. B. Rubin. 1983. The central role of the propensity score in observational studies for causal effects. *Biometrika* 70 (1): 41-55.
Ruben, R., and R. Fort. 2012. The impact of fair trade certification for coffee farmers in Peru. *World Development* 40 (3): 570-82.
Smith, J. A., and P. E. Todd. 2005. Does matching overcome LaLonde's critique of nonexperimental estimators? *Journal of Econometrics* 125 (1): 305-53.
Southworth, J., D. Munroe, and H. Nagendra. 2004. Land cover change and landscape fragmentation—comparing the utility of continuous and discrete analyses for a western Honduras region. *Agriculture, Ecosystems & Environment* 101 (2): 185-205.
Southworth, J., and C. M. Tucker. 2001. Forest cover change in western Honduras: The role of socio-economic and biophysical factors, local institutions, and land tenure. *Mountain Research and Development* 21 (3): 276-83.
Staver, C., F. Guharay, D. Monterroso, and R. G. Muschler. 2001. Designing pest-suppressive multistrata perennial crop systems: Shade-grown coffee in Central America. *Agroforestry Systems* 53 (2): 151-70.
Takahashi, R., and Y. Todo. 2012. Impact of community-based forest management on forest protection: Evidence from an aid-funded project in Ethiopia. *Environmental Management* 50 (3): 396-404.
Taylor, P. L.. 2005. A fair trade approach to community forest certification? A framework for discussion. *Journal of Rural Studies* 21 (4): 433-47.

Tilman, D., J. Fargione, B. Wolff, C. D'Antonio, A. Dobson, R. Howarth, D. Schindler, W.H. Schlesinger, D. Simberloff, and D. Swackhamer. 2001. Forecasting agriculturally driven global environmental change. *Science* 292 (5515): 281-84.

Todo, Y., and R. Takahashi. 2011. Impact of farmer field schools on agricultural income and skills: Evidence from an aid-funded project in rural Ethiopia. *Journal of International Development*.

Toledo, V. M., and P. Moguel. 2012. Coffee and sustainability: The multiple values of traditional shaded coffee. *Journal of Sustainable Agriculture* 36 (3): 353-77.

Tucker, C. J., T. E. Goff, and J. R. G. Townshend. 1985. African land-cover classification using satellite data. *Science* 227 (4685): 369-75.

Tucker, C. J., D. A. Slayback, J. E. Pinzon, S. O. Los, R. B. Myneni, and M. G. Taylor. 2001. Higher northern latitude normalized difference vegetation index and growing season trends from 1982 to 1999. *International Journal of Biometeorology* 45 (4): 184-90.

White, M. A., and R. R. Nemani. 2006. Real-time monitoring and short-term forecasting of land surface phenology. *Remote Sensing of Environment* 104 (1): 43-49.

Wunderle Jr, J. M., and S. C. Latta. 1996. Avian abundance in sun and shade coffee plantations and remnant pine forest in the Cordillera Central, Dominican Republic. *Ornitología Neotropical* 7: 19-34.

Figure 1. Belete-Gera regional forest priority area

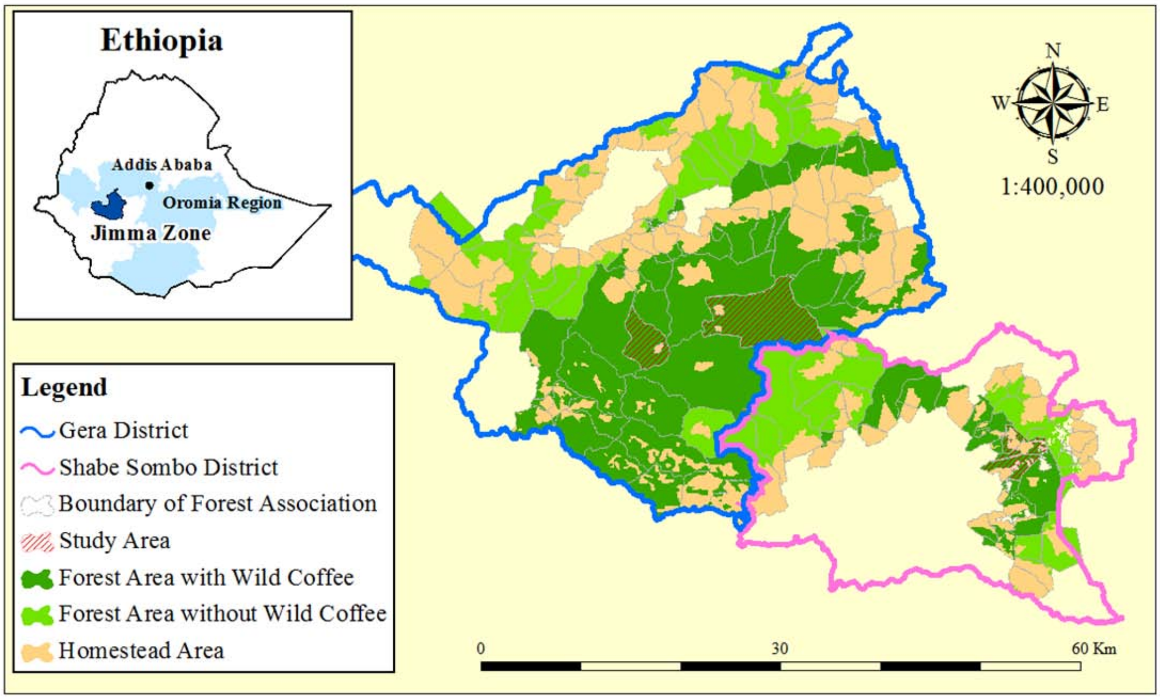

Table 1. Number of coffee-producing households participating in the coffee certification program

	2007-2008	2008-2009	2009-2010	2010-2011
Number of participating forest associations	3	21	48	58
Number of participating households	555	1,701	2,808	3,050

Table 2. Description of certified forest coffee areas in the sample

	Plot certified in 2007 (1)	Plot certified in 2009 (2)	Total (3)
Number of plots	148	92	240
Size of forest coffee area (a)	56.4	40.3	50.2
	(107.7)	(75.9)	(96.9)
Distance to the village (m)	203.3	86.6**	158.6
	(334.1)	(136.9)	(281.1)
Average elevation (m)	1,971.0	1,913.0**	1,948.8
	(124.8)	(68.2)	(110.2)
Average slope (%)	13.8	12.3	13.2
	(5.9)	(5.6)	(5.8)

Note: Standard deviations are in parentheses.

** in column 2 indicates that the means in the two groups (columns 1 and 2) are significantly different at the 1% level.

Table 3. Characteristics of the households in the sample

	Producer certified in 2007 (1)	Producer certified in 2009 (2)	Total (3)
Number of observations	122	83	205
Age of the household head	42.3	41.6	42.0
	(13.0)	(12.8)	(12.9)
Proportion of female household heads	4.1 %	3.6 %	3.9 %
Years of formal education of the household head	2.6	3.2	2.9
	(2.7)	(2.7)	(2.7)
Proportion of Muslim household heads	93.4 %	98.8 %	95.6 %
Number of household members	5.8	7.0**	6.3
	(1.7)	(3.6)	(2.7)
Proportion of male adult members (age 15-60) (%)	30.0	33.0	31.2
	(12.3)	(22.2)	(17.0)
Proportion of female adult members (age 15-60) (%)	28.2	27.1	27.7
	(12.2)	(19.7)	(15.6)
Total area of agricultural land (a)[a]	71.0	85.2	76.7
	(67.0)	(69.2)	(68.1)
Total area of certified forest coffee (a)	64.7	44.1	56.6
	(118.6)	(82.9)	(106.2)
Total area of modern coffee (a)	13.7	33.0**	21.5
	(15.1)	(30.3)	(24.4)

Note: Standard deviations are in parentheses.

** in column 2 indicates that the means in two groups (column 1 and 2) are significantly different at the 1% level.

[a] Total area of agricultural land excludes the certified forest coffee area.

Table 4. Characteristics of the observation grids

	Forest area certified in 2007:		Forest area certified in 2009:	
	Certified forest coffee area (1)	Forest area without forest coffee (2)	Certified forest coffee area (3)	Forest area without forest coffee (4)
Number of observations	1,362	20,962	646	62,353
Distance to the project office (km)	10.2	11.7**	7.6	11.8**
	(3.5)	(2.7)	(1.6)	(2.7)
Distance to the village (km)	0.4	1.5**	0.2	4.1**
	(0.4)	(1.1)	(0.2)	(2.8)
Distance to the main road (km)	1.2	1.6**	2.0	4.7**
	(1.2)	(1.1)	(1.2)	(3.4)
Average elevation (m)	1,920.5	1,955.2**	1,890.4	2,033.5**
	(126.7)	(159.1)	(96.0)	(175.5)
Average slope (%)	11.9	15.0**	11.9	13.3**
	(6.0)	(7.7)	(4.9)	(7.6)
Proportion of acrisol over the observations	2.9%	18.1%**	1.9%	12.9%**

Note: Standard deviations are in parentheses.

** indicates that the means of the certified forest coffee area in 2007 and 2009 (columns 1 and 3, respectively) are significantly different from the means of the forest area without forest coffee (columns 2 and 4, respectively) at the 1 percent level.

Table 5. Results from the probit estimation

	Benchmark estimation (1)	Additional estimation (2)
Dependent variable: 1 if forest coffee certification was issued in year *t*; 0 if forest coffee certification was made in year *t*, but there is no forest coffee in the area	*t* = 2007	*t* = 2009
Distance to the closest project office (km)	0.39**	−0.333**
	(16.82)	(−12.385)
Distance to the village (km)	−0.87**	−2.251**
	(−18.23)	(−21.916)
Distance to the main road (km)	−0.38**	−0.083
	(−9.60)	(−1.858)
Average elevation (m)	−0.00	−0.000
	(−0.46)	(−0.674)
Average slope (%)	−0.03**	−0.035**
	(−10.09)	(−7.639)
Acrisol dummy	−0.30**	0.146
	(−2.91)	(1.020)
Village dummy	−3.71**	1.025**
	(−19.39)	(7.510)
Constant	−1.48**	2.143**
	(−2.95)	(4.238)
Observations	22,324	62,999
Pseudo R^2	0.24	0.42

Note: Z-statistics are in parentheses.

** indicates statistical significance at the 1 percent level.

Table 6. Balancing tests

	Benchmark estimation		Additional estimation	
	Difference before matching	Difference after matching	Difference before matching	Difference after matching
	(1)	(2)	(3)	(4)
Distance to the closest project office (km)	−1.51**	−0.11	−4.19**	0.01
	(−19.82)	(−0.75)	(−39.29)	(0.09)
Distance to the village (km)	−1.13**	−0.02	−3.86**	−0.01
	(−36.77)	(−1.30)	(−35.60)	(−1.11)
Distance to the main road (km)	−0.47**	0.00	−2.69**	−0.06
	(−14.64)	(0.01)	(−19.97)	(−0.80)
Average elevation (m)	−34.70**	−3.30	−143.10**	1.20
	(−7.87)	(−0.63)	(−20.70)	(0.24)
Average slope (%)	−3.15**	0.27	−1.41**	0.26
	(−14.77)	(1.03)	(−4.70)	(0.92)
Acrisol dummy	−0.15**	0.01	−0.11**	0.00
	(−14.49)	(1.91)	(−8.35)	(0.23)
Village dummy	−0.29**	−0.01	−0.39**	−0.02
	(−29.31)	(−0.44)	(−37.99)	(−0.79)
Pseudo R^2	0.24	0.00	0.42	0.00

Note: t-values are in parentheses.

** indicates statistical significance at the 1 percent level.

Table 7. Average effects of the forest coffee certification program on the probability of deforestation

	Benchmark estimation (1)	Additional estimation (2)
Treatment group	Certified forest coffee area	Non-certified forest coffee area
Control group	Forest area without forest coffee	Forest area without forest coffee
Effect examined	Certification + forest coffee without certification	Forest coffee without certification
Mean of treatment group	0.028	0.118
Mean of matched control group	0.045	0.124
Difference: average treatment effect	−0.017	−0.006
Standard error	0.009	0.022
t-value	−2.02*	−0.29
Number of observations	2,546	1,274

Note: * indicates statistical significance at the 5 percent level.

Abstract (in Japanese)

要約

本論文は、エチオピアにおいて JICA が実施した「ベレテ・ゲラ参加型森林管理プロジェクト」の一環として住民が森林コーヒー認証を取得したことが、森林保全に及ぼした効果を定量的に推計したものである。森林コーヒーとは森林に自生するコーヒーであり、国際 NGO による認証を受ければ、より高い価格で販売することができるため、認証を受けることで森林を保護するインセンティブが働く可能性がある。人工衛星画像を用いて対象地域の森林の変化を観測し、そのデータを基に、傾向スコア法（propensity score matching）と差の差の手法（difference in differences）を組み合わせた手法を用いて森林コーヒー認証取得の効果を測定した。その結果、認証を受けた森林コーヒーが生育する森林の場合には、2 年の間に 2.8%の森林が破壊されて農地や居住地などの非森林に転換されたのに対して、森林コーヒーが存在しない森林ではその割合が 4.5%であり、前者の方が森林が破壊された割合が 1.7 ポイント低く、またその差は統計学的に有意であることがわかった。ところが、認証を受けていない森林コーヒー生育地域と、森林コーヒーが存在しない森林とでは、森林破壊の割合に差がなかった。この 2 つの推計結果から、森林コーヒー認証の取得が森林保全に大きく貢献したことが明らかとなった。

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