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The Economic Impact of Marena's Investments on Sustainable Agricultural Systems in Honduras

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Abstract

This study examines the economic impact of sustainable agricultural production systems in Central America. In particular, we investigate the impact of investments promoted by the MARENA Programme in Honduras on the total value of agricultural production (TVAP) of its beneficiaries. Propensity Score Matching techniques along with the Difference-in-Differences framework are used to mitigate biases stemming from differences in observed as well as unobserved (time-invariant) characteristics between beneficiaries and a control group. The econometric estimates suggest that MARENA has had a positive and significant effect on the TVAP of beneficiaries. In addition, the analysis shows that, under alternative scenarios, MARENA yielded higher than expected internal rates of return. The results of this study shed light on the response of small-scale hillside farmers to economic incentives and lend support to the role of natural resource management projects in Central America as a tool to increase household income while also promoting the conservation of natural resources.

Keywords: *Honduras; impact evaluation; internal rate of return; natural resource management*.

JEL classifications: *D24, Q2, Q12, Q16*.

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1. Introduction

Many developing countries around the world severely underfund their National Agricultural Research Systems and their publicly provided extension services (World Bank, 2008). This behaviour is at odds with the need many of these countries have to improve their competitiveness if they are to become active participants in and benefit from the growing globalisation of the economy. Moreover, there is ample research that reveals high rates of return for public investment in both agricultural research and extension in developing as well as developed countries (Alston *et al*., 2000). In addition, a large number of empirical studies suggest that considerable gains could be achieved by farm level improvements in efficiency but this would require a sustained support for extension services (Battese, 1992; Bravo-Ureta *et al*., 2007).

In Central America, the lack of public support for agricultural research and extension should be seen in the context of extensive rural poverty, as well as a rapidly deteriorating resource base. In this environment, poor farmers try to eke a living by cultivating steep slopes, a practice that is associated with deforestation, soil erosion and declining water quantity and quality, among other severe problems, all of which can feed back to lower farm productivity and worsening poverty rates (Pelupessy and Ruben, 2000; Scherr, 2000; Solís *et al*., 2009). Recognising these major challenges, the international community has come around to the old idea, formalised by Johnston and Mellor (1961), that agricultural productivity growth is an essential component of any development strategy (World Bank, 2008). Within this strategy, there is increasing pressure on multilateral organisations as well as private foundations to provide more assistance to developing country agriculture particularly as we witness growing challenges in meeting the Millennium Development Goals (UN, 2008). At the same time, there is a rising need for documenting the impact of international assistance in achieving the millennium agenda set by donors and developing country governments (World Bank, 2005; Khandker *et al*., 2010).

This article focuses on Honduras where rural poverty and environmental degradation are severe problems (IMF, 2004). Over the past decade, different multilateral organisations have provided significant financial support to the Honduran Government to fund programmes designed to decrease poverty while alleviating the pressure on the environment (IDB, 2004). One such initiative is the MARENA Programme which is the subject of this study.

The main goal of MARENA was to promote sustainable rural development by encouraging productivity growth and strengthening natural resource management, at both local and regional levels, in an area of influence covering 13,721 km^2 and about 930,000 inhabitants (Figure 1). The programme sought to reduce poverty and the physical, economic and environmental vulnerability of critical areas in order to improve the quality of life of the beneficiaries. MARENA was based on a concept of territorial management including three river basins, Ulúa, Chamelecón and Nacaome, and 11 sub-basins[2] where participatory processes defined the priorities and plans of action. The selection criteria for the basins and sub-basins were based on: (i) pressure on natural resources and deterioration of resources in the upper watersheds; (ii) concentration of the rural population and poverty levels; (iii) the watershed's economic and productive importance; and (iv) physical vulnerability and

[2] The 11 sub-basins are Chameleconcito, Chiquila, Grande de Reitoca, Gualcarque, Higuito, Humuya Alto, Humuya Medio, Lago de Yojoa, Mejocote, Sulaco and Verdugo.

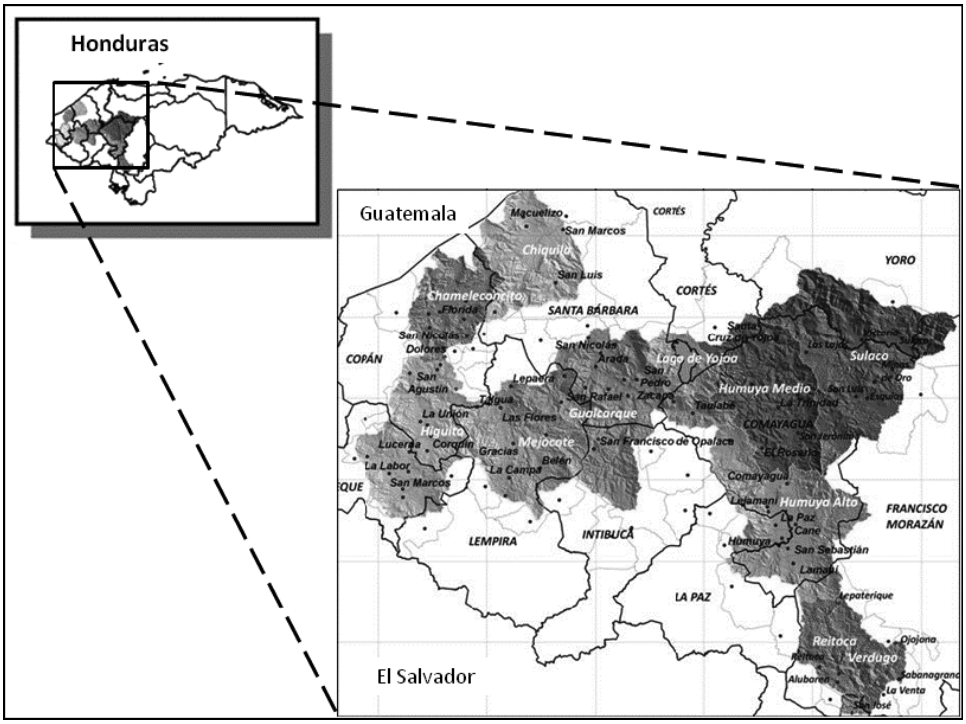

Figure 1. Area of influence of the MARENA Programme. The shaded areas correspond to the 11 sub-basins covered by the MARENA Programme

causal links between conditions in the upper and lower areas of the watersheds. To be eligible, farmers had to be small-scale hillside producers[3] located in one of the sub-basins selected by the Programme (Secretaría de Agricultura y Ganadería, 2003).

MARENA was organised into three components: Component I, addressed institutional, strategic, regulatory and management capacity needs of key sector agencies; Component II, financed investments in priority sub-basins through three complementary modules; and Component III dealt with the overall coordination of the programme. The analysis presented below is limited to Module 3 within Component II, which promoted investments in sustainable agricultural production systems with a budget of US$7.6 million for this purpose. The aim of this Module was to promote changes away from environmentally unsustainable production processes toward systems that can enhance the competitiveness of hillside farmers, through more intense and diversified farming, better use of water, soil and forests, enhanced market opportunities, and technical assistance to boost productivity and rural incomes. The strategy was to improve the competitiveness of small-scale hillside farming operations by helping producers diversify and find alternatives to subsistence crops and to adopt production options that ease soil degradation (Andino, 2005; Bravo-Ureta, 2009).

Technology packages including technical assistance were provided on a matching-fund basis under contract with service providers. The technical assistance focused

[3] An explicit definition of small-scale in terms of farm size was not specified in the eligibility criteria.

on sustainable production technologies, market access and microfinance. Specifically, MARENA focused on the following activities: (i) agroforestry and soil conservation projects; (ii) protection, sustainable use and development of forests; (iii) environmentally sustainable coffee production; (iv) dual-purpose livestock production; (v) small irrigation systems for diversified production; and (vi) seed production. Programme implementation relied heavily on a participatory framework, so needs and demands came out of the local and regional spheres. Those demands became embodied in environmental management plans at the sub-basin level where communities prioritised their concerns and the best options for their particular agro-ecological conditions. A detailed description of the strategies and activities implemented by MARENA can be found in Bravo-Ureta (2009) and Andino (2005).

Despite the effort and financial resources invested to promote rural and environmental programmes in Central America, little work has been done to examine the impact of such initiatives. The lack of research in this field is probably due to cost considerations and lack of adequate data collection efforts by project implementers. MARENA is an exception in this regard, as the collection of farm-level data to monitor and evaluate the programme was a priority from the beginning. Thus, this article adds to the literature by offering a rare opportunity to study the economic impact of a major component of a natural resource management programme in a developing country in Central America.

The objective of this article is to conduct an evaluation of the impact of Module 3 in Component II of MARENA on the farm income of its beneficiaries and to examine the overall rate of return of the Programme. Our intention is to shed light on the response of small-scale hillside farmers in Central America to economic incentives and thus to contribute to the emerging literature concerning the impact of development initiatives on the competitive or complementary interaction between resource conservation and poverty alleviation (Scherr, 2000).

A typical problem found when measuring the impact of development programmes relates to potential biases stemming from observed and unobserved characteristics of the studied sample. To address these issues our empirical framework uses Propensity Score Matching (PSM) along with a fixed effects approach. In addition, the matching technique is conducted using two alternative samples in an attempt to gauge the robustness of the results. Efforts are made as well to ascertain the possible presence of spillover effects from MARENA, which is an issue of general interest in impact evaluation, and for this purpose the data include non-beneficiary farms living within the area of influence of the project and farms located outside of this area. We also examine the internal rate of return (IRR) of the Program under different scenarios which is often neglected in impact evaluation studies (Del Carpio, 2010).

The rest of this article is organised as follows. The next section presents a review of the literature followed by a description of the data and methodology. We then discuss the key results and end with concluding remarks.

2. Review of the Literature

Bresciani and Valdés (2007) argue that improving the income of rural households is an essential strategy to reduce the overall poverty in a developing country due to close linkages with the labour and food markets, and a high multiplier effect on other sectors of the economy. Furthermore, Vosti and Reardon (1997) claim that to reach an adequate level of economic development in peasant economies, it is necessary to address the 'critical triangle' of economic growth, poverty alleviation and environmental sustainability. Consistent with these views, alternative strategies have been implemented by governments, international donors and multilateral agencies to improve the economic well-being in less favourable rural areas. Unfortunately, the number of quantitative studies analysing the economic impact of such interventions on farm income in Central America is limited.

Among the few available articles, López and Romano (2000) and López (2000) evaluate, respectively, the determinants of household income in Honduras and El Salvador. Both studies use socioeconomic and farm-household characteristics to develop a *per capita* income model. López and Romano (2000) concluded that to improve rural income in the area under study, it is necessary to promote the development of the labour and credit markets and improve human capital by expanding extension systems and rural education. Using a multiple equation household income model, Bravo-Ureta *et al.* (2006) analysed the effect of participating on two natural resource management programmes in El Salvador (PAES) and Honduras (CAJON) on the income of beneficiaries. Their results suggest that output diversification, soil conservation practices and structures, and the adoption of forestry systems have a positive and statistically significant association with farm income. In addition, households who own land enjoy higher farm incomes than those who do not.

The income studies just mentioned provide useful insights but do not focus on the evaluation of the impact that can be attributed to the interventions analysed. Table 1 shows recent studies that have used impact evaluation methods to explicitly quantify the welfare effects that can be attributed to various projects conducted in rural communities in several countries. It is worth noting that only one of these articles focuses on a Central American country.

Among these recent studies, Sadoulet *et al.* (2001) evaluated the impact of the PROCAMPO programme in Mexico on rural household income. The aim of this programme was to compensate farmers, using cash transfers, for potential lower commodity prices stemming from the incorporation of Mexico to NAFTA. Using a difference-in-differences (DID) approach, the authors found that PROCAMPO had a positive indirect effect on the household income of beneficiaries. Sadoulet *et al.* (2001) argue that the cash transfer programme helped in reducing credit constraints allowing farmers to improve production and productivity and, consequently, their income levels.

Godtland *et al.* (2004) analysed the impact of farmer-field schools (FFS) in Peru and find that participating farmers were able to raise their average potato output by 52% in a normal year. Feder *et al.* (2004), using data for rice-growing villages in Indonesia, also examined the impact of FFS and found no significant impact on yield growth or reduction in the use of pesticides. The authors used DID estimates along with fixed effects to address selection bias arising from time-invariant unobservable characteristics; however, they did not use any matching techniques to ensure that the control and treated groups had similar observable characteristics at the baseline. Along the lines of the Feder study, Praneetvatakul and Waibel (2006) evaluated the impact of FFS in Thailand between 2000 and 2003 and found that pesticide expenditures were reduced by the farm extension intervention.

Skoufias (2005) studied the effect of PROGRESA on the well-being of rural families in areas of extreme poverty in Mexico. The impact of the project was measured

Table 1
Recent papers analysing project interventions in developing countries

Study	Country	Intervention/project: Indicator	Panel data
Cerdán-Infantes *et al.* (2008)	Argentina	Extension: Grape, yield and quality	Yes
Lopez and Maffioli (2008)	Uruguay	Livestock: Management, productivity and specialisation	Yes
Essama-Nssah *et al.* (2008)	Rwanda	Privatisation programme: Tea sector	No
Dillon (2008)	Mali	Irrigation: Value of agricultural production	Yes
Nakasone (2008)	Peru	Land titling programme and labour allocation	Yes
Cocchi and Bravo-Ureta (2007)	El Salvador	Soil conservation	Yes
Rodriguez *et al.* (2007)	Philippines	Agricultural development: Coconut producers	Yes
Praneetvatakul and Waibel (2006)	Thailand	Farmer field schools: Rice yields and pesticide use	Yes
Skoufias (2005)	Mexico	PROGRESA: Welfare impact of rural households	Yes
Feder *et al.* (2004)	Indonesia	Farmer field schools: Rice yields and pesticide use	Yes
Godtland *et al.* (2004)	Peru	Farmer field schools: Potato farmers	No
Sadoulet *et al.* (2001)	Mexico	PROCAMPO: Cash transfer for agricultural production	Yes

using a statistical analysis which included farmers associated with the programme as well as a control group. The results show that in a two-year period PROGRESA decreased poverty by 17% in its area of influence with respect to the control area.

Rodriguez *et al.* (2007) evaluated a rural development project aiming to improve income among coconut producers in the Philippines. These authors implemented a DID income model which included farmers associated with the project and a control group using a balanced panel dataset for a two-year period. The authors show that the implementation of this project had positive and significant effects on poverty reduction among beneficiaries. They also concluded that one of the most important restrictions facing small-scale farmers in the area under study was credit availability.

The only study found dealing with a Central American country is the analysis of PAES in El Salvador by Cocchi and Bravo-Ureta (2007). These authors examined the relationship between farm income, output diversification and the adoption of soil conservation technologies promoted by PAES using data for the treatment group for 2002 and 2005 whereas data for the control group was only available for the latter year. Among the main conclusions is that soil conservation and crop diversification are positively associated with farm income and with the length of exposure of the beneficiaries to the Programme.

More recently, other agricultural studies that use matching techniques and DID to analyse interventions in developing countries include the work of Nakasone

(2008) for Peru on land titling programmes, Dillon (2008) for irrigation in Mali, Lopez and Maffioli (2008) for livestock in Uruguay, Cerdán-Infantes *et al*. (2008) for grapes in Argentina, and Essama-Nssah *et al*. (2008) for tea farming in Rwanda (Table 1).

The present study contributes to the limited literature that examines the economic impact of natural resource management projects, particularly for Central America where this genre of intervention has been quite prevalent. Unlike previous studies, we make an effort to capture possible spillover effects on non-beneficiaries living within the Programme's area of influence and to estimate the expected returns of the project under alternative scenarios.

3. Methodological Framework and Data

The impact of MARENA on the total value of agricultural production (TVAP) of those individuals who participated in the programme is measured following the 'treatment effect' framework (Cameron and Trivedi, 2005). Formally, for each farmer i let the dummy variable $D_i = 1$ if the farmer received the treatment (T) and $D_i = 0$ if the same farmer did not (C), Y_i is the potential outcome (TVAP in our case) and X_i is a vector of covariates. Then, the conditional average treatment effect (ATE) is given by:

$$\text{ATE} = E\left[Y_i^{\text{T}} \,\middle|\, X_i, D_i = 1\right] - E\left[Y_i^{\text{C}} \,\middle|\, X_i, D_i = 0\right]. \tag{1}$$

Clearly, both outcomes (Y_i^{T} and Y_i^{C}) cannot be observed at the same time for the ith individual, which constitutes one of the main analytical problems in impact evaluation (Ravallion, 2008). However, using an outcome from a non-participant to approximate Y_i^{C} is also not recommended because his or her observable attributes would likely differ from those who are enrolled in the programme generating a selection bias (Cerdan-Infantes *et al*., 2008). Duflo *et al*. (2008) illustrate this selection bias by subtracting and adding the term $E[Y_i^{\text{C}} \,|\, X_i, D_i = 1]$, which is not observable but is well defined, in (1):

$$\begin{aligned}\text{ATE} &= E\left[Y_i^{\text{T}} \,\middle|\, X_i, D_i = 1\right] - E[Y_i^{\text{C}} \,|\, X_i, D_i = 1] - E\left[Y_i^{\text{C}} \,\middle|\, X_i, D_i = 0\right] + E[Y_i^{\text{C}} \,|\, X_i, D_i = 1] \\ &= E[Y_i^{\text{T}} - Y_i^{\text{C}} \,|\, X_i, D_i = 1] + E[Y_i^{\text{C}} \,|\, X_i, D_i = 1] - E[Y_i^{\text{C}} \,|\, X_i, D_i = 0].\end{aligned} \tag{2}$$

The first term in the second line of (2) is the ATE on the treated (ATET) and the second and third terms correspond to the selection bias which captures potential differences in the outcomes between the treated and untreated individuals. Duflo *et al*. (2008) show that unbiased estimates of the ATE are possible if individuals are randomly assigned to the treatment and comparison groups. Randomisation implies that $E[Y^{\text{C}}|X_i,\ D_i = 1] - E[Y^{\text{C}}|X_i,\ D_i = 0] = 0$, which means that the ATE is indentified (Angrist and Pischke, 2009). In practical terms, randomised experiments in rural development projects are often difficult to carry out and most of the recent evaluations have been conducted as quasi-experimental designs by estimating the ATET (Ravallion, 2008). The ATET, conditional on X_i and D_i, is given by:

$$\text{ATET} = E[Y_i^{\text{T}} \,|\, X_i, D_i = 1] - E[Y_i^{\text{C}} \,|\, X_i, D_i = 1] = E[Y_i^{\text{T}} - Y_i^{\text{C}} \,|\, X_i, D_i = 1]. \tag{3}$$

To calculate ATET in equation (3) it is necessary to find a group of farmers not associated with the project (Control) that resembles beneficiary farmers (Treated) as much as possible prior to project implementation (baseline). The PSM method is often used to generate such counterfactual group. PSM yields a 'score' equal to the probability of receiving treatment, considering both treated and non-treated groups, given a set of predetermined covariates.

PSM requires first the implementation of a dichotomous model to estimate the probability that a farmer in the sample will become associated with the project (participation model). The second step is to do the matching which can be done using various alternative procedures (Cameron and Trivedi, 2005). Although PSM does not completely eliminate biases that might stem from observable characteristics across the treated and non-treated groups, Imbens and Wooldridge (2008), among other authors, argue that this method yields reasonable results. In this article, the matched sample is constructed using the '1-to-1 nearest neighbour without replacement' criterion in which every beneficiary is simply matched with a farmer in the non-treated group imposing the common support condition (Sianesi, 2001).[4] Later on the article, the robustness of this criterion is evaluated by comparing the results with those obtained from two other matching criteria.

Once the matched control group is selected, the impact of the project on the TVAP of its beneficiaries can be estimated using a DID estimator assuming that panel data are available (Ravallion and Chen, 2005), as is the case in the present study. In general terms, the DID approach compares the difference between the indicator under analysis for beneficiaries and the control group at the baseline vs. the difference of the indicator at a point typically close to the end of the implementation of the project. Using the DID estimator coupled with a properly matched sample is desirable because it makes it possible to address biases stemming from both observable (e.g. farm size, education) and unobservable time invariant characteristics (e.g. managerial ability, motivation) (Angrist and Pischke, 2009).

In this article, we use a modified DID approach where the impact of the project is estimated using matched data for beneficiaries and a control group based on the following fixed effects model:

$$Y_{it} = \alpha_0 + \rho D_{it} + \gamma N_{it} + \lambda T_t + \beta X'_{it} + \sum_{i=1}^{n} \alpha_i F_i + \varepsilon_{it} \quad i = 1, \ldots, n; \;\; t = 1, 2. \qquad (4)$$

The elements in equation (4) are as follows: Y_{it} is TVAP; D_{it} is a dummy that measures the treatment effect (1 if the farmer is a beneficiary of MARENA); N_{it} is a dummy if the farmer is not a beneficiary of MARENA but lives within its area of influence, the omitted category is non-beneficiaries living outside the area of influence; T_t is a dummy variable equal to 0 for the baseline; X_{it} is a vector of observed control variables; F_i is the farm fixed effects; ε_{it} is the error term; and the Greek characters are parameters to be estimated. In this study, the control group is composed of two subgroups, non-beneficiaries living inside and outside the area of influence, in an attempt to capture spillover effects, as explained below.

To estimate the model in equation (4), we have a panel dataset that includes 109 MARENA beneficiaries and 262 non-treated households in each of two time periods. The beneficiaries were selected from a comprehensive list of beneficiary farmers using a stratified sampling method. In doing so, the 11 sub-basins selected by

[4] For this matching procedure, no caliper is specified (see Leuven and Sianesi, 2003 for details).

Table 2
Definition of variables

Variable	Unit	Definition
TVAP	HNL*	Total value of agricultural production
BENEF	Dummy	1 if the household is a beneficiary of MARENA
NEIGHBOUR	Dummy	1 if the household is not a beneficiary of MARENA and lives within its area of influence
NNEIGH	Dummy	1 if the household is not a beneficiary of MARENA and lives outside its area of influence (excluded category)
EXPEND	HNL	Total expenditures on purchased farm inputs
LABOUR	HNL	Total value of family labour plus hired labour expenses
AGLAND	Hectares	Total land devoted to agricultural production
DIVER	Dummy	1 if the household produces crops in addition to maize and beans
CAFEECO	Dummy	1 if the household produces coffee using ecological practices
ALTITUD	Dummy	1 if the farm is located at an altitude higher than the mean
AGE	Years	Age of household head
EDUC	Years	Years of schooling of the household head
NUMBER	Number	Number of people in the household
ORGA	Dummy	1 if the household head participates in farmer organisations
TITLE	Dummy	1 if the household has legal title to at least some of the land farmed
ASSIST	Dummy	1 if the household receives technical assistance
YEAR	Dummy	0 = 2004, 1 = 2008

Note: *HNL stands for Honduran Lempiras and the exchange rate used is US$1 = HNL 19.3.

MARENA to implement its activities were used as the strata to have a proportional representation of farmers located within the treated area. The non-treated group includes 145 households living inside the area of influence of the Programme (Neighbours) and 117 located outside this area (Non-Neighbours). Specifically, Neighbours include farmers living in intervened villages, but that were not part of the project. Conversely, Non-Neighbours were selected from intervened municipalities but from villages outside the area of influence of MARENA to insure similarity. In both cases (Neighbours and Non-Neighbours), an effort was made to select farmers located at similar altitudes than those working with MARENA (ESA Consultores, 2008).

The data were collected for the 2003–2004 (baseline) and 2007–2008 agricultural years. The data include information on socioeconomic characteristics of the household as well as alternative sources of income, quantity of agricultural inputs and outputs, costs and revenues. Table 2 defines all the variables included in both the participation and income models.

4. Results

4.1. Selection of the matched groups

As indicated, PSM was used to match beneficiaries with a control group. In doing so, we first fitted a Logit model to calculate the probability of being a MARENA beneficiary where the dichotomous dependent variable is equal to 1 if the household

Table 3
Descriptive statistics for variables included in the logit model (baseline year)

	Baseline year (2004)	
Variable	Mean	SD
Beneficiaries ($N = 109$)		
AGLAND	1.80	0.12
CAFEECO	0.02	0.01
NUMBER	6.20	0.26
ALTITUD	0.46	0.05
EDUC	3.50	0.26
AGE	46.61	1.38
ORGA	0.73	0.04
ASSIST	0.44	0.05
DIVER	0.52	0.05
Control Neighbour ($N = 145$)		
AGLAND	2.62	0.51
CAFEECO	–	–
NUMBER	5.93	0.21
ALTITUD	0.55	0.04
EDUC	3.59	0.27
AGE	45.81	1.10
ORGA	0.24	0.04
ASSIST	0.26	0.04
DIVER	0.46	0.04
Control Non-Neighbour ($N = 117$)		
AGLAND	3.22	0.52
CAFEECO	0.01	0.01
NUMBER	6.01	0.24
ALTITUD	0.49	0.05
EDUC	3.04	0.27
AGE	50.96	1.34
ORGA	0.26	0.05
ASSIST	0.21	0.04
DIVER	0.42	0.05

is a beneficiary and 0 otherwise. The Logit equation can be written in general terms as:[5]

$$BENEF = \boldsymbol{f}(AGLAND, CAFEECO, NUMBER, ALTITUD, AGE, EDUC, ORGA, ASSIST, DIVER) + error\ term. \quad (5)$$

All variables are defined in Table 2 and descriptive statistics are presented in Table 3.

Equation (5) was first estimated using the baseline data for all beneficiaries and control farmers (neighbours and non-neighbours) and the matching was done based

[5] Agricultural land was selected as an explanatory variable to be consistent with our impact model which used TVAP as an output measure. The use of agricultural or cultivated land can also be found in Cerdán-Infantes *et al.* (2008) and Rodriguez *et al.* (2007).

Table 4
Logit results for participation in MARENA for two alternative groups (baseline year)

Variable	Total sample	Beneficiaries and control Non-Neighbours
AGLAND	−0.374*** (0.099)	−0.425*** (0.122)
CAFEECO	4.008** (1.976)	3.621* (2.264)
NUMBER	0.042 (0.053)	0.033 (0.064)
ALTITUD	−0.468* (0.279)	−0.426 (0.340)
AGE	−0.011 (0.010)	−0.020* (0.012)
EDUC	−0.035 (0.050)	0.006 (0.066)
ORGA	2.282*** (0.288)	2.269*** (0.346)
ASSIST	0.655** (0.287)	0.877** (0.3653)
DIVER	0.499* (0.290)	0.592* (0.364)
CONSTANT	−1.278** (0.605)	0.050 (0.844)
Likelihood ratio test (χ^2 [8 d.f.])	108.93***	86.89***
Pseudo R^2	0.24	0.27
N	371	226
Predicted correctly (%)	79.0	77.4

Notes: All values are given as a coefficient (SE).
*, $P < 0.10$; **, $P < 0.05$; ***, $P < 0.01$.

on the '1-to-1 nearest neighbour without replacement' criterion (Leuven and Sianesi, 2003). The matched sample resulting from these data are referred to below as the Matched Total Sample (MTS). Then, the Logit model was re-estimated using beneficiaries and the Non-Neighbour subgroup only, which gives rise to the Matched Non-Neighbours only (MNN) sample. The results of these two Logit models, shown in Table 4, are compatible. Specifically, the null hypothesis that all coefficients are simultaneously zero is rejected at the 1% significance level. In addition, the percentages of correctly predicted responses are high (79.0% and 77.4%). In general, households participating in a farmer organisation, receiving technical assistance, producing a diversified cropping plan and using ecological practices are more likely to be beneficiaries of MARENA. Conversely, producers with larger farms and those located at a higher altitude are less likely to be beneficiaries.

The matched samples from both Logit models are determined for those propensity scores that fall within the common support area (Caliendo and Kopeinig, 2005).[6] This procedure yields a total of 100 pairs (i.e. 100 beneficiaries paired with 56 Neighbours and 44 Non-Neighbours) when the MTS sample is used and 102 pairs when the MNN sample is used.

Once the matching is done, the next step is to confirm if the values of the observable characteristics of treated and control groups are equal, on average, for the baseline data. This analysis is referred to as the balancing property (Becker and Ichino, 2002). Tables 5 and 6 report *t*-tests conducted before and after matching, for the MTS and the MNN samples following Leuven and Sianesi (2003). The results of the *t*-tests for both matched samples, MTS and MNN, show

[6] The 1-to-1 common support for the MTS and the MNN samples are [3.80E-09, 0.771] and [1.77E-08, 0.928], respectively.

Table 5

Balancing test: *t*-tests conducted before and after matching (baseline year)* Beneficiaries vs. Neighbours and Non-Neighbours (MTS)

Variable	Sample	Mean		% Bias	% Reduction in bias	*t*-test	
		Treated	Control			*t*	*P* > *t*
AGLAND	Unmatched	1.80	2.89	−25.5	98.1	−1.91	0.057
	Matched	1.80	1.78	0.5		0.11	0.912
CAFEECO	Unmatched	0.02	0.00	13.9	−26.3	1.42	0.155
	Matched	0.02	0.00	17.5		1.42	0.157
NUMBER	Unmatched	6.20	5.97	9.1	49.5	0.81	0.419
	Matched	6.20	6.08	4.6		0.34	0.734
ALTITUD	Unmatched	0.47	0.53	−12.5	56.1	−1.1	0.273
	Matched	0.47	0.50	−5.5		−0.4	0.686
AGE	Unmatched	46.61	48.11	−10.6	59.2	−0.93	0.352
	Matched	46.61	45.99	4.3		0.32	0.747
EDUC	Unmatched	3.50	3.34	5.2	−105.3	0.45	0.656
	Matched	3.50	3.81	−10.7		−0.77	0.441
ORGA	Unmatched	0.74	0.26	111.3	60.5	9.77	0.000
	Matched	0.74	0.55	44.0		3.02	0.003
ASSIST	Unmatched	0.44	0.24	43.0	54.1	3.90	0.000
	Matched	0.44	0.35	19.7		1.39	0.167
DIVER	Unmatched	0.52	0.44	16.0	54.2	1.41	0.159
	Matched	0.52	0.49	7.3		0.54	0.590

Notes: *The Balancing test follows Leuven and Sianesi (2003).
MTS, Matched Total Sample.

that the mean of most of the observed characteristics are not statistically different. In addition, similarly to Godtland *et al.* (2004), we tested if the balancing property is satisfied using the algorithm developed by Becker and Ichino (2002). This test consists on dividing the sample in equal intervals or strata according to the distribution of the propensity scores. Then, the similarity between the treated and control group is examined, within each interval, by testing the equality of the means of each of the variables included in the Logit estimation using *t*-tests. The results of this test (Table 7) indicate that the balancing property is satisfied for the MTS sample but not for the MNN for some variables. Nevertheless, in the remainder of the analysis we use both groups in order to gauge the sensitivity of the analysis in terms of the non-treated group used for the matching as discussed below.

4.2. Economic impact of MARENA on its beneficiaries

The Unmatched Total Sample (UTS) along with the two matched datasets MTS and MNN are used to estimate the following equation using the fixed effects framework:

$$TVAP = \boldsymbol{f}(BENEF, NEIGHBOUR, YEAR, AGLAND, EXPEND, LABOUR, ORGA, TITLE) + error\ term, \tag{6}$$

Table 6
Balancing test: *t*-tests conducted before and after matching (baseline year)* beneficiaries vs. Non-Neighbours (MNN)

Variable	Sample	Mean		% Bias	% Reduction in bias	*t*-test	
		Treated	Control			*t*	*P* > *t*
AGLAND	Unmatched	1.80	3.22	−35.0	91.2	−2.59	0.010
	Matched	1.85	1.98	−3.1		−0.53	0.597
CAFEECO	Unmatched	0.02	0.01	8.5	100.0	0.64	0.522
	Matched	0.01	0.01	0.0		0.00	1.000
NUMBER	Unmatched	6.20	6.01	7.4	−1.4	0.55	0.580
	Matched	6.25	6.05	7.5		0.53	0.595
ALTITUD	Unmatched	0.47	0.50	−5.5	64.8	−0.42	0.677
	Matched	0.49	0.48	2.0		0.14	0.889
AGE	Unmatched	46.61	50.96	−30.1	38.9	−2.26	0.025
	Matched	47.28	49.93	−18.4		−1.30	0.195
EDUC	Unmatched	3.50	3.04	15.9	−4.0	1.20	0.233
	Matched	3.36	2.89	16.6		1.24	0.216
ORGA	Unmatched	0.74	0.26	108.4	5.7	8.14	0.000
	Matched	0.74	0.28	102.2		7.18	0.000
ASSIST	Unmatched	0.44	0.21	49.6	13.5	3.74	0.000
	Matched	0.41	0.22	42.9		3.07	0.002
DIVER	Unmatched	0.52	0.42	20.9	34.1	1.57	0.118
	Matched	0.49	0.42	13.8		0.98	0.328

Notes: *The Balancing test follows Leuven and Sianesi (2003).
MNN, Matched Non-Neighbours.

where all variables are as defined in Table 2. The specification of the TVAP model is consistent with what can be found in the literature (e.g. López, 2000; Bravo-Ureta *et al*., 2006; Rodriguez *et al*., 2007; Solís *et al*., 2007).

The Box–Cox transformation (Cameron and Trivedi, 2009) is used to test the loglinear vs. the linear specifications and the latter is favoured in all three cases. We should note that the linear functional form has been used by other authors conducting similar impact evaluation studies (e.g. Sadoulet *et al*., 2001; Rodriguez *et al*., 2007). The estimates for the three TVAP linear models using the UTS, MTS and MNN data configurations are presented in Table 8.[7] The F statistic in all three cases is significant at the 1% level; thus, the null hypothesis that all slope coefficients are equal to zero is rejected. The UTS equation presents five statistically significant slope parameters (10% or better) whereas the MTS and MNN have three significant parameters. The corrected-R^2 for the UTS regression is 0.54, compared to 0.74 and 0.76 for the MTS and MNN cases, respectively.

The parameters of particular interest are those associated with the dummy variables BENEF and NEIGHBOUR. The parameter for BENEF is positive and statistically significant in all three equations in Table 8. The value of this parameter is lowest (16,456) for the UTS model, whereas the values for the other two

[7] The least-squares with dummy-variable (LSDV) estimator is used (Cameron and Trivedi, 2009).

Table 7

Balancing test based on Becker and Ichino (2002)

	MTS		MNN	
	Stratum 1	Stratum 2	Stratum 1	Stratum 2
AGLAND	0.30	1.13	0.56	0.69
CAFEECO	0.40	1.02	0.60	0.75
NUMBER	0.21	0.79	0.64	0.49
ALTITUD	1.33	1.53	0.48	1.44
AGE	1.44	0.04	0.87	0.11
EDUC	1.58	0.11	1.12	0.48
ORGA	0.36	0.72	0.49	1.36
ASSIST	0.65	0.49	1.10	0.59
DIVER	0.24	1.64	0.44	0.91
N	194	133	105	104

Notes: Reported values are the *t*-tests for the null hypothesis that the mean between treated and control groups for each variable is equal. The null is not rejected at the 10% level or lower in all cases. This balance test is applicable to the robustness checking results in Table 10. Common support is imposed.
MTS, Matched Total Sample; MNN, Matched Non-Neighbours.

Table 8

Regression results for total value of agricultural product: MARENA beneficiaries and non-beneficiaries

Variables	UTS	MTS	MNN
BENEF	16,456* (9,091)	25,570** (12,544)	20,306** (9,254)
NEIGHBOUR	3,118 (8,504)	1,525 (13,769)	–
YEAR	−1,605 (6,558)	−13,163 (10,670)	−8,688 (6,914)
AGLAND	877** (759)	9,757*** (3,160)	1,2190*** (2,907)
EXPEND	0.24*** (0.08)	0.13 (0.15)	−0.19 (0.17)
LABOUR	0.41*** (0.13)	0.41* (0.21)	0.51*** (0.16)
ORGA	4,205 (6,847)	−2,403 (8,681)	−2,572 (8,600)
TITLE	−682 (6,429)	6,640 (8,604)	8,585 (8,470)
CONSTANT	18,381** (7,499)	2,145 (12,047)	−6,575 (10,886)
FARM FIXED EFFECTS	YES	YES	YES
F	3.80***	2.96***	5.22***
Box–Cox test H_0: $\theta = 0$	57.90***	11.71***	15.81***
R^2	0.77	0.75	0.78
N	742	400	408

Notes: Values in parentheses are standard errors.
UTS, Unmatched Total Sample; MTS, Matched Total Sample; MNN, Matched Non-Neighbours.
*, $P < 0.10$; **, $P < 0.05$; ***, $P < 0.01$.

models are higher but relatively close to each other; 25,570 for the MTS and 20,306 for the MNN regressions. The variable NEIGHBOUR appears in two of the three models and its parameter is positive but not statistically significant, suggesting that no spillover effects are present. One possible explanation for the non-significant spillover effect is that the skills required to implement the farming practices supported by MARENA might be sufficiently complex so that casual exchanges between beneficiaries and their non-participating neighbours are insufficient for an effective diffusion of the knowledge required to adopt the technologies promoted by the Programme. This explanation is consistent with the argument presented by Feder *et al.* (2004) in their study of FFS in Indonesia.

The 25,570 parameter value for BENEF in the MTS model suggests that the total impact of MARENA on TVAP over the four years encompassed by the data, with respect to the combined control group (Neighbours and Non-Neighbours), amounts to US$1,324 or a simple annual average equal to US$331 per household at an exchange rate of Honduran Lempiras 19.3 per US Dollar. If we now focus on the results from the MNN model, the parameter for BENEF suggests a simple average annual MARENA effect equal to US$263. As indicated above, we use both of these estimates to calculate alternative internal rates of return for MARENA in an attempt to evaluate the sensitivity of the final results.

Table 9 presents four scenarios of expected rates of return for the component of the MARENA Programme evaluated in this article. Scenarios 1 and 3 show an IRR equal to 49% and 32% resulting from an impact on beneficiaries for the MTS and MNN samples, respectively. Scenario 2 indicates that to get an IRR of 12% only 7,500 beneficiary families are needed per year from 2007 to 2009 for the MTS sample.[8] The corresponding number of families for the MNN sample is 9,900 (Scenario 4). These numbers of families needed to get the 12% IRR compares with the 13,686 actually reached by the Programme, according to data available from MARENA's Implementing Unit and displayed in Table 9 (Bravo-Ureta, 2009).

4.3. Robustness checking for the ATET

Following the impact evaluation literature, it is desirable to use alternative matching methods to verify the robustness of the results (Ravallion, 2008). Table 10 reports the ATET for MARENA using two matching techniques beyond the '1-to-1 nearest neighbour' criterion discussed earlier. These alternative techniques are the Nearest Neighbour with a caliper of 0.05 and the Kernel matching (Becker and Ichino, 2002). The data in Table 10 indicate that there is no substantial difference among the three matching methods used, which corroborates the results obtained above. The overall effect attributable to the programme ranges from $16,425 to $22,285 for the MTS sample and from $18,874 to $24,897 for the MNN sample.

5. Concluding Remarks

This study uses the PSM technique along with a fixed effects estimator to examine the economic impact of a sizeable agricultural and environmental component of the MARENA Programme on the farm income of its beneficiaries. These methods

[8] The 12% cut-off rate is based on historical estimates for the opportunity cost of capital in developing countries (ADB (Asian Development Bank), 1997). This rate has been used widely by multilateral organisations including the World Bank (Gittinger, 1982), the Asian Development Bank and the Inter-American Development Bank (IADB). Discussions with IADB professionals reveal that such practice might be changing but it was in place at the time MARENA was evaluated.

Table 9

Analysis of MARENA'S expected internal rate of return

		Beneficiaries matched with control Neighbours and Non-Neighbours (MTS)								Beneficiaries matched with control Non-Neighbours (MNN)							
		Scenario 1				Scenario 2				Scenario 3				Scenario 4			
Year	Outflow	No. of bene-ficiaries	Inflow	Net flow	NPV	No. of bene-ficiaries	Inflow	Net flow	NPV	No. of bene-ficiaries	Inflow	Net flow	NPV	No. of bene-ficiaries	Inflow	Net flow	NPV
2003	675,736	–	–	(675,736)	(675,736)	–	–	(675,736)	(675,736)	–	–	(675,736)	(675,736)	–	–	(675,736)	(675,736)
2004	361,253	205	67,855	(293,398)	(261,963)	205	67,855	(293,398)	(261,963)	205	53,915	(307,338)	(274,409)	205	53,915	(307,338)	(274,409)
2005	750,156	825	273,075	(477,081)	(380,326)	825	273,075	(477,081)	(380,326)	825	216,975	(533,181)	(425,049)	825	216,975	(533,181)	(425,049)
2006	1,079,109	3,228	1,068,468	(10,641)	(7,574)	3,228	1,068,468	(10,641)	(7,574)	3,228	848,964	(230,145)	(163,813)	3,228	848,964	(230,145)	(163,813)
2007	3,163,173	13,686	4,530,066	1,366,893	868,685	7,500	2,482,500	(680,673)	(432,580)	13,686	3,599,418	436,245	277,241	9,900	2,603,700	(559,473)	(355,555)
2008	1,597,192	13,686	4,530,066	2,932,874	1,664,191	7,500	2,482,500	885,308	502,347	13,686	3,599,418	2,002,226	1,136,117	9,900	2,603,700	1,006,508	571,120
2009	–	13,686	4,530,066	4,530,066	2,295,072	7,500	2,482,500	2,482,500	1,257,712	13,686	3,599,418	3,599,418	1,823,577	9,900	2,603,700	2,603,700	1,319,115
Total	7,626,620		14,999,596	7,372,976	0		8,856,898	1,230,278	1,880		11,918,108	4,291,488	0		8,930,954	1,304,334	(4,327)
TIR (%)					49				12				32				12
Total value of agricultural production (TVAP)/ year – beneficiaries =						$331								$263			

Notes: Exchange rate: US$1 = HNL 19.3; Interest rate: 12%; MTS, Matched Total Sample; MNN, Matched Non-Neighbours; NPV, Net Present Value.

Table 10
Robustness checking of MARENA's treatment effect using different matching procedures based on Becker and Ichino (2002)

	MTS		MNN	
Matching procedure $Y = \Delta TVAP$	N	Coefficient (SE)	N	Coefficient (SE)
Nearest Neighbour (NN) 1-to-1 (from regression results)				
Treated	100	25,570**	102	20,306**
Control	100	(12,544)	102	(9,254)
NN – Radius, $r = 0.05$†				
Treated	105	16,425**	109	19,259*
Control	228	(−7,930)	100	(−10,655)
Kernel matching†				
Treated	109	20,654**	109	24,897**
Control	228	(9,268)‡	100	(−13,010)‡

Notes: MTS, Matched Total Sample; MNN, Matched Non-Neighbours.
*, $P < 0.10$; **, $P < 0.05$.
†The regions of common support are [0.169, 0.905] for MTS and [0.092, 0.957] for MNN. The balancing property is satisfied for the MTS sample but not for the MNN sample.
‡Bootstrap standard errors with 200 replications. The optimal bandwidth (0.11) was calculated based on the cross-validation method (Cameron and Trivedi, 2005).

reduce potential biases stemming from differences in observed factors between treated and control groups as well as from unobserved characteristics such as managerial skills assuming that the latter are time-invariant.

The analysis presented offers useful insights concerning our understanding of the behaviour of small-scale farmers in Central America. The results stemming from the matching procedures reveal that farmers that belong to organised groups, receive technical assistance, adopt a diversified cropping plan and use ecological practices are more likely to participate in a natural resource management programme, and such information can be useful in the formulation and implementation of development programmes (Raitzer and Norton, 2009). The economic analysis also reveals important features concerning the effectiveness of this programme. Comparable results are obtained from two alternatively matched subgroups which suggest that MARENA has indeed contributed significantly to the economic well-being of beneficiaries. Specifically, over four years of implementation, the contribution of MARENA to the average annual value of agricultural production per beneficiary ranges from US$263 to US$331, depending on the matched samples used, relative to the control group that lives outside the area of influence.

Furthermore, the results suggest that MARENA has not had an impact on non-beneficiaries living within its area of influence (spillover effects). To our knowledge, this type of spillover effect, although discussed in the literature, has not been well documented and is a subject that warrants further attention. An implication of (positive) spillovers would be that beneficiaries, particularly those that are leaders within their villages, could be included in farm extension efforts directed to their communities. This could be a cost effective way to reach non-beneficiaries and thus have a multiplier effect on the work done by extensionists that are typically hired in projects to provide technical assistance.

Another important implication of this study is that resource conservation can go hand in hand with improvements in household income. This has been an issue that has attracted attention in the literature (Vosti and Reardon, 1997; Scherr, 2000; Cocchi and Bravo-Ureta, 2007); but the empirical evidence is limited and mixed, and thus it is a question that deserves further scrutiny. Finally, our results reveal rates of return in excess of the typical 12% cut-off rate; however, the data available do not make it possible to infer whether the stream of benefits extends beyond the life of the project which is an important consideration when time comes to judge the sustainability of these types of investments. This is clearly one more topic that needs additional work.

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