Rural Employment and Income Effects of a Jatropha Plantation in Madagascar

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Abstract

This paper assesses the potential impact of wage work generated by a Jatropha plantation on household income and poverty alleviation using socio-economic characteristics of rural Malagasy households. We analyse data from 336 randomly selected households from three villages in the vicinity of a Jatropha plantation in central Madagascar. To overcome the problem of selection bias we apply a propensity score matching method to assess the effect of offering labour to the Jatropha plantation on household income. The findings show that households working for the Jatropha plantation have on average higher incomes per person compared to control group households. These differences are more distinct among poor households.

Keywords: Madagascar, impact assessment, poverty, Jatropha plantation
JEL: C21, I32, J30, Q42

1 Introduction

In light of increasing fossil fuel prices and concerns about climate change, the quest for sustainable alternative energy sources is of growing political importance globally. One partial solution is to substitute fossil fuels with agrofuels, which for their production need agricultural raw materials, residues, and by-products which are feedstocks. Ethanol derived from sugar cane in Brazil, and agrodiesel from palm oil mainly produced in South-East Asia, when valued at market prices are economically competitive with fossil fuels, despite potential negative environmental impacts (e.g. deforestation and the social costs if plantations displace smallholder agriculture). Since agrofuel as it is currently produced is dependent on the same feedstocks and production areas that are needed for food production, VON BRAUN (2008) concluded that the production of agrofuels poses an additional threat to food security.

Especially if food prices rise, poor net consumers of food in developing countries will lose first. Will rural populations in developing countries lose in general? The case of Brazil shows that agrofuel production can be beneficial for rural employment; VON BRAUN and PACHAURI (2006) stress that the bioethanol sector provided employment for about one million people in 1997. DOMAC et al. (2005) present further evidence on employment generation due to renewable energy production. If income generation from employment in agrofuel production is able to overcompensate rising food expenditures, there is a chance that this new technology can in fact improve food security in developing countries. As the production of agrofuels is a new business, it bears, like all innovations, the risk of creating socio-economic inequalities if the benefits remain only in the hands of a few. When driven by stakeholders seeking only to maximize profit large scale agrofuel production can cause deforestation, loss of biodiversity, land grabbing and land degradation. VON BRAUN and PACHAURI (2006) conclude that policy makers must monitor the development of the agrofuel industry to ensure that agrofuel production is regulated and managed in a way that avoids these pitfalls.

One possible solution might come from a plant called Jatropha *(Jatropha curcas)*, a bush which produces nuts containing a high level of non-edible oil suitable for the production of biodiesel. This alone does not make Jatropha special; but it is suggested in the literature as reviewed by GRASS et al. (2011) that Jatropha could be grown under semi-arid conditions on marginal land not suitable for food production. Hence, some authors argue that Jatropha may not compete directly with food production. However, this assumption is not yet confirmed by empirical evidence, and critical to the success of Jatropha production on marginal lands not fit for food production would be obtaining economically viable Jatropha seed yields under different production costs and crude oil prices as calculated by GRASS et al. (2011). At the present low-yielding technology level for Jatropha production, we reckon that conflicts with food production have been underestimated.

Early estimates of possible Jatropha production expansion worldwide are given in a study presented by GEXSI (2008): planted areas could reach 1.8 million ha in Asia, 2 million ha in Africa and 1.6 million ha in Latin America by 2015. One important outcome of this study shows that Jatropha will likely be produced on plantation estates rather than by smallholders or contract farmers. Will this focus on Jatropha plantations offer local income opportunities which enable at least part of rural populations to overcome poverty? This question is highly relevant as most of the Jatropha production will be located in poor, developing countries. Unfortunately, knowledge on the issue is limited as a large scale production of Jatropha just began three or four years ago. An earlier, more in-depth description of the Jatropha sector in Madagascar is presented by UELLENBERG (2007; 2008). He shows that within Madagascar five currently active enterprises plan to establish more than 600,000 ha of Jatropha, and the entrance of other firms could further increase these numbers to more than one million ha. As of now, no studies are available in order to shed light on the environmental and social impacts of such projects.

In order to quantify the possible impact on income generation, we focus on a project implemented in the region of Fianarantsoa, Madagascar by a German-Malagasy joint venture in 2007. This Jatropha plantation reached a cultivated area of approximately 500 ha in early 2009 and could be extended to 3,000 ha. The plantation employs rural labourers for enlargement and maintenance. The question of whether this additional income opportunity enables at least part of the rural population to overcome poverty is of special importance for Madagascar, as in rural areas about 71.3% of the population lives below the national poverty line (HDR, 2009). Based on a socio-economic household survey undertaken by the authors in 2009, we analyze 336 randomly selected households from three villages near the Jatropha plantation. The surveyed households represent about 50% of total households in each village. As household members are free to decide whether to work on the Jatropha plantation or not, we have to overcome the problem of selection bias for impact assessment.

2 Conceptual Framework

In the analysis of treatment effects for binary outcomes we work with a randomly selected number of units N indexed by i = 1, …, N, where each unit is characterized by two realized outcomes Y_{i1} and Y_{i0} where Y_{i1} reflects realized outcome for unit i if treatment was received[1], and Y_{i0} reflects realized outcome for unit i without treatment. Furthermore, each unit i has a vector of characteristics (covariates) denoted by X_i which should not be affected by the treatment status. Finally, each unit possesses a single treatment value; $W_i = 0$ if unit i receives no treatment and $W_i = 1$ when unit i receives treatment. In non-experimental studies we observe for each unit i either the realized outcome Y_{i1} when unit i was exposed to treatment or the realized outcome Y_{i0} when unit i was not exposed to treatment. But we never observe the possible outcome Y_{i0} when unit i was exposed to treatment, nor Y_{i1} when unit i was not exposed to treatment. Therefore estimating the causal effects of treatments is a missing data problem, since either Y_{i1} or Y_{i0} but never the contrary are possible observed outcomes for unit i. The problem of unobserved possible outcome $E(Y_0|W=1)$ for the treatment group can be overcome by using $E(Y_0|W=0)$ as proxy to estimate the counterfactual $E(Y_0|W=1)$. CALIENDO and KOPEINIG (2008) state that the standards approach "to formalize this problem is the potential outcome approach or Roy-Rubin model". "The widely-used evaluation parameter" (HECKMAN et al., 1998) is the average treatment effect on the treated (ATT) for persons with characteristics X, given by

$$(1) \qquad ATT = E(Y_1 - Y_0 | W=1, X)$$

[1] Two reasons may result in sample selection bias: "First, there may be self selection by the individuals or data units being investigated. Second, sample selection decisions by analysts or data processors operate in much the same fashion as self selection" (HECKMAN, 1979).

Since the outcomes of units belonging to either the treated or the control group differ, serious problems of selection bias can arise, especially as $E(Y_0|W=1)$ is approximated by using $E(Y_0|W=0)$. HECKMAN et al. (1998) calculate the selection bias (B(X)) due to this approximation with the following formula.

(2) $B(X) = E(Y_0|W=1, X) – E(Y_0|W=0, X)$.

Furthermore, HECKMAN et al. (1998) state that “matching on X, or regression adjustment of Y_0 using X, is based on the assumption that B(X) = 0 so conditioning on X eliminates the bias.”

This assumption implies that treatment assignment W (0, 1) and response (Y_1, Y_0) are conditionally independent on a vector of (observable) attributes X. The vector X includes all covariates which are used for treatment assignment W and which are at the same time possibly related to the response (possible outcome Y_1, Y_0). For this assumption different interchangeable terms are used in the literature, “ignorable treatment assignment” (ROSENBAUM and RUBIN, 1983), “conditional independence” (LECHNER, 2002), “exogeneity” (IMBENS, 2004), “unconfoundedness” (IMBENS and WOOLDRIDGE, 2009).

For this ignorable treatment assignment, ROSENBAUM and RUBIN (1983) conclude that if the assignment of treatment is strongly ignorable for given X, then it is also strongly ignorable for any given balancing score. Assuming complete data, ROSENBAUM and RUBIN (1983) define the propensity score as possible balancing score for unit i (i=1,…, N) as the “conditional probability of assignment to” particular treatment (W=1) versus nontreatment (W=0), given a vector of observed covariates, X_i. When comparing units via propensity score matching, the multidimensional covariates which are included by the vector X are reduced to a one-dimensional score. In our analysis we apply a binary logit regression model to calculate the propensity score. After the propensity score is calculated we focus on the average treatment effect on treated.

To estimate the treatment effects via propensity score matching, a wide range of matching algorithms can be applied. An in-depth overview of possible choices is presented in CALIENDO and KOPEINIG (2008). Depending on data diversity and sample size, the choice of a matching algorithm can be important (HECKMAN et al., 1998), as related to the chosen matching approaches trade-offs[2] between bias reduction and variance have to be considered. In our analysis we compare results derived via Nearest Neighbour matching with and without replacement. CALIENDO and KOPEINIG (2005) conclude that Nearest Neighbour matching is “the most straightforward matching

[2] Occurring trade-offs between bias and variance depending on matching approach is explained in detail by CALIENDO and KOPEINIG (2008).

estimator”. Furthermore, we apply Epanechnikov Kernel matching and calculate the weighted average of control units to create the counterfactual outcome. In this way more information is used, so lower variance levels can be obtained. Furthermore, we restrict our sample to the common support region and we apply Bandwidth and Caliper restrictions to ensure that only units with equivalent characteristics (propensity scores) are compared (CALIENDO and KOPEINIG, 2008). Units (in our case households) which participated but were impossible to match within the Caliper or Bandwidth are excluded from the analysis.

To verify if matching on the propensity score was able to balance the distribution of all covariates for the control and treatment group we apply several procedures: standardised differences test, estimation of pseudo-R² and likelihood ratio test. The theory behind these tests is to use before and after matching comparisons to discover if “the matching procedure is able to balance the distribution of the relevant variables in both the control and treatment group” (CALIENDO and KOPEINIG, 2008). The standardised bias or standardised differences (SD) test was suggested by ROSENBAUM and RUBIN (1985) to assess whether or not the reduction in bias relied on the matching based on the propensity score. This approach was used in evaluation studies by LECHNER (2000), SIANESI (2004) and ROSENBAUM and RUBIN (1985). Here the distance in marginal distribution of the X-variables (covariates) can be expressed as standardised differences using the following formula:

(3) $$SD_{before}(X) = 100 \times \frac{\overline{X}_T - \overline{X}_C}{\sqrt{\frac{[V_T(X) + V_C(X)]}{2}}} \quad SD_{after}(X) = 100 \times \frac{\overline{X}_{TM} - \overline{X}_{CM}}{\sqrt{\frac{[V_T(X) + V_C(X)]}{2}}}.$$

For each covariate $\overline{X}_T$ and $\overline{X}_{CM}$ are the sample means for the full sample of treatment and comparison groups, $\overline{X}_{TM}$ and $\overline{X}_{CM}$ are the sample means for the matched sample of treatment and comparison groups, $V_T(X)$ and $V_C(X)$ are the mean (variance) of treatment and comparison groups. ROSENBAUM and RUBIN (1985) suggest that absolute values of standardised difference should be lower than 20% for all covariates.

To further validate the results of SD we re-estimate the pseudo-R² after matching on the new sample. Here the pseudo-R² before and after matching shows how well the regressors X explain the participation probability. After matching, the pseudo-R² should be lower than before, as this would indicate that there are no systematic differences in the distribution of covariates between both groups.

Propensity score estimations are not robust against hidden bias that is rooted in the existence of unobserved variables such as entrepreneurial attitudes or work ethic which simultaneously affect participation and the outcome variable. One solution can be the calculation of Rosenbaum-bounds[3] suggested by ROSENBAUM (2002). With this method[4] it can be determined how strongly an unmeasured variable must influence the selection process to change the implications derived by the matching analysis. However, this test is not able to directly prove the unconfoundedness assumption. Therefore, no statement exists on “whether the conditional independence assumption does (not) hold for the given setting (including, among others, the used data, the chosen covariates, and the specification of the propensity score)” (BECKER and CALIENDO, 2007).

3 Data and Descriptive Statistics

This study is based on data obtained from a survey carried out by the authors from January to March 2009, in the district Ambalavao in the province Fianarantsoa of central Madagascar. According to MINTEN and RALISON (2005) this province is the poorest within Madagascar. The research area is characterized by grassland used traditionally as pasture for zebu keeping, and to a lesser extent for subsistence rain fed agriculture. Access to the area is limited by secondary road conditions. The nearest paved road is 55 km from Fenoarivo village. Within the region neither piped water nor a permanent electricity supply exists. Three villages were chosen according to their distance from the plantation and local field work restrictions. These villages represent the majority of households offering labour to the plantation and make up the majority of the population which lives within about 10 km of the plantation. Based on a census of all households, we estimate the total population in the three villages at 3,432 persons from 685 households. To assess the impact of the plantation on rural livelihoods we selected 50% of total households in each village randomly. The resulting sample contains 336 households. These households where interviewed using a structured questionnaire with modules covering demographics, household assets owned and purchased, cost and revenue of plant and animal production, as well as off-farm income sources, including rural employment. Furthermore, information on short, medium and long term food security, as well as expenditures was asked for. In our sample of 336 households the mean population age is 20.4 years. Citizens aged 17 and

[3] For the calculation of Rosenbaum bounds we used the STATA application rbounds from GANGL (2004). Here rbounds calculates Rosenbaum bounds for average treatment effects on the treated in the presence of unobserved heterogeneity (hidden bias) between treatment and control cases. Currently, rbounds implements the sensitivity tests for matched (1x1) pairs only. Therefore, it was not possible to calculate Rosenbaum bounds for Nearest Neighbour matching with replacement or Epanechnikov Kernel matching, as here several control households were matched to each JP household.

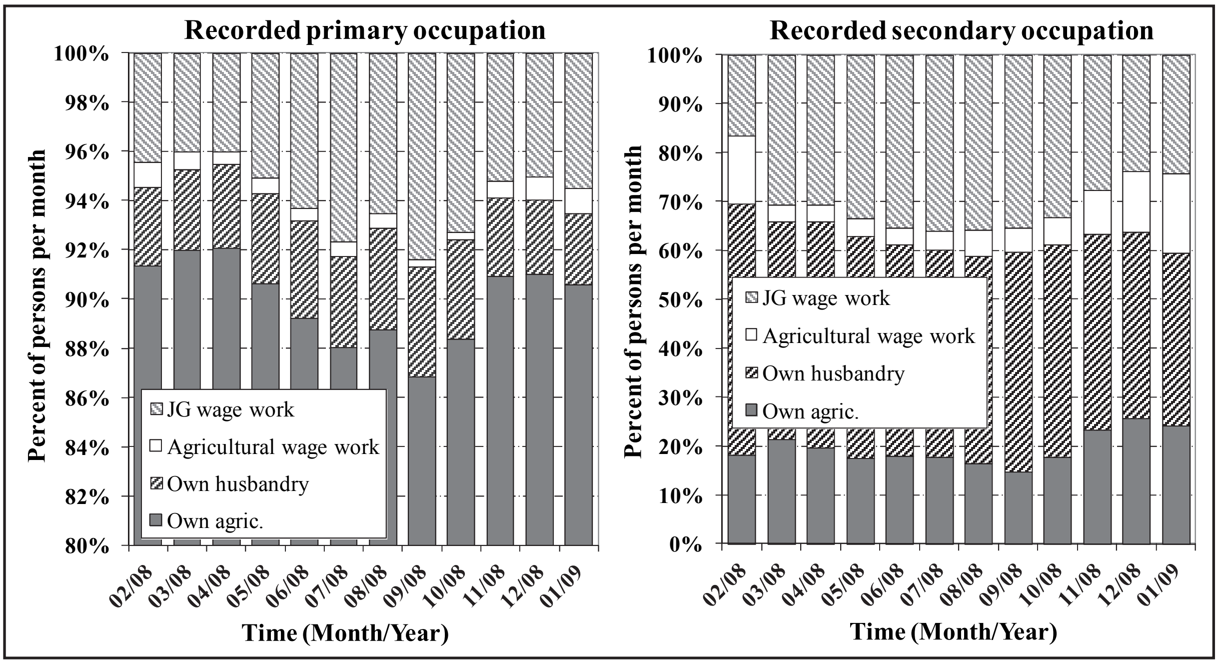
[4] DIPRETE and GANGL (2004) stated that Rosenbaum bounds could be used in a worst-case scenario.

older attended on average 3.18 years in school, 25% reported that they had never attended school, even though compulsory schooling exists.

For the impact assessment, we focus on household income generated in the 12-month time span between February 2008 and January 2009. This recall period for income was chosen so as to account for the seasonality of rural on-farm and off-farm income sources which include net income derived from farming and non-farming activities, as well as net money transfers (i.e. remittances/gifts received and given). For the purpose of this study, participating households are defined as JP households when at least one household member worked a minimum of one day on the Jatropha plantation during the 12-month recall period. Female and male plantation workers earn an average daily salary of 3,000 Ariary. According to our data on wages and rural employment, this salary level is comparable with local salaries for agricultural wage work.

On average, persons working for the Jatropha plantation (n 269) spend 115.95 days working on the plantation (S.D. 81.15 person days, range 2-312 person days). Twenty males and 26 females recorded working on the Jatropha plantation as their primary occupation; they worked on the plantation an average of 132.34 (S.D. 85.17 person days, range 7-288 person days) and 113.75 (S.D. 74.88 person days, range 18-288 person days) person days, respectively. One hundred and fourteen males and 109 females recorded working on the Jatropha plantation as their secondary occupation; they worked on the plantation an average of 116.10 (S.D. 80.80 person days, range 3-308 person days) and 113.31 (S.D. 82.92 person days, range 2-312 person days) person days, respectively. Because of the questionnaire's design, it was not possible for specific persons in each household to record working on the Jatropha plantation as their tertiary occupation. Of the JP households, 8.6% invested less than 20 person days for working at the Jatropha plantation during the recall period. The distribution of labour allocation over one year fluctuates given the seasonal nature of work on the Jatropha plantation. This labour allocation is presented in figure 1. Here the primary and secondary occupation with one’s own agriculture and animal husbandry, as well as wage work for local farmers and the Jatropha plantation labour supply on a monthly basis are shown for persons above the age of ten years. This is an age at which it is quite common to see children make a significant contribution to domestic or agricultural work within the household. Working for the Jatropha plantation seems to be less attractive than working on one’s own agricultural and animal husbandry endeavours in general, but it is as lucrative as agricultural salary work for local farmers, especially during the rainy season between December and March. The increasing number of persons working on the Jatropha plantation and the effect of seasonality is evident in the recorded secondary occupation data.

Figure 1. Distribution of primary and secondary occupation during one year



Source: own calculation

Following the standards[5] of the International Labour Organization, people under 18 years of age are not officially accepted as Jatropha plantation workers. This control mechanism, however, is only weakly enforced as evidenced by the fact that 8.8% of the hired labour force (n=26) was between 14 and 17 years of age and worked an average 84 days (S.D. 68 days). Nearly all persons met the minimum age requirement for hiring (15 years) according to the national regulations of Madagascar[6].

The existence of child labourers could be due to children claiming to be older in order to be hired, or it could be a result of incorrect reporting during interviews. It is common for young people of the area to help their parents with field work, to guard zebus, or

5 Following the ILO (1999) convention 182 the term "child" applies to all persons under the age of 18 and therefore persons below this age should not be involved in labour activities. However, ILO (1973) convention 138 may allow employment at 16 years of age under the condition that "the health, safety and morals of the young persons concerned are fully protected" (ILO, 1973). This principle should be applied to work for "plantations and other agricultural undertakings mainly producing for commercial purposes, but excluding family and small-scale holdings producing for local consumption and not regularly employing hired workers" (ILO, 1973).

6 Madagascar ratified Convention 182 (1999) in 2001 and Convention 138 in 2000 (ITUC, 2008). However, in 2004, the Malagasy parliament adopted the "*LOI N° 2003–044*" which states that children have to be at least 15 years old before they can be employed (Section 100).

even to do agricultural wage work during school holidays. The biggest group of plantation workers, namely 71%, consists of workers between 18 and 40 years of age (n=210) who worked an average of 118 days on the plantation (S.D. 82 days). Only 21% of the plantations workers were 41 years and older (n=61) and worked an average of 135 days during the observed time span (S.D. 97 days).

To compare the findings of the local poverty level with nationwide data we adjusted the national poverty line of 305,300 Ariary per capita for 2005 (INSTAT, 2005) with respect to inflation rates (IMF, 2008) to 407,433 Ariary per capita at the end of 2008. According to INSTAT (2005) the share of rural households living below the national poverty line was 73.5% in 2005. Comparing this official rural poverty level with our findings shows a slight decline in the rural poverty level, to 69.3%, within our research region in 2008.

To present a more detailed picture of the determination of JP households and the related impact on JP households' income, we initially take a look at the full sample of 336 households and then focus on a subsample (n=233) including households obtaining incomes below the national poverty line. It is important to take a close look at households living below the poverty line because we want to observe which income effects occur in this group. Descriptive statistics including mean differences between control and JP households with respect to full and subsample are presented in table 1.

From these mean comparisons between JP and control households insight into JP household characteristics can be gained. When comparing JP households with control households within the full sample, significant mean differences show that JP households are poorer, are relatively new to the region, are bigger in household size, possess smaller amounts of land and zebus, are less involved in agricultural wage work and business activities, and have significantly lower rice yields. These differences suggest that JP households are generally worse off than control households.

The differences between JP households and control households change when one only considers the subsample of households with incomes below the national poverty line. In this case JP households are able to obtain significantly higher incomes per capita than control households. JP households are newer residents and have a significantly larger household size, but possess fewer houses. No significant differences are revealed for land ownership and rice yield. Furthermore, JP households own fewer zebus and work less as agricultural labours. These results suggest that differences between JP and control households are smaller within this subsample. The significantly higher income of JP households suggests that working for the Jatropha plantation might have had a positive effect on JP household incomes.

Table 1. Mean differences between JP and control households' characteristics, differentiated by full sample and subsample

	Full sample (n=336)					Subsample (n=233)				
	Control Group (156)		JP Group (180)			Control Group (104)		JP Group (129		
	Mean	S. D.	Mean	S. D.	Sign. Levels	Mean	S. D.	Mean	S. D.	Sign. Levels
Outcome variables										
Income per capita (in 1,000 Ariary)	465.68	511.96	383.72	280.85	**	203.91	109.20	246.49	94.05	***
% income at national poverty line	114.30	125.66	94.18	68.93	**	50.05	26.80	60.50	23.08	***
Number of meals with rice (last 7 days)	14.26	6.00	14.17	5.10		13.19	6.23	13.88	5.08	
Days with not enough to eat (last 30 days)	7.92	11.61	6.59	10.98		9.09	11.87	7.25	11.42	*
Months with less than three meals per day (last 12 months)	1.30	2.77	1.05	2.37		1.30	2.78	1.27	2.69	
Independent variables										
Residency (Year)	1990	14.73	1995	12.36	***	1988	15.38	1996	11.18	***
HH Head Age (Years)	41.38	13.91	41.68	13.73		41.69	13.88	41.57	12.75	
HH Head Education (Years)	3.58	3.16	3.64	3.42		3.01	2.55	3.42	3.31	
HH Size (1; 2)	2.52	1.09	2.76	0.94	**	2.69	1.05	2.90	0.90	**
Total Dependency Ratio (2)	0.95	0.85	1.02	0.79		1.15	0.88	1.13	0.74	
% Illiterate Adults (2)	24.32	35.09	24.97	34.01		25.76	34.92	24.38	33.09	
% Secondary Education Adults (2)	3.95	11.83	5.67	15.34		3.23	9.89	6.24	16.10	
No. children attending public school	1.19	1.36	1.32	1.34		1.34	1.39	1.43	1.36	
No. children attending private school	0.06	0.40	0.04	0.32		0.03	0.22	0.05	0.37	
No. children up to one year old	0.35	0.51	0.39	0.51		0.37	0.52	0.44	0.53	
Mean age possible JP worker (4)	33.77	8.77	33.32	8.11		33.86	8.70	33.43	7.97	
% woman on possible JP worker (4)	55.48	27.20	54.06	19.00		58.78	25.08	56.08	18.04	
No. Houses	0.92	0.66	0.80	0.57		0.94	0.65	0.75	0.58	**
Av. house value by HH Size (1,000 Ariary)	201.13	348.27	124.46	216.04		176.49	372.38	101.95	167.49	
Val. HH assets owned in 01/08 by HH size (1,0000 Ariary)	83.56	95.28	68.02	162.78		65.08	78.08	55.17	47.84	
Val. agr. assets by HH Size (1,000 Ariary)	94.03	226.15	70.47	77.98		67.04	144.57	57.66	148.75	

Table 1. continued

	Full sample (n=336)					Subsample (n=233)				
	Control Group (156)		JP Group (180)			Control Group (104)		JP Group (129)		
	Mean	S. D.	Mean	S. D.	Sign. Levels	Mean	S. D.	Mean	S. D.	Sign. Levels
Tot. land ha per workforce (3)	1.29	1.86	0.87	1.39	**	0.82	1.45	0.62	0.92	
% Riceland on total land size	43.53	23.74	43.04	24.86		45.91	24.32	41.62	26.10	
% Riceland cultivated 07/08	83.26	32.54	84.48	30.55		84.56	32.29	82.63	33.87	
% Dry land cultivated 07/08	77.71	35.07	82.06	33.29		76.83	36.25	81.02	35.10	
Yield Rice 07/08 (t)	1.35	1.51	0.97	1.05	**	0.92	0.99	0.76	0.79	
Yield Manioc 07/08 (t)	3.44	15.45	1.84	2.19		1.41	1.77	1.40	1.51	
Yield Peanuts 07/08 (t)	0.10	0.21	0.10	0.18		0.05	0.10	0.06	0.14	
Dummy more than 2 Zebu owned 01/09	0.38	0.49	0.23	0.42	**	0.35	0.48	0.19	0.40	**
No. Zebu lost during last 12 months	0.17	0.60	0.41	2.13		0.23	0.71	0.23	0.97	
No. Chickens 01/09	4.20	7.50	5.93	10.28	*	4.20	7.87	4.75	8.09	
No. Turkeys 01/09	0.39	1.92	0.13	0.82		0.44	2.12	0.09	0.45	
% Workforce with self-employment in own agric. (3)	84.25	27.82	84.47	26.22		84.49	27.92	83.40	27.66	
% Workforce with employment in agric. wage work (3)	17.45	32.67	11.41	25.80	*	21.09	34.67	12.49	26.78	**
Dummy for village commune center being near plantation	0.48	0.50	0.67	0.47	***	0.44	0.50	0.70	0.46	***
Dummy recording own business	0.35	0.48	0.21	0.41	**	0.26	0.44	0.19	0.40	
Dummy recording public and military service employment	0.06	0.23	0.03	0.18		0.04	0.19	0.03	0.17	

* significant at 10%, ** significant at 5%, *** significant at 1%
Note: Test statistics for significance levels for mean differences are Fischer's exact test for dummy variables and Mann-Whitney U rank sum test for all other variables.
(1) based on OECD modified
(2) adults 13 - 65 years old, children < 13 years, and old > 65 years
(3) Workforce of HH is defined in this case by all persons between 13 and 65 years. This definition follows informal employment practices in the region.
(4) Possible workforce for Jatropha plantation employment took into account persons between 17 and 65 years of age.
Source: own calculations

4 Empirical Results

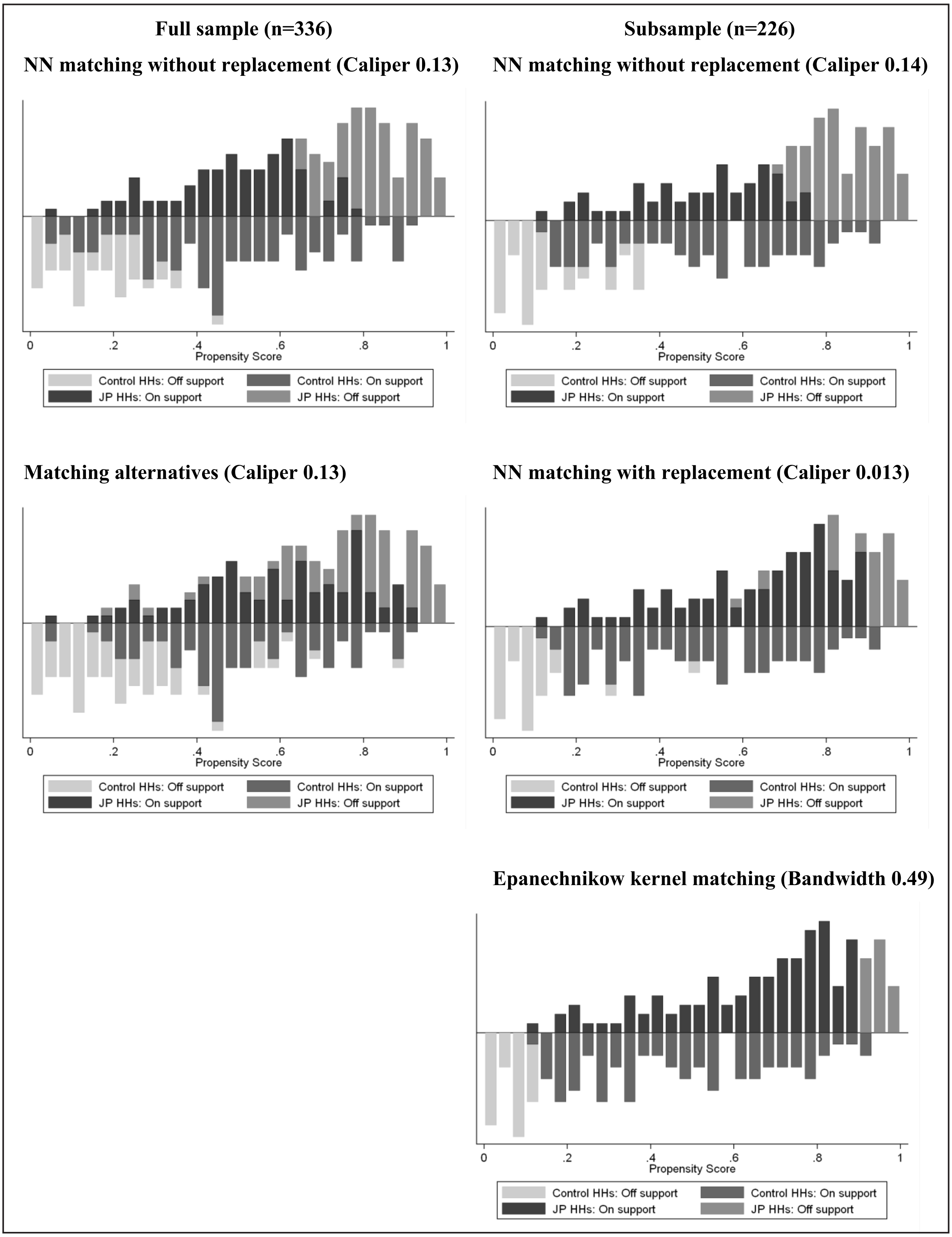
Based on the requirements for propensity score matching analysis, appropriate covariates were chosen from the socio-economic survey data. They take into account the restriction that covariates should influence the participation decision and the outcome variable simultaneously, but are at the same time unaffected by participation (HECKMAN et al., 1998). The collection of covariates which appear appropriate for determining household participation decision and are at the same time adequate for the propensity score calculation[7] represents household characteristics including demographics, household asset endowment, own farm activities, access to other income possibilities, and location characteristics. That chosen variables influence the households' participation is proven by the results of a binary logit regression shown in table A1. Here, we were able to correctly predict control and JP households in total for the full and subsample at 73.8% and 74.7% level, respectively.

We decided to use Nearest Neighbour matching as this approach was classified by CALIENDO and KOPEINIG (2008) as "the most straightforward estimator". Furthermore, we use Epanechnikov Kernel matching as one possibility to introduce weights for control households. These weights take into account the propensity score distance of control households to compared JP household propensity scores. The distribution of matched JP and control households with respect to applied matching methods are shown in figure 2.

As already presented by the binary logistic regression results our covariates explain participation slightly differently for the full and the subsample. To account for these differences we estimate propensity scores for each sample separately. The results for the average treatment effect for the treated (ATT), which in our case are JP households, are shown in table 2. In order to confirm that propensity score matching worked out we checked if the covariates are balanced for control and JP households after matching. For this purpose CALIENDO and KOPEINIG (2008) suggested to test for standardized differences, pseudo-R^2 and to apply the likelihood ratio test. The results presented in table 3 follow this suggestion.

[7] We used STATA and psmatch2 programs for our empirical analysis. The program psmatch2 accounts for the latest version developed by LEUVEN and SIANESI (2003).

Figure 2. Frequencies of estimated propensity score for JP and control households, full and subsample



Source: own calculation

The findings show that working on the Jatropha plantation has a significant positive effect on households' income for JP households compared to control households in both samples. Only the Nearest Neighbour matching without replacement provided significant results for the full sample case. Here the resulting ATT of 93,008 Ariary per capita is significant at the 10% level and was able to decrease mean standardized differences by 72.3%. Sensitivity analysis using rbounds presents critical levels (upper bound, 5% significance level) of gamma 1.25-1.3 for hidden bias. Further propensity matching methods reported lower ATT effects but were all insignificant with respect to full sample data. Within the matched full sample the share of JP households living below the national poverty line still accounts for 67.4%.

For the subsample of households living from incomes below the national poverty line Nearest Neighbour matching revealed an ATT of 69,509 Ariary per capita. This effect is significant at the 1% level and it reduced mean standardized differences by 52.7%. In this case, hidden bias can be assumed to be less likely to influence the result as gamma values between 1.65 and 1.7 are quite high. Alternative matching methods as Nearest Neighbour with replacement and Epanechnikov Kernel matching obtained highly significant results too. Their ATT levels for income per capita are as low as the ones obtained by Nearest Neighbour matching without replacement. To account for the fact that with Nearest Neighbour matching without replacement bad matches can occur, either Nearest Neighbour matching with replacement can be used, or an Epanechnikov Kernel matching which increases matching quality but at the same time decreases the level of possible standardized differences reduction. When comparing these three methods as applied to the subsample, we obtain three different results of ATT with respect to total income per capita and percent income on poverty line. These effects are all significant at the 1% level. Taking this into account, we believe Nearest Neighbour matching with replacement provides the most appropriate results: they are highly significant under severe restrictions. Therefore, we determine that the ATT of households' income per capita is 50,526 Ariary, and that a reduction of mean standardized differences of 42.9% was reached.

One possible distortion of the applied calculations could be that households working for the plantation would have had other income opportunities had the plantation not existed. In our opinion, the probability that alternative income opportunities, like own agriculture and off farm labour, would lead to a distortion is quite low. The variables of self-employment in one's own agriculture, agricultural wage work and running one's own business show a particularly negative influence on the decision to work on the Jatropha plantation. Therefore, we conclude that it is unlikely that a household offering labour to the plantation would have many other income opportunities if the Jatropha plantation did not exist.

Table 2. Average treatment effects for JP households

Matching algorithm	Full sample (n=336)			Subsample (n=223)		
	NN without replacement	NN with replacement	Epan. Kernel	NN without replacement	NN with replacement	Epan. Kernel
Restrictions:	Caliper 0.13	Caliper 0.00343	Bandwidth 0.00343	Caliper 0.14	Caliper 0.013	Bandwidth 0.49
Income per capita during 12 months observed time span (1,000 Ariary)						
JP HHs	444,900	406,626	406,626	267,851	257,422	253,668
Control HHs	351,892	336,130	335,022	198,343	206,896	194,042
ATT	93,008 *	70,496	71,604	69,509 ***	50,526 ***	59,626 ***
S.E.	46,279	59,716	54,954	19,093	21,643	16,285
% income on national poverty line						
JP HHs	109.20	99.80	99.80	65.74	63.18	62.26
Control HHs	86.37	82.50	82.23	48.68	50.78	47.63
ATT	22.83 *	17.30	17.57	17.06 ***	12.40 ***	14.63 ***
S.E.	11.36	14.66	13.49	4.69	5.31	4.00
Dishes with rice (last 7 days)						
JP HHs	14.69	13.98	13.98	13.85	14.10	14.02
Control HHs	13.92	12.31	12.38	13.42	13.09	13.15
ATT	0.77	1.67	1.60	0.44	1.01	0.87
S.E.	0.88	1.19	1.14	1.09	1.31	0.93
Days with less than 3 dishes (last 30 days)						
JP HHs	6.37	6.64	6.64	7.38	6.56	6.99
Control HHs	6.67	8.19	7.88	8.76	10.34	8.40
ATT	-0.32	-1.55	-1.25	-1.38	-4.07	-1.41
S.E.	1.65	2.22	2.17	2.23	2.50	1.73
Months with less than 3 dishes per day (last 12 months)						
JP HHs	0.90	1.13	1.13	1.25	1.03	1.24
Control HHs	1.13	1.07	1.14	1.00	0.86	1.03
ATT	-0.23	0.05	-0.02	0.25	0.17	0.21
S.E.	0.37	0.56	0.52	0.50	0.58	0.42
No. treated	85	98	98	56	95	106
No. control	111	88	88	69	67	77

* significant at 10%, ** significant at 5%, *** significant at 1%

Source: own calculation

On average, matched JP households spend more than 60% of their salary on food purchases. The results show that there are not any significant differences for matched pairs with respect to several indicators of food security, namely "Number of dishes with rice during the last seven days", "Number of days with less than three dishes during the last 30 days" and "Months with less than three dishes per day during the last

12 months". Rice is the major food staple in Madagascar. We used these indicators as they are widely used in the literature among severely undernourished populations. The survey took place at the beginning of the hungry season, from the end of the dry season to the start of the rainy season when most of the households usually suffer from food insecurity and when their own food stocks are depleted.

The lack of a significant effect on food security can be explained as follows. The chosen indicators of food security are frequently used, but they are fairly imprecise and fail to give more exact measurements, such as caloric intake, which can be gathered with food expenditure surveys or 24-hour recalls. Furthermore, it is well known that the income elasticity for total food demand is below one even for poor households. Given that the estimated income effects are quite small as shown above, it is on the other hand also possible that even with more precise indicators no significant effect would be observed.

Table 3. Results of assessing propensity score matching quality

Matching algorithm	Pseudo R^2 before matching	Pseudo R^2 after matching	$p > \chi^2$ before matching	$p > \chi^2$ after matching	Mean SD before matching	Mean SD after matching	% SD reduction
Full sample							
NN without repl. (Caliper 0.13)	0.235	0.019	0.000	1.000	14.94	4.14	72.3
Alternative matching algorithm (1)	0.235	0.059	0.000	0.995	14.94	5.88	60.6
Subsample							
Matching algorithm	**Pseudo R^2 before matching**	**Pseudo R^2 after matching**	**$p > \chi^2$ before matching**	**$p > \chi^2$ after matching**	**Mean SD before matching**	**Mean SD after matching**	**% SD reduction**
NN without repl. (Caliper 0.14)	0.274	0.057	0.000	1.000	15.34	7.26	52.7
NN with repl. (Caliper 0.013)	0.274	0.088	0.000	0.944	15.34	8.76	42.9
Epan. Kernel (Bandwidth 0.49)	0.274	0.113	0.000	0.648	15.34	9.59	37.5

Note: (1) Nearest Neighbor with replacement Caliper 0.00343, Epanechnikov Kernel Bandwidth 0.00343

Source: own calculation

5 Conclusions

This study presented the possible impact of employment opportunities generated by a Jatropha plantation on the incomes of nearby households. We applied different propensity score approaches to deal with the potential of selection bias, a common research issue in the analysis of the impact of rural employment. The revealed bias in the distribution of covariates between JP and control households confirmed that it was important to take into account possible selection bias.

The impact assessment was conducted to determine the average treatment effects on households offering labour to a nearby Jatropha plantation with respect to income and food security in central Madagascar. The results point out that labour demand by the Jatropha plantation increased JP households' per capita income with respect to comparable control households.

The findings show that households working for the Jatropha plantation have on average a higher per capita income compared to control group households. While full sample analysis showed a 93,008 Ariary higher mean income per capita for JP households, the analysis of subsample households found that mean income per capita of JP households is 50,526 to 69,509 Ariary higher than that of control households. With respect to short-, mid-, and long-term food security, no significant effects could be detected when applying propensity score matching.

In summary it can be stated, that households working for this Jatropha plantation generated significantly higher incomes during the observed time span than comparable households not working for the plantation, even though there exists a difference in man days worked per household. Even with this additional income source only a few households could overcome poverty with respect to national poverty line figures, but results show that significantly more JP households earn better incomes than control group households within the subsample and therefore are found to be much closer to the national poverty line than control households. Nevertheless, the Jatropha plantation can offer a possibility to generate income in a permanent way. Especially in a rural region, where labour demand for unskilled persons is limited to agricultural work during the rainy season, this plantation offers valuable opportunities to households with abundant labour. We further conclude from the analysis that households with higher opportunity costs for labour tend to participate less as wage labourers on the plantation. This is shown in the significant differences between the two groups for households having alternative income possibilities such as running their own business or already having salaried employment in agriculture. Moreover, the income effects calculated must be interpreted as net additional income effects for those households that choose to work on the plantation in comparison with matched control group households.

This study analyses the situation with respect to one Jatropha investor and a young Jatropha plantation where the wages have been pre-financed by the investor only and are not yet recovered through revenues from the plantation. That other investors behave in the same way cannot be concluded. Nevertheless, the findings show that if wages are similar to those offered for local agricultural wage work and (seasonal) unemployment exists, positive income effects for rural households can be achieved. A possible major constraint on wage rates at Jatropha plantations is the yield level of Jatropha seeds that can be obtained on marginal land. The paper does not provide any empirical evidence on the economic viability of Jatropha plantations and therefore cannot speculate whether such plantations can sustainably offer additional employment at competitive wage rates. Apart from the yield level of Jatropha, other critical variables here are the opportunity costs of labour and potential costs of food production losses, as well as crude oil prices and production and marketing costs of biodiesel derived from Jatropha seeds.

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Anhang

Table A 1. Determinants of household decision to work on Jatropha plantation

	Full sample (n=336)				Subsample (n=233)			
	Coef.	S.E.	Sign. Level	Odds Ratio	Coef.	S.E.	Sign. Level	Odds Ratio
Residency (Year)	0.055	0.013	***	1.057	0.083	0.019	***	1.087
Age of household head (Years)	0.041	0.015	**	1.042	0.039	0.021	*	1.04
Formal education of household head (Years)	0.038	0.056		1.038	0.06	0.076		1.062
Household size (1; 2)	0.772	0.239	***	2.165	0.981	0.33	**	2.667
Total Dependency Ratio (2)	-0.005	0.199		0.995	-0.027	0.262		0.974
% illiterate adults in household (2)	0.004	0.005		1.004	0.002	0.006		1.002
% adults with secondary education (2)	0.001	0.01		1.001	0.006	0.013		1.006
No. of children in public school	-0.035	0.153		0.966	0.04	0.187		1.041
No. of children in private school	-0.67	0.475		0.511	-0.623	0.896		0.536
No. of children younger than one year	-0.08	0.287		0.923	0.049	0.34		1.05
Mean age of possible JP workers (4)	-0.023	0.021		0.978	-0.022	0.027		0.978
% female among possible JP worker (4)	-0.008	0.006		0.992	-0.006	0.009		0.994
No. of houses possessed	-0.383	0.279		0.682	-0.347	0.333		0.707
Per-capita value of house (in 1,000 Ariary)	0	0		0.999	0	0		0.999
Per-capita value of household assets owned in 01/08 (in 1,000 Ariary)	0	0		1	0	0		1
Per-capital value of Agricultural assets (in 1,000 Ariary)	0	0		1	0	0		1
Per-capita cultivated land (in hectare) (3)	0.096	0.109		1.101	0.097	0.217		1.102
% of riceland of total cultivated land	0.003	0.007		1.003	0.002	0.008		1.002
% of riceland cultivated in July 2008 (07/08)	0.003	0.006		1.003	-0.002	0.007		0.998
% of dry land cultivated in 07/08	0.001	0.005		1.001	0.006	0.006		1.006
Yield of rice in 07/08 (in kg/ha)	0	0	**	0.999	0	0		0.999
Yield of manioc in 07/08 (in kg/ha)	0	0		0.999	0	0		0.999
Yield of peanuts in 07/08 (in kg/ha)	0.001	0.001		1.001	0	0.001		1
Dummy =1 if more than 2 zebu owned in 01/09	-1.063	0.373	**	0.345	-0.977	0.451	**	0.377
Number of zebu lost during last 12 months	0.272	0.208		1.312	-0.006	0.214		0.994

Table A 1. continued

	Full sample (n=336)				Subsample (n=233)			
	Coef.	S.E.	Sign. Level	Odds Ratio.	Coef.	S.E.	Sign. Level	Odds Ratio
No. of chickens in 01/09	0.041	0.021	**	1.042	0.028	0.028		1.029
No. of turkeys in 01/09	-0.149	0.111		0.861	-0.237	0.161		0.789
% workforce with self-employment in own agric. (3)	-0.003	0.006		0.997	-0.002	0.008		0.998
% workforce with employment in agric. wage work (3)	-0.015	0.005	**	0.986	-0.013	0.006	**	0.987
Dummy for village commune center being near plantation	1.126	0.302	***	3.085	1.451	0.386	***	4.267
Dummy recording own business	-1.206	0.337	***	0.299	-1.065	0.438	**	0.345
Dummy recording employment with public and military service	-1.636	0.774	**	0.195	-0.993	1.063		0.371
Constant	-111.692	26.332	***		-169.148	37.734	***	
Log likelihood	-177.555				-116.214			
Pseudo-R^2	0.235				0.274			
% of JP households correctly predicted	77.2				81.4			
% of control households correctly predicted	69.9				66.3			
% correctly predicted	73.8				74.7			

* significant at 10%, ** significant at 5%, *** significant at 1%

Note:

(1) Calculation based on OECD modified.

(2) adults 13 - 65 years old, children < 13 year and old > 65 years.

(3) Workforce of household is defined in this case as all persons between 13 and 65 years. This definition follows informal employment practices in the region.

(4) Possible workforce for Jatropha plantation employment took into account persons between 17 to 65 years of age.

Source: own calculations