As You Sow, So Shall You Reap: The Welfare Impacts of Contract Farming

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Abstract

What is the impact of participation in commodity chains on producer welfare? Contract farming – wherein a processing firm delegates its production of agricultural commodities to growers – is often viewed as a means of increasing grower welfare in developing countries. Because the nonrandom participation of growers in contract farming has so far not been dealt with convincingly, whether participation in contract farming increases welfare is up for debate. This paper uses the results of a contingent valuation experiment to estimate willingness to pay to enter contract farming, which is then used to control for actual participation in contract farming. Using data from Madagascar, results indicate that contract farming entails a 12- to 18-percent increase in income; a 16-percent decrease in income volatility; a two-month decrease in the duration of the hungry season; and a 30-percent increase in the likelihood that a household receives a formal loan.

Keywords: Contract Farming, Welfare, Grower-Processor Contracts, Outgrower Schemes
JEL Classification Codes: L23, L24, O13, O14, Q12

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1. Introduction

With rising incomes and falling trade barriers over the past 60 years, consumers throughout the industrialized world have increasingly valued food diversity and availability. This is why the average US supermarket offers several varieties of tomatoes at any given time, for example, or why it commonly sells summer crops such as strawberries in the middle of winter. Likewise, with rising incomes throughout the developing world, supermarkets are playing an increasingly important role in providing consumers in developing countries with a more stable supply of a greater number of agricultural commodities.

Rather than relying on commodities purchased at the farm gate or on spot markets, however, supermarkets rely on complex supply chains in which commodities are produced under contract (Reardon and Berdegué, 2002; Reardon et al., 2003). Consequently, contract farming – the economic institution wherein a processing firm and a grower enter a contract in which the firm delegates its production of agricultural commodities to the grower – is playing an increasingly important role in developing countries.

Moreover, although industrialized countries remain the top sources of US food imports, "the greatest growth [of US food imports] between 1998 and 2007 was among imports from the developing countries" (USDA, 2009), and with the advent of Fair Trade labeling in the late 1980s and the growing popularity of Fair Trade commodities in industrialized countries over the last decade, industrialized-country consumers are increasingly linked to developing-country producers, as Fair Trade commodities can now be purchased from Whole Foods in the US; Tesco in the UK; Loblaws in Canada; and Carrefour in France and elsewhere. In India, for example, Nestlé's biggest milk processing facility in the Punjab contracts with over 140,000 agricultural households (McMichael, 2009). Lastly, if the US offers any guidance as to what the future has in store for developing countries, 36 percent of the crops and livestock produced in the US are produced under contract, with estimates ranging from 21 percent for cattle to almost 90 percent for poultry (IATP, 2010).

But what is the impact of participating in contract farming on the welfare of the growers? Although much has been written on agricultural supply chains in general (Reardon and Timmer,

2005) and on contract farming in particular (Minot, 1986; Grosh, 1994; and Bijman, 2008), little is known about the actual welfare impacts of the institution on the households that choose to participate as growers. Intuition suggests that contract farming should at the very least increase the expected welfare of the households involved. If this were not the case, the assumption of individual rationality – the cornerstone of modern social science – dictates that they should refuse to participate in contract farming, just as it dictates that they should stop participating if these arrangements fail to increase their welfare. Thus, although contract farming is viewed by some as a means of fostering economic development by resolving several market failures (Grosh, 1994), however, others view the institution as a means of labor exploitation by capitalists (Watts, 1994; Porter and Phillips-Howard, 1997).[1]

Using data from Madagascar, this paper therefore studies the direct impact of participation in contract farming on several indicators of household welfare (i.e., income, income per capita, income per adult equivalent, income net of revenues from contract farming, duration of the hungry season, and whether the household has received a formal loan over the past year) as well as the indirect impact of participation in contract farming on welfare by testing whether the households who participate in contract farming have comparatively less volatile income measures.

The contribution of this paper lies in the way it identifies impact of contract farming on welfare. Indeed, because participation in contract farming is not randomly distributed across households, an important challenge is to find a suitable instrumental variable (IV) to identify the impact of contract farming on welfare. That is, one must find a variable which explains participation in contract farming but which is also exogenous to household welfare. Without such a variable, one's estimate of the impact of participation in contract farming on household welfare will be biased.

[1] Such conclusions are not exclusive to social scientists. The executive director of the US-based Organization for Competitive Markets, a think-tank whose mission is to oppose the consolidation of firms in US agriculture, has been quoted as saying that farmers who enter contract farming arrangements "essentially become indentured servants on their own land" (Laskawy, 2009).

The IV used to identify the impact of participation in contract farming in this paper is a respondent's willingness to pay (WTP) to participate in contract farming, which is derived from a dichotomous choice contingent valuation experiment. Respondents were asked whether they would agree to participate in a contract farming arrangement which would require an initial investment whose value was randomly generated during fieldwork, but which would increase their annual income with certainty. Because the hypothetical initial investment was randomly generated, the source of variation used in estimating WTP is completely exogenous to welfare. Moreover, because WTP captures a respondent's marginal utility of participation in contract farming, it effectively controls for the various sources of unobserved heterogeneity between respondents, such as various subjective perceptions, risk preferences, entrepreneurship, technical ability, etc. which all affect preferences over contract farming. These changes in preferences which are captured by different WTPs.[2]

Previous studies have instrumented participation in contract farming using a measure of respondent trustworthiness (Warning and Key, 2002); the number of organizations (including agricultural organizations) a respondent belongs to (Simmons et al., 2005); the distance between a respondent's farm and the farm of the village chief (Miyata et al., 2009); the number of female laborers in the respondent's household as well as a dummy for whether a female in the household is a member of a women's organization (Maertens, 2009); and respondent membership in a farmer group (Rao and Qaim, 2010).[3] In all cases, the exogeneity of the IVs used – whether they are orthogonal to the welfare measure of interest – is debatable, and one can easily come up with reasons why they are, in fact, not exogenous to the outcomes studied. Similarly, Minten et al. (2009) only observe households who participate in contract farming, and so they resort to comparing households who participate in contract farming with households who do not participate in contract farming by constructing a control group from a different data set.

[2] No less important is the question of reverse causality. Indeed, both (i) whether there is cognitive dissonance (i.e., whether actual participation in contract farming affects WTP); or (ii) whether welfare causally affects WTP are discussed at length in section 3 and tested for in section 4.

[3] Instead of using an IV, one could rely instead on propensity score matching, as in Maertens and Swinnen (2009). The latter, however, assumes that the difference between the treatment and control groups (i.e., in this case, between the households who participate in contract farming and those who do not) can be fully accounted on the basis of observables (Dehejia and Wahba, 2002). Because several unobservable factors (e.g., risk preferences, entrepreneurship, technical ability, etc.) likely drive the decision to go into contract farming, however, this paper does not further discuss propensity score matching.

Consequently, the nonrandom participation of growers in contract farming has so far not been dealt with convincingly, which calls into question the welfare impacts of contract farming estimated in the extant literature. Thus, whether participation in contract farming increases welfare is still up for debate.

The empirical results in this paper indicate that participation in contract farming increases household income by 12 percent; household income per capita by 16 percent; household income per adult equivalent by 18 percent; it decreases the duration of the hungry season experienced by the household by about two months; that it increases the likelihood that a household receives a loan from a bank or a microfinance institution (MFI) by about 33 percent; but it has no impact on income sources other than contract farming revenue, i.e., there are no spillovers from contract farming on other sources of income. Perhaps more importantly, empirical results indicate that participation in contract farming decreases vulnerability and indirectly increases welfare by decreasing the volatility of total household income, income per capita, and income per adult equivalent by 16 percent, but that it has no such impact on household income net of contract farming revenue. In addition, a comparison of the parametric WTP approach with a simple nonparametric method developed in this paper of computing a lower-bound on WTP for each respondent shows robust ATE estimates for all welfare outcomes. Finally, a comparison of the WTP approach with the naive ordinary least squares (OLS) case where one assumes that participation in contract farming is randomly distributed – and therefore exogenous to welfare – leads to a number of results that are important for policy.

The remainder of this paper is organized as follows. In section 2, the data is discussed along with descriptive statistics. Section 3 presents the empirical framework and the strategy used in this paper to identify the effect of contract farming on welfare. In section 4, empirical results are presented and discussed at length. Section 5 concludes by discussing the research and policy implications of the empirical findings.

2. Data and Descriptive Statistics

The data used in this paper were collected between July and December 2008 for a study of contract farming commissioned by the Economic Development Board of Madagascar (EDBM)

on behalf of the World Bank. Six regions were visited by the survey team, three of which were chosen from commune census data for their relatively high density of contract farming, with the remaining three chosen on account of their being classified as high-priority "growth areas" by EDBM. Figure 1 shows a map of the 22 regions of Madagascar: the six regions chosen for data collection were Alaotra-Mangoro (region 11 on the map in figure 1), Analamanga (4), Anosy (22), Diana (1), Itasy (3), and Vakinankaratra (5). The "growth areas" are regions 1, 5, and 22.

Within each region, the two communes with the highest density of contract farming were retained. Finally, within each of the 12 communes, 50 households were interviewed who participated in contract farming, and 50 households were interviewed who did not participate in contract farming.[4] For each household, data were collected at the household, plot, crop, and – whenever applicable – contract levels. The data thus consist of 1200 households, half of which are participants in contract farming. Because of the sampling scheme, probability weights are used to bring the sample as close as possible to a random sample throughout the paper unless noted otherwise. Table 1 synthesizes the six regions and 12 communes included in the data as well as the main contracted crops in each commune.

Table 2 presents summary statistics. Although the sample was designed so as to have 50 percent of the households participating in contract farming, the presence of missing observations for some of the variables means that only 1,178 households were retained for analysis, of which 49.8 percent are participants in contract farming.

The average household in the data is composed of 5.6 individuals, almost half of whom are dependents.[5] The majority of households in the sample are headed by a male, with only nine percent of households headed by a female. Almost one in eight households is headed by an individual who is single (i.e., who has never married or is widowed), and one in eight households is headed by a migrant (i.e., someone who was not born in the commune). The average

[4] Such a factorial design (List et al., 2010), in which the sample is split evenly between the treatment and the control group, is ideally suited for cases where the variance of the outcome (in this case, the variance of the various welfare measures) is constant across the treatment and the control group, which is unfortunately not the case in this context.
[5] A household's dependency ratio is obtained by dividing the number of individuals under 15 or above 65 years of age in the household by the total number of individuals in the household. The inverse of a household's dependency ratio is thus a rough proxy for labor quality within the household.

household head is 43 years old, has completed six years of education, and has almost 21 years worth of agricultural experience. Finally, about one in four household heads is a member of one or more peasant organizations other than contract farming groups, and the average household head is forbidden from doing agricultural work a little over three weeks per year.[6]

In terms of welfare, total annual household income is on average equal to US$977, but this figure drops down to US$868 when excluding income from contract farming.[7,8] A very naive back-of-the-envelope calculation therefore suggests that the average contract farming participant household derives an extra $218 per year from its participation in contract farming, or just about a 25 percent increase in income. In a country where the nominal GDP was of US$468 the year the data were collected, this difference in mean income between participants in contract farming and nonparticipants thus appears *a prima facie* nontrivial (IMF, 2009). Of course, this is only suggestive as it fails to control for the nonrandom nature of participation in contract farming as well as for a number of confounding factors.

Similarly, total income per capita within the household is equal to US$188, and total income per adult equivalent is equal to US$233.[9] The average household experienced a hungry season – a period during which one or more individual within the household unwillingly eat less than three meals a day – that lasted three and a half months, and 12 percent of the households had received a formal (i.e., bank or MFI) loan in the year preceding data collection.

The average household owns US$222 in working capital (i.e., plow, cart, weeder, harrow, tractor, and other agricultural equipment), and $698 in other assets (i.e., television, radio, bicycle, cattle, pigs, sheep, goats, poultry, jewelry, businesses, bank account balance, and

[6] The Malagasy observe a multiplicity of taboos, including a prescription against doing agricultural work on certain days. This taboo, which varies between households within a given village, has been found to have a significant negative impact on agricultural productivity by Stifel et al., 2008. See Ruud (1960) for a detailed anthropological survey of the many taboos observed by the Malagasy.

[7] US$1 ≈ 2000 Ariary when the data were collected.

[8] A household's total income includes (i) its income the sales of animals (cattle, pigs, sheep, goats, and poultry); (ii) its wages from various sources of labor (herding, agriculture, state, business, and other wages); (iii) its income from nonagricultural activities (crafts, trade, hunting and fishing, forestry, mining, pensions, transfers, and transportation); (iv) its income from leases (land, cattle, and equipment rentals) and from sales of animal byproducts (milk and eggs); and (v) its income from contract farming.

[9] A household's total number of adult equivalents (Deaton, 1997) was obtained by treating each individual under 15 as 0.5 adult, each individual between the ages of 15 and 65 as one adult, and each individual over 65 as 0.75 adults.

landholdings). Finally, as far as landholdings go, the average household owns 1.5 hectares of land in total.

3. Empirical Framework

The core equation to be estimated in this paper is such that

$$y_i = \alpha_1 + \beta_1 x_i + \gamma_1 w_i + \delta_1 d_j + \epsilon_{ij}, \quad (1)$$

where y_i is an indicator of welfare (i.e., income, income per capita, income per adult equivalent, duration of the hungry season, and a dummy for whether the household receives a formal loan) for household *i*; x_i is a vector of household characteristics; w_i is a dummy equal to one if the household participates in contract farming and equal to zero otherwise; d_j is a vector of dummies for each region *j*; and ϵ_{ij} is an error term with mean zero. Equation 1, however, does not and cannot control for the crop grown by the household, because the unit of analysis is the household and not the plot. The fact that most households grow more than one crop makes it difficult, if not impossible, to control for the crops grown. Because rice is the main crop grown by almost every household in Madagascar, however, and because the variation in contracted crops can be largely explained by regional differences (table 1), the variation in crops is largely controlled for by regional dummies in this paper.

The goal of this paper is to estimate γ, which represents the impact of participation in contract farming on household welfare. In this sense, γ allows calculating the average treatment effect of contract farming (ATE; see Wooldridge, 2002, chapter 18), which is such that

$$ATE = E(y_1 - y_0), \quad (2)$$

where y_1 is household welfare if the household participates in contract farming and where y_0 is household welfare if the household does not participate in contract farming. One can thus think of the problem posed by estimating the ATE as a missing data problem: data is missing on y_0 for the households that participate in contract farming, and data is missing on y_1 for the households that do not participate in contract farming.

Because participation in contract farming is not randomly distributed across households, the equation

$$w_i = \alpha_2 + \beta_2 x_i + \varphi_2 z_i + \delta_2 d_j + \nu_{ij}, \quad (3)$$

is first estimated as a probit and used to derive obtain $\hat{G}_i$, the vector of predicted probabilities obtained from estimating equation 3 (i.e., the predicted value of w_i). Equation 1 can then be estimated using $\hat{G}_i$, x_i, and d_j as instruments for w_i (see Wooldridge, 2002, procedure 18.1 for a discussion). The next section discusses the identification strategy adopted in this paper to identify the impact of contract farming on household welfare, i.e., the instrument for participation in contract farming.

3.1. Identification Strategy

As is often the case, the identification of the ATE is far from given in this context. Indeed, because the data are cross-sectional and include only one observation per household, one cannot control for the unobserved heterogeneity between households by incorporating household fixed effects. Moreover, participation in contract farming is almost surely driven by some unobservable factor, which would bias any estimated ATE from contract farming obtained from a naive estimation of equation 1. For example, because contract farming often insures growers against price risk via the use of piece rates (Grosh, 1994), it is likely that participation in contract farming is driven by the respondent's risk preferences. Risk preferences, however, are difficult to estimate from survey data, and proxies for risk preferences are only correlated with true risk preferences by assumption (e.g., constant relative risk aversion; decreasing absolute risk aversion; etc.). Even if one were to correctly hypothesize the relationship between risk preferences and a risk proxy included on the right-hand side of equation 1, the error term could still be correlated with that proxy (Ackerberg and Botticini, 2002), which would bias the estimate of γ. It could also be that participation in contract farming is driven by the respondent's entrepreneurial or technical abilities, which are very difficult to measure and which are consequently omitted from most studies such as this one.

To overcome this difficulty, this paper instruments w_i – the dummy variable measuring whether a household participates in contract farming – using a respondent's willingness to pay to participate in contract farming, which is derived from a simple dichotomous choice contingent valuation experiment conducted during fieldwork (Mitchell and Carson, 1989; Arrow et al., 1993). Each household in the sample was asked the question

> "Would you be willing to enter a contract farming agreement that would necessitate an initial investment of 25,000–50,000–75,000–100,000–125,000–150,000 Ariary (i.e., US$ 12.5–25–37.5–50–62.5–75) but which would increase your annual income by 10 percent?,"

where the initial investment was randomly generated by the throw of a die. This allows estimating the following equation as a probit (Cameron and James, 1987)

$$c_i = \alpha_3 + \beta_3 x_i + \theta_3 r_i + \delta_3 d_j + \xi_{ij}, \tag{4}$$

where c_i is equal to one if the respondent would accept entering a contract that would require an initial investment equal to r_i but increase her annual income by 10 percent and equal to zero otherwise and the other variables are defined as before. Using the results from estimation 4, one can compute

$$WTP_i = -\frac{\widehat{\alpha}_3 + \widehat{\beta}_3 x_i + \widehat{\delta}_3 d_j}{\widehat{\theta}_3}, \tag{5}$$

where WTP_i is household i's willingness to pay to enter contract farming.[10] Estimated WTP is then used as the instrument z_i for participation in contract farming.

Thus, because the value of the initial investment required by the hypothetical contract offered in the contingent valuation exercise was randomly generated during fieldwork, the variation in estimated WTP is exogenous to welfare. More importantly, estimated WTP controls for the unobserved heterogeneity between respondents because it is a direct measure of the marginal

[10] The use of a probit in equation 4 assumes that WTP is normally distributed. The normality assumption is relaxed in section 3.3, which develops a simple nonparametric lower-bound WTP estimate to conduct robustness checks.

utility derived by respondents from participation in contract farming. For example, a respondent who is risk-averse, and who perceives that participating in contract farming would help him transfer the price risk he would otherwise face to the processing firm, is different from an otherwise identical risk-neutral respondent who does not mind bearing price risk, and this difference in risk preferences is captured by the different valuation between individuals for the hypothetical contract. Likewise, an entrepreneurial respondent, who would rather start his own business, is different from an otherwise identical but less entrepreneurial respondent who would rather produce under contract for a processing firm, and this difference is also perceived by the different valuation between individuals for the hypothetical contract. Similarly, a respondent with a high level of agricultural ability and for whom the total cost of producing a given level is different from an otherwise identical but low-ability respondent, a difference that is once again reflected in the different valuations between individuals for the hypothetical contract. In other words, observationally identical respondents can derive different marginal utilities from contract farming due to unobservable characteristics, but those differences in marginal utilities are captured by WTP for contract farming.

Some may object that the IV used in this paper suffers from a reverse causality problem when studying the impact of contract farming on income, income per capita, and income per adult equivalent. It is *a priori* true that because respondents are asked to evaluate a hypothetical contract that would increase their income by 10 percent, and because income differs between respondents, a respondent's response to the contingent valuation question may depend on his income. This is something one can test for, however. Indeed, because two of the welfare outcomes studied in this paper (i.e., the duration of the hungry season and the likelihood the household has received a formal loan in the past 12 months) depend on income, WTP is estimated both without (for the income measures) and with income (for the duration of the hungry season and for the likelihood of having received a formal loan) as a conditioning variable in what follows. The empirical results for WTP estimation show that income is (i) statistically insignificant as a determinant of WTP; and (ii) whether income is included or not, the estimated coefficients and significance levels for all other estimated coefficients do not change, and neither does the *R*-square measure (see table 4, discussed below along with additional nonparametric

evidence), which invalidates the concern that there may be reverse causality between income and WTP.

Lastly, one could also object that a respondent's actual participation in contract farming could affect her answer to the hypothetical participation question posed by the contingent valuation exercise because they have first-hand knowledge of the institution. The sampling strategy, however, should insure against such reverse causality given that even respondents who do not participate in contract farming have a thorough knowledge of the institution by virtue of living in the same small, close-knit villages as the respondents who participate in contract farming. Moreover, recent research at the intersection of psychology and economics has invalidated almost every study that had previously found evidence in favor of the hypothesis that choices affect rather than reflect preferences, i.e., in favor of cognitive dissonance (Chen, 2008). In any event, section 4 tests for this kind of cognitive dissonance and shows empirically, both parametrically and nonparametrically, that estimated WTP does not differ systematically between the respondents who actually participate in contract farming and those who do not.

3.2. Grower Selection or Firm Discrimination?

Even though the WTP method presented above controls for the supply of growers (i.e., the nonrandom selection of households into contract farming), there is also a demand for growers on the part of processing firms, and firms discriminate between potential growers when choosing contracting partners.

This is a valid concern, as failure to accurately model the decision process of firms regarding how they choose their contracting partners may result in an omitted variables problem, which would bias the estimated coefficients in equation 1 even when controlling for household selection into contract farming using the WTP method presented above. For example, firms could discriminate between potential growers by choosing to contract only with individuals who have a level of technical ability higher than a specific threshold. In that case, if technical ability is unobserved by the econometrician and correlated with the covariates on the right-hand side of equation 1, the estimated coefficients in equation 1 are biased. Consequently, it may not be

sufficient to control for selection into contract farming, as discrimination between potential growers may also lead to biased estimates of the ATE of contract farming on welfare.

In practice, however, it is unlikely that firms choose their growers on the basis of unobservables such as technical ability, entrepreneurial ability, or risk aversion. Even in cases where firms exploit decentralized local knowledge by asking growers with whom they have contracted in the past to recommend new growers, firms discriminate on the basis of observables. Given the richness of the data used in this paper, the econometrician has access to more information on observables than the firm does. The inclusion of household characteristics on the right-hand side of equation 1 that are more informative than what processing firms have access to should thus control for the way firms discriminate between potential growers.

3.3. Robustness Checks Using a Nonparametric Lower Bound WTP Estimate

In order to check the robustness of the empirical results, equation 1 is also estimated using a nonparametric lower-bound WTP estimate for each respondent. When someone answers "Yes" to the contingent valuation question, the only thing the econometrician knows with certainty is that they would be willing to pay at least r_i to participate in contract farming. Alternatively, when someone answers "No" to the contingent valuation question, they would be willing to pay any value in the $[-\infty, r_i)$ interval to participate in contract farming.

The nonparametric lower-bound WTP estimate thus proceeds as follows. Every respondent who answers "Yes" to the contingent valuation question is assigned the randomly-generated value of r_i drawn for him as his WTP. Alternatively, every respondent who answer "No" to the contingent valuation question is assigned a value of zero as his WTP. Compared to the parametric method described above, which assumes that WTP is distributed normally, this nonparametric method only assumes that (i) WTP is nonnegative; and that (ii) respondents are individually rational, i.e., that they would accept a contract which would increase their annual income by 10 percent but which would require no initial investment.

Although the latter assumption is the cornerstone of economics and of social sciences, some may balk at imposing the requirement that WTP be nonnegative. After all, there are significant

nonmonetary costs to participating in contract farming, which means that WTP could be negative for some respondents. Indeed, section 4 shows that some respondents do have negative WTP when computing WTP using the parametric method discussed above.

It is not clear, however, whether imposing nonnegative WTP is a better or worse assumption than imposing that WTP be normally distributed. More importantly, given that WTP is ancillary in this paper – the interest lies is in estimating the ATE of contract farming on a number of welfare outcomes rather than getting an unbiased estimate of the WTP of respondents to participate in contract farming – what matters in this context is the *variation* in WTP, which is used here to identify the impact of participation in contract farming. Recall that WTP is a measure of marginal utility, and that a utility function only represents individual preferences up to an affine transformation. Because several utility functions can represent the same preferences, what matters for utility functions is their ordinality, not their cardinality. Likewise, the assumption that the nonparametric lower-bound WTP estimate be nonnegative affects the cardinality of WTP, but what matters in this context is ordinality.

4. Estimation Results and Discussion

This section first looks at whether contract farming increases welfare nonparametrically by comparing, for the households that participate in contract farming and the households that do not participate in contract farming, (i) kernel density estimates for the welfare measures selected for analysis that are measured continuously; and (ii) the unconditional means of all the welfare measures selected for analysis. Because the nonparametric evidence fails to control for confounding factors and is only suggestive, the parametric evidence, which presents estimation results for the treatment regressions discussed in section 3, follows the nonparametric evidence and constitutes the bulk of this section.

4.1. Nonparametric Evidence

Before proceeding with the estimation sequence outlined in section 3, it is helpful to take a first pass at determining whether contract farming has a positive impact on the welfare of the households involved by looking at the problem nonparametrically, i.e., by comparing kernel

density estimates for a subset of welfare measures as well as the unconditional means of all welfare measures by participation regime.

Figures 2 to 6 plot kernel density estimates by participation regime (nonparticipants, i.e., households who do not participate in contract farming, and participants, i.e. households who participate in contract farming) for the five continuous indicators of welfare retained for analysis, i.e., household income, household income per capita, household income per adult equivalent, household income net of revenues from contract farming, and duration of the hungry season. Figures 2 to 4 suggest that total household income is higher for participants along all three measures considered here, but that there are no spillovers from participation in contract farming to other income categories, as suggested by figure 5. That is the income, income per capita, and income per adult equivalent of households who participate in contract farming is seemingly higher than the income, income per capita, and income per adult equivalent of households who do not participate in contract farming, but income net of contract farming revenue does not seem to vary between participation regimes. Figure 6 suggests that households who participate in contract farming experience a shorter hungry season than households who do not participate in contract farming. Lastly, figures 2 to 4 further suggest that the income of the households who participate in contract farming may be slightly less volatile than the income of households who do not participate.

Similarly, table 3 presents mean comparisons by participation regime for the variables retained for analysis as well as the result of a *t*-test of difference in means for each variable. These tests suggest that participants and nonparticipants in contract farming differ along almost all indicators, and that they are indistinguishable only along their dependency ratios, whether respondents are migrants, as well as along the education and agricultural experience of the respondents.

More importantly, these tests suggest that the households who participate in contract farming report a significantly higher income, income per capita, income per adult equivalent, and income net of contract farming revenue; that they experience a shorter hungry season; that they are more likely to have obtained a bank or MFI loan over the past 12 months; and that they are wealthier

in that they own more in working capital, assets, and landholdings than the households who do not participate in contract farming. Thus, table 3 suggests that the households who participate in contract farming are better off along all welfare indicators, but that it is the financially better off households who may be electing to participate in contract farming.

4.2. Parametric Evidence

While the foregoing is helpful if one is interested in determining whether participation in contract farming is correlated with differences in various welfare indicators (e.g., income; income volatility; duration of hungry season; access to formal credit), it says nothing about causality. To properly answer the question of whether participation in contract farming systematically increases the welfare of the households involved, one must use the statistical apparatus presented in section 3.

This section first presents estimation results for the dichotomous choice contingent valuation exercise (i.e., equation 4) in table 4. It then presents in tables 5 to 10 estimation results for treatment regressions of the various welfare indicators retained for analysis, split between the participation (equation 3) and welfare (equation 1) equations. Tables 5 to 10 also present naive versions of the welfare equation (equation 1), i.e., versions of the welfare equation in which participation is not instrumented.

Although the estimation results presented in tables 5 to 11 allow determining whether participation in contract farming has direct impacts on welfare, they do not allow determining whether the institution has indirect expected utility impacts on welfare by reducing income volatility. For each income measure, table 11 thus presents the results of heteroskedasticity tests aimed at determining whether income volatility is equal between the households that participate in contract farming and those that do not or whether there are systematic differences in income volatility between the two groups. Lastly, table 12 synthesizes the empirical results by presenting the estimated ATEs, both for the parametric WTP as well as for the nonparametric WTP.[11]

[11] In the interest of brevity, complete estimation results for the treatment regressions using nonparametric WTP as an instrument are not discussed, but they can be found in appendix tables A2 to A6.

Table 4 presents estimation results for the dichotomous choice contingent valuation experiment, both excluding income as a covariate in column 1 and including it in column 2 (the latter being done to study the duration of the hungry season and the likelihood a household receives a formal loan, both of which depend on income). Recall that respondents were asked whether they would be willing to enter a contract farming arrangement that would increase their annual income by 10 percent with certainty but which would require a substantial random initial investment. As one would expect, this random initial investment has a significant negative impact on the likelihood that the respondent will accept the contract. Moreover, the quantity and the quality of labor within the household (i.e., the size of the household and the proportion of dependents within the household) also affect the respondent's answer at the margin: the more labor within the household, the more the respondent is likely to be willing to enter contract farming, and the lower the quality of the labor available within the household, the less the respondent is likely to be willing to enter contract farming.

Older respondents are less likely to be willing to enter contract farming, but the number of days on which agricultural work is forbidden for the respondent actually has a positive impact on a respondent's willingness to enter contract farming. This latter finding is interesting in that it suggests that respondents perceive agricultural work done under contract as falling outside of the purview of taboos and that, as a consequence, one can do contract work on days that are otherwise taboos for agricultural work. Lastly, that the results in the second column of table 4 vary only infinitesimally when including income as a covariate in equation 4. Indeed, the estimated coefficient for the dummy capturing whether the respondent is a migrant is decreased by 0.001 when including income; all other point estimates and all significance levels remain the same. This provides empirical support for the hypothesis that respondents with different income levels do not evaluate different contracts when answering the contingent valuation question, i.e., that there is no reverse causality between income and the estimated ATE of contract farming.

An estimate of each respondent's WTP to participate in contract farming is obtained by using the formula in equation 5. Figures 7 and 8 present histograms of estimated WTP both excluding and including income as a covariate. Once again, the inclusion of income does not seem to impact WTP estimates. The last part of table 1 shows descriptive statistics for the estimated

WTP. The average respondent would be willing to make an initial investment of US$76.35 when excluding income (also US$76.35 when including income) to enter a contract farming arrangement that would increase her annual income by 10 percent, with the associated 99 percent confidence interval covering the range [US$71.93, US$80.76] when excluding income ([US$71.94, US$80.77] when including income). That the WTP estimate varies only infinitesimally (the means differ only by thousandths of a US dollar, or tenths of a cent) when including income as a covariate in equation 4, which is further empirical support in favor of the hypothesis that respondents with different income levels do not evaluate different contracts when answering the contingent valuation question, i.e., that there is no reverse causality between income and the estimated ATE of contract farming. Unsurprisingly, at US$24.28, the mean of the nonparametric lower-bound WTP estimate is significantly lower than the mean of the parametric WTP estimate.

Interestingly, a little over 10 percent (n=136) of respondents have a negative WTP to enter contract farming, i.e., one would need to subsidize their entry in contract farming. In this context, as in Vossler and Kerkvliet (2003), WTP is not constrained to be nonnegative. In the interest of knowing whose participation should be subsidized, table A1 presents estimation results for a linear probability model (LPM) in which the dependent is equal to one if WTP is negative and equal to zero otherwise. The results of this LPM indicate that larger households, who have access to more labor, are less likely to have negative WTP, but households with higher dependency ratios, whose labor is of lower quality, are more likely to have negative WTP. Likewise, single, female, and elderly respondents are more likely to have negative WTP, but respondents who are members of a peasant organization and respondents for whom agricultural work is forbidden on a greater number of days are less likely to have negative WTP.

In order to test whether respondents suffer from cognitive dissonance, i.e., whether WTP is systematically different between the households who participate in contract farming and those who do not, estimated WTP was regressed on a constant and on the contract farming dummy. As it turns out, the estimated coefficient for the contract farming dummy was not statistically different from zero and it had a *p*-value of 0.78. The last part of table 3 shows the result of *t*-test that mean WTP is equal between groups: in neither case can the null hypothesis be rejected.

Figures 9 and 10 further show that mean WTP is the same for the households who participate in contract farming and for those who do not. In all three of these tests of cognitive dissonance (i.e., the regression of WTP on actual contract farming participation as well as figures 9 and 10), one does not need to further condition on observables given that WTP itself is estimated conditional on observables.

Armed with the respondents' estimated WTP to enter contract farming, one can estimate treatment regressions for each welfare outcome retained for analysis. Table 5 presents estimation results for (i) the treatment regression of household income in columns 1 and 2, in which the dummy for whether the household participates in contract farming is instrumented with the respondent's WTP to enter contract farming; and (ii) a naive regression of household income in column 3, in which the dummy for whether the household participates in contract farming is not instrumented. Tables 6 to 10 essentially follow the same plan, but for the other indicators of welfare selected for analysis (i.e., household income per capita; household income per adult equivalent; household income net of contract farming revenue; duration of the hungry season experienced by the household; and a dummy for whether the household receives a formal loan).

Because the empirical results for household participation in contract farming (i.e., the first column of table 5) are qualitatively the same in tables 5 to 10, only the results in table 5 are discussed here. For every additional year of age, respondents are 1.4 percent less likely to have chosen to participate in contract farming, but for every additional year of agricultural experience, they are 1.2 percent more likely to have chosen to participate in contract farming. Participation in peasant organizations other than contract farming organizations is also associated with participation in contract farming in that a household that is a member of a peasant organization is almost 50 percent more likely to participate in contract farming than a household who is not a member of such an organization. Moreover, for every additional day on which agricultural work is forbidden for the respondent, the respondent is 0.6 percent less likely to participate in contract farming. Note that although the number of days on which agricultural work was forbidden had the opposite impact on whether the likelihood that the respondent would accept the (hypothetical) contract in table 4, the results in tables 4 and 5 are not inconsistent given that the former did not control for a respondent's marginal utility of contract farming, which is an

important source of unobserved heterogeneity, while the latter do. Finally, for every additional dollar of WTP, the average respondent is 0.4 percent more likely to participate in contract farming, an effect that is significant at the 5 percent level.

As regards the impact of participation in contract farming, table 5 shows that the institution has a positive impact on total household income, but that there is a considerable difference in estimated ATEs between the treatment regression and the naive regression. Indeed, while the latter regression indicates that participating in contract farming increases a household's total income by US$42 or 3.6 percent of total income, the former indicates that participating in contract farming really increases a household's total income by US$117, or 12 percent of total income. So while one may *a priori* believe that the naive regression would tend to overestimate the ATE of contract farming because it fails to control for the fact that households whose income is *ex ante* higher are more likely to participate in contract farming, it turns out that the selection mechanism operates in the opposite way. That is, households whose income is *ex ante* lower are the ones who are more likely to participate in contract farming, which biases the naive ATE estimate downwards.

Comparing the results of the treatment regression in the first two columns with the results of the naive regression in the third column, table 5 also indicates that failing to take into account the nonrandom nature of participation in contract farming would lead to false conclusions, and so to mistaken policy recommendations for someone interested in increasing participation in contract farming. For example, based on the results in the third column of table 5, one would mistakenly conclude that female-headed households have a systematically lower income; that the age of the respondent does not matter in determining income, but these findings disappear once one controls for selection into contract farming in the first two columns of table 5. Interestingly, the naive regression also indicates that members of peasant organizations (other than contract farming organizations) have systematically higher incomes, but the results in the first two columns of table 5 show instead that members of peasant organizations (i) are more likely to participate in contract farming; which (ii) increases their income.

Turning to the other income measures retained for analysis, the empirical results show that participation in contract farming increases household income per capita by US$29.49 or 16 percent (table 6) and that it increases household income per adult equivalent by US$40.77 or 17.5 percent (table 7). Participation in contract farming, however, does not have any spillover effects on sources of income other than income from contract farming (table 8).

The results in table 9 show that participation in contract farming causes a 2.2-month decrease in the duration of the hungry season experienced by the respondent's household. Likewise, table 10 presents results for the likelihood that the household has received a formal (i.e., bank or MFI) loan. Both the naive and the treatment regression approaches in this case show that the households who participate in contract farming are more likely to receive a formal loan, but the naive approach biases the result downward. Indeed, while column 3 suggests that households who participates in contract farming are on average 7.2 percent more likely to receive a formal loan, the results in column 2 show that they are actually 34 percent more likely to receive a formal loan. Once again, although one may expect that the naive regression would overestimate the ATE of contract farming because it fails to control for the fact that households who are *ex ante* more likely to receive a formal loan are also more likely to participate in contract farming, it turns out that the selection mechanism operates in the opposite way. That is, households who are *ex ante* less likely to receive a formal loan are the ones who are more likely to participate in contract farming, which biases the naive ATE estimate downwards. Furthermore, the naive approach would also suggest that members of peasant organizations are on average more likely to receive formal loans than respondents who are not members of such organizations, but as in the case of total household income, this finding disappears once the respondents' selection into contract farming is controlled for in the second column.

As regards the expected-utility impact of contract farming (i.e., the impact of participation in contract farming on income volatility), table 11 reports the results of tests of group-wise heteroskedasticity for each of the dependent variables in tables 5 to 8. That is, it reports the results of tests of the null hypothesis that the variance of the residuals is the same for households who participate into contract farming and for those who do not in the equations presented in tables 5 to 8. The null hypothesis of homoskedasticity (i.e., the hypothesis that the variance of

the residual is equal between groups) is rejected for all three measures of total income (i.e., household income, household income per capita, household income per adult equivalent), but it cannot be rejected for income net of contract farming revenue. Moreover, the rejection lies in a direction which shows that participation in contract farming significantly reduces the volatility of total household income, income per capita, and income per adult equivalent, and that it does so by about 16 percent in every case. Over and above directly increasing the welfare of the households who participate in contract farming by increasing their income, income per capita, and income per adult equivalent as well as by decreasing the duration of the hungry season they experience, contract farming indirectly increases their welfare by reducing the amount of income risk they are exposed to.

Lastly, table 12a synthesizes the estimation results by presenting the ATE of contract farming for each outcome in tables 5 to 10 estimated in one of two ways: (i) using the parametric WTP estimate discussed in section 3.1; and (ii) using the nonparametric lower-bound WTP estimate discussed in section 3.4.[12] These results show that the estimated ATEs are robust to the estimation method used to compute respondent WTP to participate in contract farming. Likewise, in order to determine whether the impacts of contract farming are significantly different between the regions closer to the capital and more remote regions, table 12b synthesizes the estimation results for the ATEs of contract farming on income between the regular regions (i.e., regions 3, 4, and 11 in figure 1) and the so-called "high-priority growth areas" (i.e., regions 1, 5, and 22 in figure 1; see section 2). These results indicate that although the ATEs are statistically significantly higher in the regions closer to the capital, they are still economically significant and positive in the more remote areas.

What to make of these results? First off, participation in contract farming has a significant direct effect on welfare in that it significantly increases total household income, household income per capita, and household income per adult equivalent, and the ATEs for these three variables are respectively equal to 12 percent of household income, 16 percent of household income per capita, and 18 percent of household income per adult equivalent.

[12] Complete estimation results for the ATEs estimated using nonparametric WTP can be found in the appendix.

Second, participation in contract farming decreases the duration of the hungry season experienced by the household by about two months and it increases the likelihood that a household will receive a formal (i.e., bank or MFI) loan by over 30 percent, probably because participation in contract farming sends a credible signal to banks and MFIs that the household has been screened for trustworthiness by the processing firm.

Third, participation in contract farming has a significant indirect welfare effects in that it reduces by 16 percent the volatility of total household income, household income per capita, and household income per adult equivalent. This is a key finding given that in rural areas of developing countries, poverty and risk have been found to entail welfare losses of comparable magnitude (Ligon and Schechter, 2003; Dercon, 2005).

Finally, although the data are cross-sectional and therefore do not lend themselves to analyzing welfare dynamics in relation to contract farming, one can still say something about the impact of the institution on inequality. Looking once again at the results in the first column of table 5, it looks as though households whose heads are older and less experienced, households with smaller landholdings, and households whose heads are not members of a peasant organization and for whom more days cannot be spent working in agriculture are less likely to participate in contract farming. Thus, it looks as though contract farming may increase inequality because it favors those with larger landholdings – who already have more opportunities for diversification – and those for whom agricultural work is forbidden on fewer days, a cultural artifact that has been shown by Stifel et al. (2008) to significantly reduce agricultural productivity at the margin.

5. Conclusion

Using data collected in six regions of Madagascar in 2008, this paper has studied the welfare impacts of participation in contract farming. Because participation in contract farming is not random, the results of a dichotomous choice contingent valuation experiment were used to estimate the WTP of respondents to participate in contract farming, which was then used to predict participation in contract farming. This has allowed identifying the change in welfare due to a household's participation in contract farming.

The empirical results show that participation in contract farming directly increases total household income by 12 percent; household income per capita by 16 percent; household income per adult equivalent by 18 percent; and the likelihood that a household will received a formal loan by over 30 percent. Moreover, participation in contract farming decreases both the duration of the hungry season experienced by the average household by about two months and the volatility of the total income of the average household by 16 percent. The latter result implies that participation in contract farming has indirect expected utility impacts on household welfare.

What are the policy implications of these findings? In a context where some within the development community perceive participation in contract farming as something close to bonded labor (Little and Watts, 1994), these findings indicate that contract farming has overwhelmingly positive impacts on the welfare of the households involved. As such, even though the institution may increase inequality, fostering industrial development by providing incentives for processing firms to delegate their production of agricultural commodities and for households to participate in agricultural commodity chains would likely contribute to alleviating poverty in these data. Concretely, policy makers could stimulate participation in contract farming by targeting households headed by older individuals; individuals who are less experienced and who are not members of peasant organizations; individuals for whom agricultural work is forbidden on more days than others; and households with smaller landholdings, as many of these characteristics are also associated with persistent poverty in Madagascar (Stifel et al., 2010).

Finally, it is important to qualify these empirical findings by offering a few caveats. First, as Foster and Rosenzweig (2010) point out, a household's income is not the best measure of welfare given that it does not take into account the various costs borne by the household. Instead, farm profits would constitute a much better measure of welfare. Second, and perhaps more importantly, contract farming activities in the developing world are usually concentrated in areas that are easily accessible. Thus, although the findings in this paper indicate that contract farming has positive impacts on the welfare of the households involved, whether these findings would hold if processing firms were to expand their activities to other communities is an empirical question.

References

Ackerberg, Daniel A., and Maristella Botticini (2002), "Endogenous Matching and the Empirical Determinants of Contract Form," *Journal of Political Economy* 110(3): 564-591.

Arrow, Kenneth, Robert Solow, Paul R. Portney, Edward E. Leamer, Roy Radner, and Howard Schuman (1993), "Report of the NOAA Panel on Contingent Valuation," *Federal Register* 58: 4601-4614.

Bijman, Jos (2008), "Contract Farming in Developing Countries: An Overview," Working Paper, Wageningen University.

Cameron, Trudy Ann, and Michelle D. James (1987), "Efficient Estimation Methods for Close-Ended Contingent Valuation Surveys," *Review of Economics and Statistics* 69(2): 269-276.

Chen, M. Keith (2008), "Rationalization and Cognitive Dissonance: Do Choices Affect or Reflect Preferences?," Working Paper, Cowles Foundation.

Deaton, Angus (1997), *The Analysis of Household Surveys*, Washington, DC: World Bank Publications.

Dehejia, Rajeev H., and Sadek Wahba (2002), "Propensity Score Matching Methods for Nonexperimental Causal Studies," *Review of Economics and Statistics* 84(1): 151-161.

Dercon, Stefan (2005), "Risk, Poverty, and Vulnerability in Africa," *Journal of African Economies* 14(4): 483-488.

Foster, Andrew D., and Mark R. Rosenzweig (2010), "Microeconomics of Technology Adoption," Working Paper, Yale University.

Grosh, Barbara (1994), "Contract Farming in Africa: An Application of the New Institutional Economics," *Journal of African Economies* 3(2): 231-261.

Institute for Agriculture and Trade Promotion (2010), "Complaints of Contract Farm Abuses Increasing," http://www.agobservatory.org/agribusiness_records.cfm?nID=241 accessed on February 24, 2010.

International Monetary Fund (2009), World Economic Outlook Database, http://www.imf.org/external/pubs/ft/weo/2009/02/weodata/index.aspx accessed on November 18, 2009.

Laskawy, Tom (2009), "Will Whole Foods' New Mobile Slaughterhouse Squeeze Small Farmers?," http://www.grist.org/article/2009-11-20-Whole-Foods-chicken-farms/ accessed on February 25, 2010.

Ligon, Ethan, and Laura Schechter (2003), "Measuring Vulnerability," *Economic Journal* 113(486): C95-C102.

List, John A., Sally Sadoff, and Mathis Wagner (2010), "So You Want to Run an Experiment, Now What? Some Simple Rules of Thumb for Optimal Experimental Design," NBER Working Paper.

Maertens, Miet (2009), "Horticulture Exports, Agro-Industrialization, and Farm—Nonfarm Linkages with the Smallholder Farm Sector: Evidence from Senegal," *Agricultural Economics* 40(2): 219-229.

Maertens, Miet, and Johan F.M. Swinnen (2009), "Trade, Standards, and Poverty: Evidence from Senegal," *World Development* 37(1): 161-178.

McMichael, Philip (2009), "A Food Regime Analysis of the 'World Food Crisis'," *Agriculture and Human Values* 26(4): 281-295.

Minot, Nicholas (1986), "Contract Farming and Its Effect on Small Farmers in Less Developed Countries," Working Paper, Michigan State University.

Minten, Bart, Lalaina Randrianarison, and Johan F.M. Swinnen (2009), "Global Retail Chains and Poor Farmers: Evidence from Madagascar," *World Development* 37(11): 1728-1741.

Mitchell, Robert C., and Richard T. Carson (1989), *Using Surveys to Value Public Goods: The Contingent Valuation Method*, Washington, DC: Resources for the Future.

Miyata, Sachiko, Nicholas Minot, and Dinghuan Hu (2009), "Impact of Contract Farming on Income: Linking Small Farmers, Packets, and Supermarkets in China," *World Development* 37(11): 1728-1741.

Porter, Gina, and Kevin Phillips-Howard (1997), "Comparing Contracts: An Evaluation of Contract Farming Schemes in Africa," *World Development* 25(2): 227-238.

Rao, Elizabeth J.O., and Matin Qaim (2010), "Supermarkets, Farm Household Income, and Poverty: Insights from Kenya," Working Paper, University of Göttingen.

Reardon, Thomas, and Julio Berdegué (2002), "The Rapid Rise of Supermarkets in Latin America: Challenges and Opportunities for Development," *Development Policy Review* 20(4): 371-388.

Reardon, Thomas, C. Peter Timmer, Christopher B. Barrett, and Julio Berdegué (2003), "The Rise of Supermarkets in Africa, Asia, and Latin America," *American Journal of Agricultural Economics* 85(5): 1140-1146.

Reardon, Thomas, and C. Peter Timmer (2005), "Transformation of Markets for Agricultural Output in Developing Countries Since 1950: How Has Thinking Changed?," in Robert E.

Evenson, Prabhu Pingali, and T. Paul Schultz, eds., *Handbook of Agricultural Economics 3: Agricultural Development: Farmers, Farm Production, and Farm Markets*, Amsterdam: Elsevier.

Ruud, Jørgen (1960), *Taboo: A Study of Malagasy Customs and Beliefs*, Antananarivo: Printy Loterana and Oslo: Oslo University Press.

Simmons, Phil, Paul Winters, and Ian Patrick (2005), "An analysis of contract farming in East Java, Bali, and Lombok, Indonesia," *Agricultural Economics* 33(s3): 513-525.

Stifel, David C., Marcel Fafchamps, and Bart Minten (2008), "Taboos, Agriculture, and Productivity," Working Paper, Lafayette College.

Stifel, David S., Felix Forster, and Christopher B. Barrett (2010), "The Evolution of Groupwise Poverty in Madagascar, 1999-2005," *Journal of African Economies* forthcoming.

USDA (2009), "Trade Data Show Value, Variety, and Sources of US Food Imports," http://www.ers.usda.gov/AmberWaves/September09/DataFeature/ accessed on February 26, 2010.

Vossler, Christian A., and Joe Kerkvliet (2003), "A Criterion Validity Test of the Contingent Valuation Method: Comparing Hypothetical and Actual Voting Behavior for a Public Referendum," *Journal of Environmental Economics and Management* 45(3): 631-649.

Warning, Matthew and Nigel Key (2002), "The Social Performance and Distributional Consequences of Contract Farming: An Equilibrium Analysis of the Arachide de bouche Program in Senegal," *World Development* 30(2): 255-263.

Watts, Michael J. (1994), "Life under Contract: Contract Farming, Agrarian Restructuring, and Flexible Accumulation," in Peter D. Little and Michael J. Watts, *Living under Contract: Contract Farming and Agrarian Transformation in Sub-Saharan Africa*, Madison, WI: University of Wisconsin Press.

Wooldridge, Jeffrey M. (2002), *Econometric Analysis of Cross Section and Panel Data*, Cambridge, MA: MIT Press.

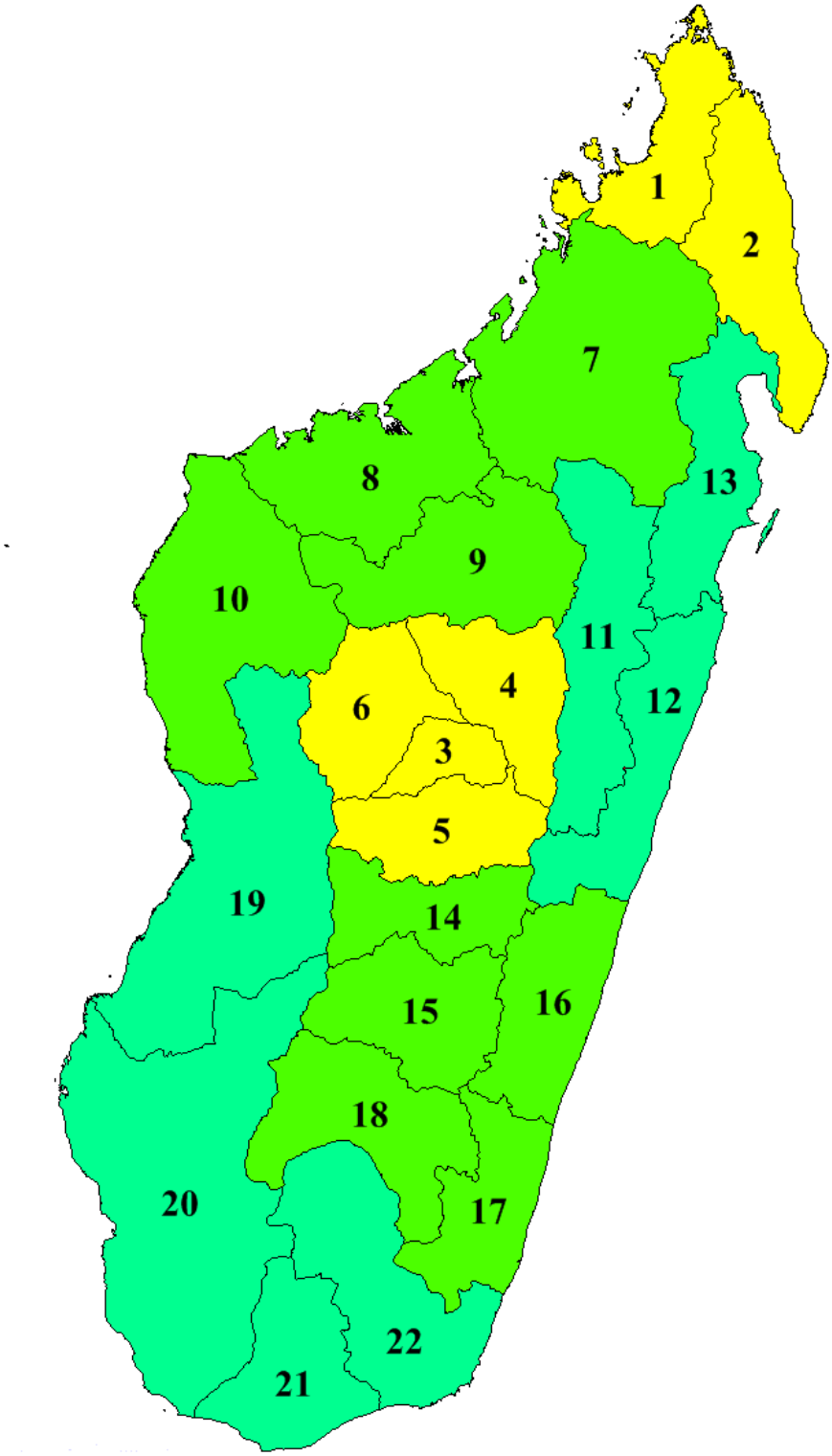

Figure 1. Map of Madagascar. Numbers Denote Regions and Colors Denote Provinces. (Source: Per Johansson/Wikimedia Commons.)

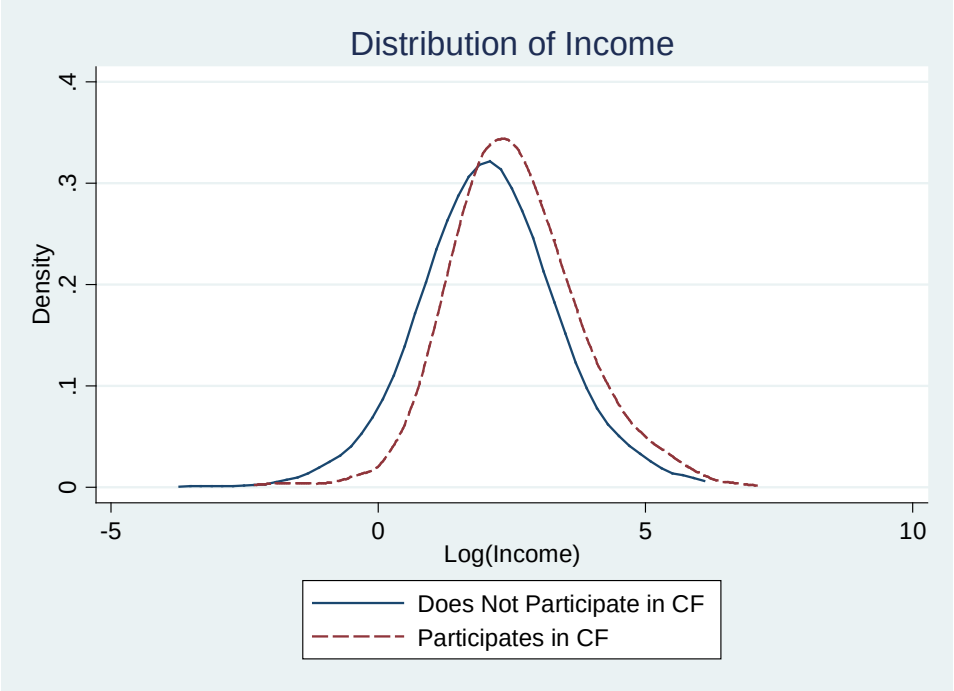

Figure 2. Kernel Density Estimation of Household Income by Participation Regime with Epanechnikov Kernel and Bandwidth Set Equal to 0.5.

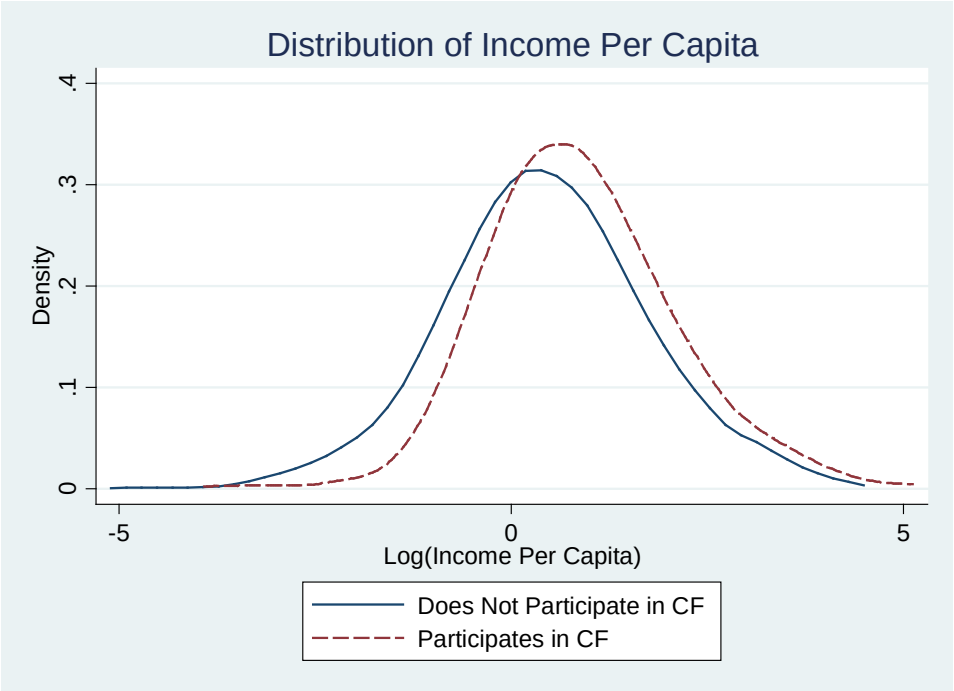

Figure 3. Kernel Density Estimation of Household Income Per Capita by Participation Regime with Epanechnikov Kernel and Bandwidth Set Equal to 0.5.

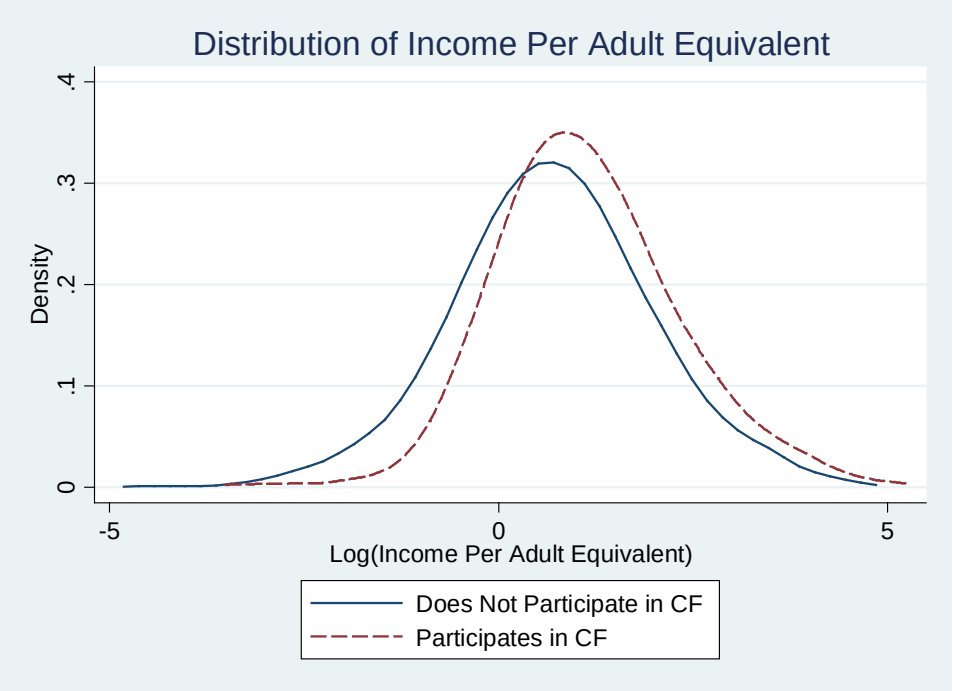

Figure 4. Kernel Density Estimation of Household Income Per Adult Equivalent by Participation Regime with Epanechnikov Kernel and Bandwidth Set Equal to 0.5.

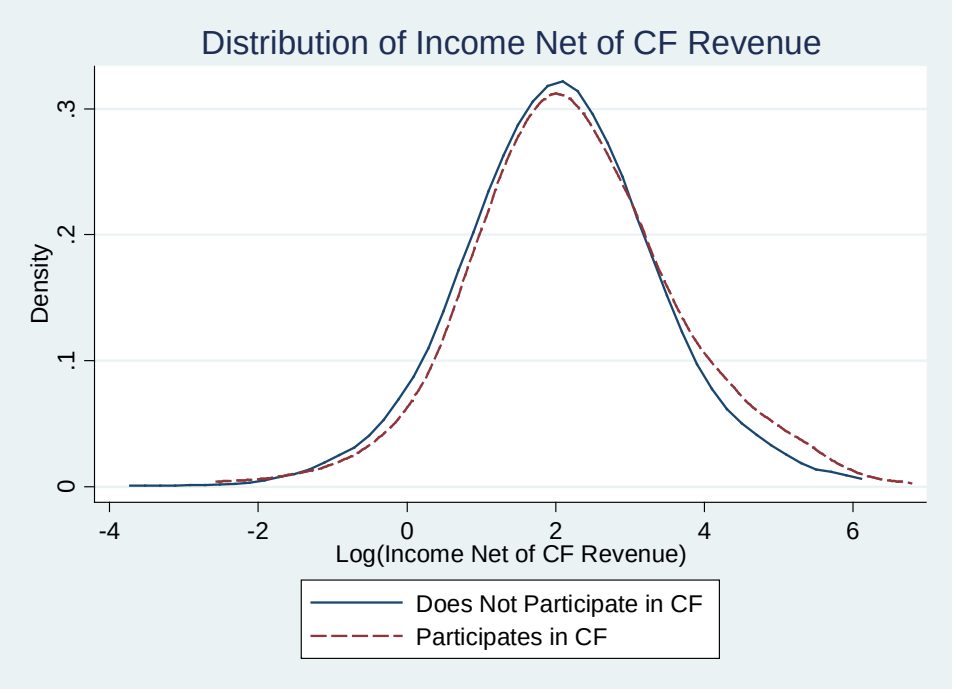

Figure 5. Kernel Density Estimation of Household Income Net of Contract Farming Revenue by Participation Regime with Epanechnikov Kernel and Bandwidth Set Equal to 0.5.

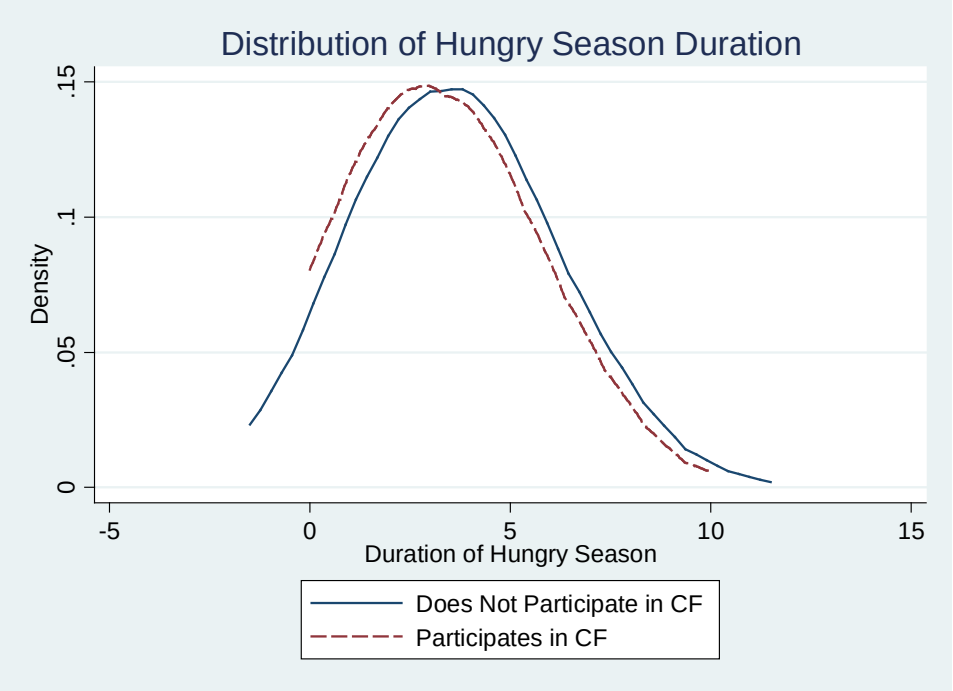

Figure 6. Kernel Density Estimation of Hungry Season Duration by Participation Regime with Epanechnikov Kernel and Bandwidth Set Equal to 0.5.

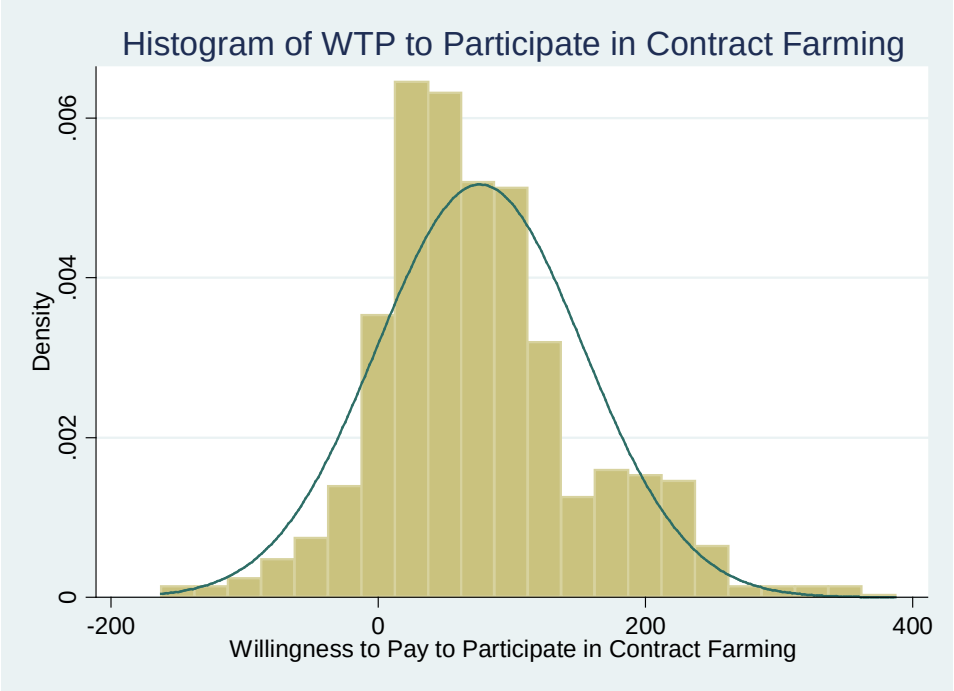

Figure 7. Histogram of Estimated WTP to Participate in Contract Farming (Excluding Income as a Conditioning Variable) Overlaid with Normal Distribution.

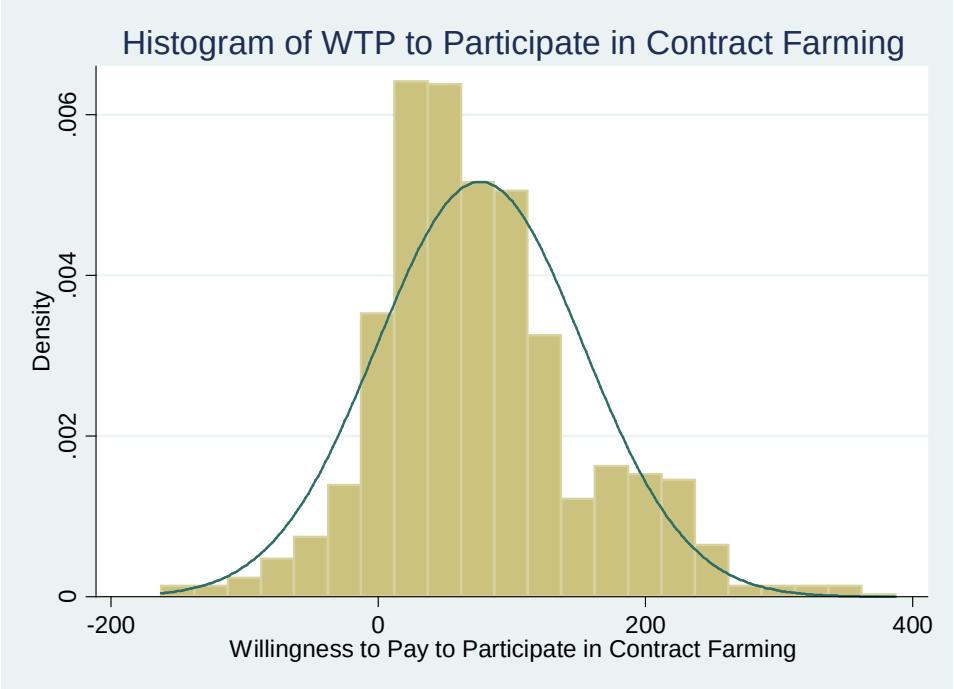

Figure 8. Histogram of Estimated WTP to Participate in Contract Farming (Including Income as a Conditioning Variable) Overlaid with Normal Distribution.

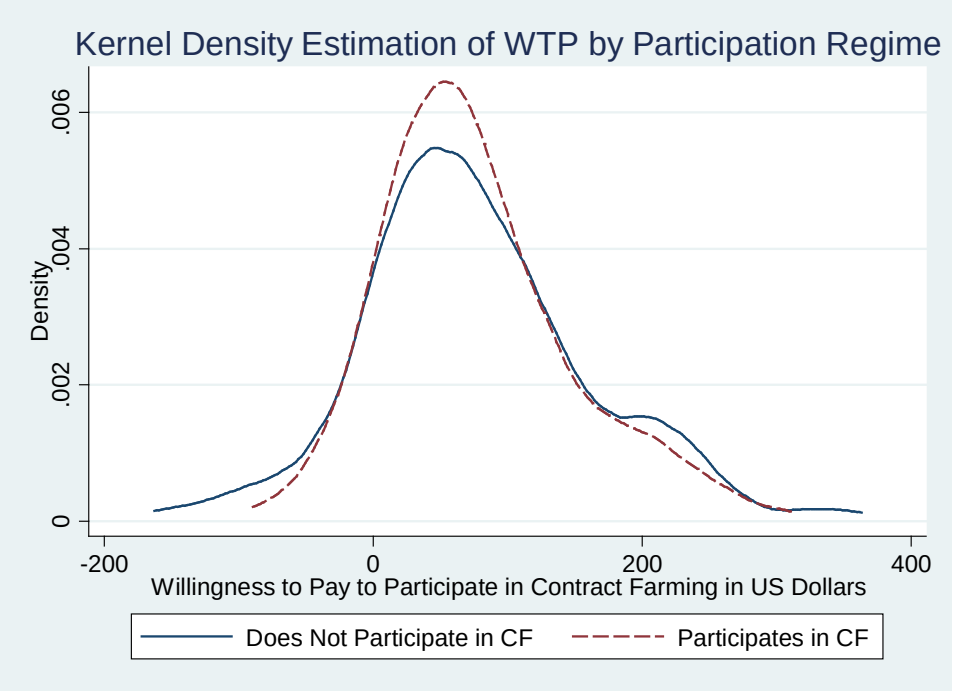

Figure 9. Kernel Density Estimation of Estimated WTP by Participation Regime (Excluding Income as a Conditioning Variable) with Epanechnikov Kernel and Bandwidth Set Equal to 25.

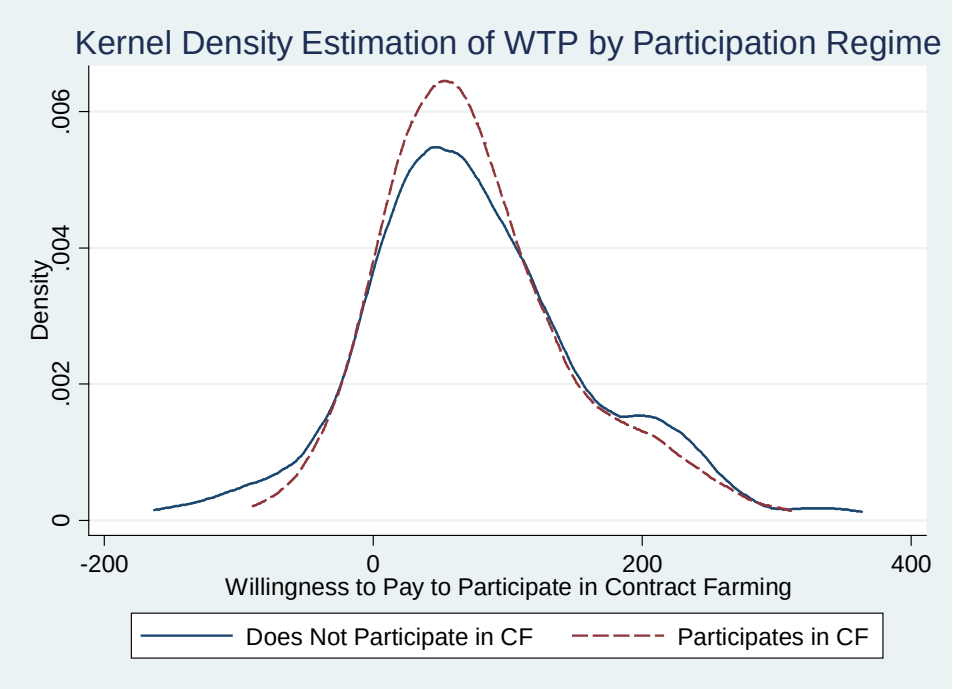

Figure 10. Kernel Density Estimation of Estimated WTP by Participation Regime (Including Income as a Conditioning Variable) with Epanechnikov Kernel and Bandwidth Set Equal to 25.

Table 1. Regions, Communes, and Crops

		Main Crops under Contract	
Region	**Commune**	**Primary**	**Secondary**
Alaotra Mangoro (11)	Bejofo	Rice	-
	Feramanga North	Rice	Tomatoes
Analamanga (4)	Amboasary North	Rice	-
	Mangamila	Rice	Cassava
Anosy (22)	Ebelo	Rice	Cassava
	Andranobory	Maize	-
Diana (1)	Ambodibonara	Cotton	Sugarcane
	Anketrakabe	Rice	-
Itasy (3)	Miarinarivo I	Green Beans	Leeks
	Soavinandriana	Green Beans	Leeks
Vakinankaratra (5)	Morarano	Rice	Potatoes
	Betafo	Barley	Onions

Note: Numbers between parentheses in the first column refer to the region numbers on the map in figure 1.

Table 2. Descriptive Statistics (n=1178)

Variable	Mean	(Std. Err.)
Contract Farming Participant Dummy	0.498	(0.016)
Household Demographic Characteristics		
Household Size (Individuals)	5.571	(0.075)
Dependency Ratio	0.449	(0.008)
Household Head Characteristics		
Female Dummy	0.088	(0.010)
Single Dummy	0.124	(0.011)
Migrant Dummy	0.125	(0.011)
Age (Years)	43.274	(0.431)
Education (Completed Years)	5.682	(0.106)
Agricultural Experience (Years)	20.621	(0.433)
Member of Peasant Organization Dummy	0.222	(0.014)
Forbidden Agricultural Work Days	22.204	(1.105)
Household Welfare and Financial Characteristics		
Income (100,000 Ariary)	19.531	(1.506)
Income Per Capita (100,000 Ariary)	3.765	(0.238)
Income Per Adult Equivalent (100,000 Ariary)	4.665	(0.278)
Income Net of Contract Farming (100,000 Ariary)	17.359	(1.257)
Duration of Hungry Season (Months)	3.507	(0.076)
Obtained Formal Loan Dummy	0.121	(0.010)
Working Capital (100,000 Ariary)	4.440	(0.522)
Household Assets (100,000 Ariary)	13.965	(0.876)
Household Landholdings		
Total Landholdings (Ares)	145.569	(10.138)
Willingness to Pay for Contract Farming in US Dollars		
Parametric WTP (Excluding Income as a Covariate)	76.35	(2.250)
Parametric WTP (Including Income as a Covariate)	76.35	(2.250)

Note: See section 3 for a discussion of how the WTP measures were estimated.

Table 3. Descriptive Statistics by Participation Regime (n=1178)

	Does Not Participate in Contract Farming		Participates in Contract Farming		
Variable	**Mean**	**(Std. Err.)**	**Mean**	**(Std. Err.)**	**Difference**
Household Demographic Characteristics					
Household Size	5.452	(0.108)	5.692	(0.104)	**
Dependency Ratio	0.452	(0.012)	0.446	(0.010)	
Female	0.119	(0.016)	0.057	(0.011)	***
Single	0.158	(0.017)	0.089	(0.014)	***
Migrant	0.124	(0.015)	0.125	(0.015)	
Age	44.428	(0.652)	42.110	(0.554)	***
Education	5.650	(0.154)	5.715	(0.147)	
Agricultural Experience	21.074	(0.653)	20.165	(0.566)	
Peasant Organization	0.149	(0.017)	0.296	(0.022)	***
Forbidden Days	23.968	(1.684)	20.427	(1.424)	*
Household Welfare and Financial Characteristics					
Total Income	14.843	(1.198)	24.255	(2.762)	***
Income Per Capita	3.072	(0.239)	4.463	(0.413)	***
Income Per AE	3.802	(0.294)	5.535	(0.471)	***
Income Net of CF	14.816	(1.197)	19.922	(2.216)	***
Duration of Hungry Season	3.696	(0.109)	3.316	(0.105)	***
Obtained Formal Loan	0.074	(0.011)	0.168	(0.017)	***
Working Capital	2.872	(0.380)	6.021	(0.973)	***
Assets	11.672	(1.099)	16.277	(1.359)	***
Household Landholdings					
Total Landholdings	113.438	(8.982)	177.956	(18.146)	***
WTP for Contract Farming					
WTP (Excluding Income)	76.700	(3.447)	75.992	(2.873)	
WTP (Including Income)	76.696	(3.447)	75.986	(2.872)	

Note: The acronyms AE and CF are short for "adult equivalent" and "contract farming", respectively. For each row, the last column presents the results of a *t*-test of the null hypothesis that the means are equal in both samples. The symbols ***, **, and * respectively denote a difference in means that is significant at the 1, 5, and 10 percent levels.

Table 4. Probit Estimation Results for the Contingent Valuation Question

Variable	(1) Coefficient		(Std. Err.)	(2) Coefficient		(Std. Err.)
	Exluding Income as Covariate			Including Income as Covariate		
Dependent Variable: = 1 if Accepts Contract; = 0 Otherwise.						
Household Size	0.078	***	(0.023)	0.078	***	(0.023)
Dependency Ratio	-0.580	**	(0.232)	-0.580	**	(0.232)
Single	-0.030		(0.201)	-0.030		(0.201)
Female	-0.143		(0.239)	-0.143		(0.239)
Migrant	0.116		(0.152)	0.115		(0.152)
Age	-0.012	*	(0.006)	-0.012	*	(0.006)
Education	-0.002		(0.016)	-0.002		(0.016)
Experience	-0.002		(0.006)	-0.002		(0.006)
Member of Peasant Organization	0.067		(0.121)	0.067		(0.121)
Fady Days	0.007	***	(0.002)	0.007	***	(0.002)
Income				0.000		(0.001)
Working Capital	-0.002		(0.002)	-0.002		(0.003)
Assets	-0.002		(0.002)	-0.002		(0.002)
Landholdings	0.000		(0.000)	0.000		(0.000)
Random Bid (US Dollars)	-0.006	***	(0.002)	-0.006	**	(0.002)
Intercept	1.480	***	(0.299)	1.480	***	(0.299)
Number of Observations	1178			1178		
Region Fixed Effects	Yes			Yes		
p-value (Joint Significance, All Coefficients)	0.000			0.000		
Pseudo *R*-square	0.096			0.096		

Note: Estimation results are probability-weighted. The symbols ***, **, and * respectively denote significance at the 1, 5, and 10 percent levels.

Table 5. Treatment Regression and OLS Estimation Results for Household Income

	(1)			(2)			(3)		
Variable	**Coefficient**		**(Std. Err.)**	**Coefficient**		**(Std. Err.)**	**Coefficient**		**(Std. Err.)**
	Treatment Regression						**OLS**		
	Dependent Variable: = 1 if Participates in Contract Farming; = 0 Otherwise			**Dependent Variable: Log of Household Income**			**Dependent Variable: Log of Household Income**		
Household Size	-0.010		(0.031)	0.046	***	(0.016)	0.054	***	(0.015)
Dependency Ratio	0.142		(0.277)	-0.095		(0.162)	-0.146		(0.148)
Single	0.098		(0.208)	-0.159		(0.144)	-0.150		(0.140)
Female	-0.395		(0.242)	-0.229		(0.176)	-0.338	**	(0.163)
Migrant	0.026		(0.135)	0.008		(0.103)	0.026		(0.096)
Age	-0.014	*	(0.008)	0.010	**	(0.005)	0.004		(0.004)
Education	-0.004		(0.015)	0.069	***	(0.010)	0.068	***	(0.010)
Experience	0.012	*	(0.007)	-0.004		(0.004)	-0.001		(0.004)
Member of Peasant Organization	0.494	***	(0.112)	0.034		(0.103)	0.174	**	(0.072)
Forbidden Agricultural Work Days	-0.006	***	(0.002)	0.001		(0.001)	0.001		(0.001)
Working Capital	0.006		(0.005)	0.007	***	(0.002)	0.007	***	(0.002)
Assets	0.002		(0.003)	0.007	***	(0.002)	0.007	***	(0.002)
Landholdings	0.001	**	(0.000)	0.000		(0.000)	0.000	*	(0.000)
Contract Farming				1.019	***	(0.343)	0.362	***	(0.061)
WTP for Contract Farming	0.004	**	(0.002)						
Intercept	0.027		(0.368)	0.283		(0.307)	0.773	***	(0.175)
Number of Observations	1178						1178		
Region Fixed Effects	Yes						Yes		
Log Pseudo-Likelihood	-1100.957						-		
p-value (Joint Significance, All Coefficients)	0.000						0.000		
p-value (Test of Independent Equations)	0.068						-		
R-square	-						0.514		

Note: Estimation results are probability-weighted. The symbols ***, **, and * respectively denote significance at the 1, 5, and 10 percent levels. Results in the first column are marginal effects.

Table 6. Treatment Regression and OLS Estimation Results for Household Income Per Capita

	(1)			(2)			(3)		
Variable	**Coefficient**		**(Std. Err.)**	**Coefficient**		**(Std. Err.)**	**Coefficient**		**(Std. Err.)**
	Treatment Regression						**OLS**		
	Dependent Variable: = 1 if Participates in Contract Farming; = 0 Otherwise			**Dependent Variable: Log of Household Income Per Capita**			**Dependent Variable: Log of Household Income Per Capita**		
Household Size	-0.009		(0.031)	-0.133	***	(0.016)	-0.126	***	(0.015)
Dependency Ratio	0.131		(0.277)	-0.306	*	(0.163)	-0.350	**	(0.151)
Single	0.089		(0.210)	0.052		(0.150)	0.060		(0.147)
Female	-0.390		(0.244)	-0.384	**	(0.181)	-0.476	***	(0.167)
Migrant	0.023		(0.135)	0.017		(0.101)	0.033		(0.095)
Age	-0.014	*	(0.008)	0.009	*	(0.005)	0.005		(0.004)
Education	-0.004		(0.015)	0.071	***	(0.010)	0.070	***	(0.010)
Experience	0.013	*	(0.007)	-0.003		(0.004)	-0.001		(0.004)
Member of Peasant Organization	0.496	***	(0.112)	0.054		(0.102)	0.172	**	(0.070)
Forbidden Agricultural Work Days	-0.006	***	(0.002)	0.001		(0.001)	0.001		(0.001)
Working Capital	0.006		(0.004)	0.007	***	(0.002)	0.008	***	(0.002)
Assets	0.002		(0.003)	0.006	***	(0.002)	0.007	***	(0.002)
Landholdings	0.001	**	(0.000)	0.000		(0.000)	0.000	*	(0.000)
Contract Farming				0.907	***	(0.353)	0.349	***	(0.061)
WTP for Contract Farming	0.004	**	(0.002)						
Intercept	0.041		(0.369)	-0.208		(0.313)	0.209		(0.177)
Number of Observations	1178						1178		
Region Fixed Effects	Yes						Yes		
Log Pseudo-Likelihood	-1100.987						-		
p-value (Joint Significance, All Coefficients)	0.000						0.000		
p-value (Test of Independent Equations)	0.128						-		
R-square	-						0.511		

Note: Estimation results are probability-weighted. The symbols ***, **, and * respectively denote significance at the 1, 5, and 10 percent levels. Results in the first column are marginal effects.

Table 7. Treatment Regression and OLS Estimation Results for Income Per Adult Equivalent

	(1)			(2)			(3)		
Variable	**Coefficient**		**(Std. Err.)**	**Coefficient**		**(Std. Err.)**	**Coefficient**		**(Std. Err.)**
	Treatment Regression						**OLS**		
	Dependent Variable: = 1 if Participates in Contract Farming; = 0 Otherwise			**Dependent Variable: Log of Household Income Per Adult Equivalent**			**Dependent Variable: Log of Household Income Per Adult Equivalent**		
Household Size	-0.009		(0.031)	-0.126	***	(0.016)	-0.120	***	(0.015)
Dependency Ratio	0.133		(0.277)	0.232		(0.159)	0.189		(0.148)
Single	0.090		(0.210)	0.053		(0.149)	0.061		(0.147)
Female	-0.391		(0.244)	-0.374	**	(0.180)	-0.466	***	(0.167)
Migrant	0.024		(0.135)	0.023		(0.101)	0.039		(0.095)
Age	-0.014	*	(0.008)	0.008		(0.005)	0.003		(0.004)
Education	-0.004		(0.015)	0.071	***	(0.010)	0.070	***	(0.010)
Experience	0.013	*	(0.007)	-0.003		(0.004)	-0.001		(0.004)
Member of Peasant Organization	0.497	***	(0.112)	0.060		(0.101)	0.177	**	(0.070)
Forbidden Agricultural Work Days	-0.006	***	(0.002)	0.001		(0.001)	0.000		(0.001)
Working Capital	0.006		(0.004)	0.007	***	(0.002)	0.008	***	(0.002)
Assets	0.002		(0.003)	0.006	***	(0.002)	0.007	***	(0.002)
Landholdings	0.001	**	(0.000)	0.000		(0.000)	0.000	*	(0.000)
Contract Farming				0.903	***	(0.350)	0.351	***	(0.061)
WTP for Contract Farming	0.004	**	(0.002)						
Intercept	0.041		(0.370)	-0.170		(0.310)	0.243		(0.176)
Number of Observations	1178						1178		
Region Fixed Effects	Yes						Yes		
Log Pseudo-Likelihood	-1100.259						-		
p-value (Joint Significance, All Coefficients)	0.000						0.000		
p-value (Test of Independent Equations)	0.129						-		
R-square	-						0.493		

Note: Estimation results are probability-weighted. The symbols ***, **, and * respectively denote significance at the 1, 5, and 10 percent levels. Results in the first column are marginal effects.

Table 8. Treatment Regression and OLS Estimation Results for Household Income Net of Contract Farming Revenue

	(1)			(2)			(3)		
Variable	**Coefficient**		**(Std. Err.)**	**Coefficient**		**(Std. Err.)**	**Coefficient**		**(Std. Err.)**
	Treatment Regression						**OLS**		
	Dependent Variable: = 1 if Participates in Contract Farming; = 0 Otherwise			**Dependent Variable: Log of Income Net of Contract Farming Revenue**			**Dependent Variable: Log of Income Net of Contract Farming Revenue**		
Household Size	-0.011		(0.031)	0.056	***	(0.018)	0.067	***	(0.016)
Dependency Ratio	0.146		(0.274)	-0.045		(0.186)	-0.116		(0.160)
Single	0.123		(0.229)	-0.246		(0.201)	-0.234		(0.184)
Female	-0.420	*	(0.254)	-0.083		(0.235)	-0.232		(0.198)
Migrant	0.030		(0.135)	-0.004		(0.120)	0.021		(0.109)
Age	-0.014	*	(0.008)	0.013	*	(0.007)	0.006		(0.004)
Education	-0.004		(0.015)	0.075	***	(0.011)	0.074	***	(0.010)
Experience	0.012	*	(0.007)	-0.005		(0.005)	0.000		(0.004)
Member of Peasant Organization	0.489	***	(0.115)	-0.037		(0.142)	0.154	*	(0.083)
Forbidden Agricultural Work Days	-0.006	***	(0.002)	0.001		(0.001)	0.001		(0.001)
Working Capital	0.006		(0.004)	0.007	***	(0.002)	0.008	***	(0.002)
Assets	0.002		(0.003)	0.007	***	(0.002)	0.007	***	(0.002)
Landholdings	0.001	**	(0.000)	0.000		(0.000)	0.000	*	(0.000)
Contract Farming				0.880		(0.560)	-0.016		(0.069)
WTP for Contract Farming	0.004	**	(0.002)						
Intercept	0.041		(0.357)	-0.095		(0.486)	0.576	***	(0.203)
Number of Observations	1178						1178		
Region Fixed Effects	Yes						Yes		
Log Pseudo-Likelihood	-1158.073						-		
p-value (Joint Significance, All Coefficients)	0.000						0.000		
p-value (Test of Independent Equations)	0.132						-		
R-square	-						0.461		

Note: Estimation results are probability-weighted. The symbols ***, **, and * respectively denote significance at the 1, 5, and 10 percent levels. Results in the first column are marginal effects.

Table 9. Treatment Regression and OLS Estimation Results for Hungry Season Duration

Variable	(1) Coefficient		(Std. Err.)	(2) Coefficient		(Std. Err.)	(3) Coefficient		(Std. Err.)
	Treatment Regression						OLS		
	Dependent Variable: = 1 if Participates in Contract Farming; = 0 Otherwise			Dependent Variable: Duration of Household Hungry Season			Dependent Variable: Duration of Household Hungry Season		
Household Size	-0.014		(0.030)	0.074	**	(0.037)	0.050		(0.036)
Dependency Ratio	0.131		(0.270)	0.424		(0.397)	0.576		(0.365)
Single	0.088		(0.204)	-0.049		(0.368)	-0.078		(0.338)
Female	-0.414	*	(0.241)	0.399		(0.435)	0.723	*	(0.400)
Migrant	-0.011		(0.135)	0.086		(0.252)	0.033		(0.216)
Age	-0.014	*	(0.007)	0.008		(0.012)	0.024	**	(0.009)
Education	-0.004		(0.015)	-0.071	***	(0.025)	-0.069	***	(0.022)
Experience	0.013	**	(0.006)	-0.022	**	(0.011)	-0.032	***	(0.010)
Member of Peasant Organization	0.504	***	(0.111)	0.518	*	(0.266)	0.104		(0.185)
Fady Days	-0.006	***	(0.002)	-0.004		(0.003)	-0.003		(0.002)
Income	0.004	**	(0.002)	-0.004	**	(0.002)	-0.004	**	(0.002)
Working Capital	0.003		(0.003)	0.003		(0.003)	0.002		(0.003)
Assets	0.002		(0.003)	-0.012	***	(0.003)	-0.013	***	(0.003)
Landholdings	0.000	**	(0.000)	0.000		(0.000)	0.000		(0.000)
Contract Farming				-2.246	***	(0.734)	-0.294	**	(0.142)
WTP for Contract Farming	0.004	**	(0.002)						
Intercept	0.029		(0.351)	4.992	***	(0.713)	3.533	***	(0.433)
Number of Observations	1178						1178		
Region Fixed Effects	Yes						Yes		
Log Pseudo-Likelihood	-1583.265						-		
p-value (Joint Significance, All Coefficients)	0.000						0.000		
p-value (Test of Independent Equations)	0.009						-		
R-square	-						0.197		

Note: Estimation results are probability-weighted. The symbols ***, **, and * respectively denote significance at the 1, 5, and 10 percent levels.

Table 10. Treatment Regression and OLS Estimation Results for the Likelihood the Household Receives a Formal Loan

	(1)			(2)			(3)		
Variable	**Coefficient**		**(Std. Err.)**	**Coefficient**		**(Std. Err.)**	**Coefficient**		**(Std. Err.)**
	Treatment Regression						**OLS**		
	Dependent Variable: = 1 if Participates in Contract Farming; = 0 Otherwise			**Dependent Variable: = 1 if Household Received a Formal Loan; = 0 Otherwise**			**Dependent Variable: = 1 if Household Received a Formal Loan; = 0 Otherwise**		
Household Size	-0.035		(0.032)	0.000		(0.005)	0.003		(0.004)
Dependency Ratio	0.343		(0.282)	-0.018		(0.047)	-0.039		(0.041)
Single	0.113		(0.193)	-0.017		(0.041)	-0.013		(0.039)
Female	-0.360		(0.237)	0.033		(0.051)	-0.012		(0.045)
Migrant	0.010		(0.134)	0.003		(0.035)	0.010		(0.032)
Age	-0.008		(0.008)	0.004	**	(0.002)	0.002		(0.002)
Education	-0.008		(0.015)	0.014	***	(0.004)	0.014	***	(0.003)
Experience	0.011	*	(0.006)	-0.003	*	(0.002)	-0.002		(0.002)
Member of Peasant Organization	0.491	***	(0.112)	0.025		(0.029)	0.082	***	(0.028)
Fady Days	-0.009	***	(0.003)	0.000		(0.000)	0.000		(0.000)
Income	0.006	**	(0.002)	0.001		(0.001)	0.001		(0.001)
Working Capital	0.007		(0.005)	-0.002	**	(0.001)	-0.002	**	(0.001)
Assets	0.001		(0.003)	-0.001		(0.000)	0.000		(0.001)
Landholdings	0.000	**	(0.000)	0.000	***	(0.000)	0.000	***	(0.000)
Contract Farming				0.342	***	(0.055)	0.071	***	(0.019)
WTP for Contract Farming	0.006	***	(0.002)						
Intercept	-0.315		(0.394)	-0.336	***	(0.077)	-0.133	**	(0.058)
Number of Observations	1178						1178		
Region Fixed Effects	Yes						Yes		
Log Pseudo-Likelihood	-462.244						-		
p-value (Joint Significance of All Coefficients)	0.000						0.000		
p-value (Test of Independent Equations)	0.000						-		
R-square	-						0.24		

Note: Estimation results are probability-weighted. The symbols ***, **, and * respectively denote significance at the 1, 5, and 10 percent levels.

Table 11. Results of Tests of Group-Wise Heteroskedasticity (n=1178)

Null Hypothesis of Homoskedasticity (Equal Error Variance between Participation Regimes)	Test Result	Change in Volatility Due to Contract Farming
Total Income (Table 5)	Rejected	-0.160***
Total Income Per Capita (Table 6)	Rejected	-0.164***
Total Income Per Adult Equivalent (Table 7)	Rejected	-0.165***
Total Income Net of CF Revenue (Table 8)	Not Rejected	0.025

Note: The symbols ***, **, and * respectively denote significance at the 1, 5, and 10 percent levels. The acronym CF denotes contract farming. In each row, the squared residuals from each relevant regression in tables 6 and 7 were regressed on a constant and a dummy equal to one if a household participates in contract farming and equal to zero otherwise. The second column reports the result of a *t*-test of the null hypothesis of homoskedasticity, i.e., the null hypothesis that the coefficient on the contract farming dummy is equal to zero. A rejection of the null hypothesis indicates that the volatility of the dependent variable is different between participants and nonparticipants. The third column reports the percentage change in volatility due to contract farming as well as whether and at what level this change is significant.

Table 12a. Synthesis of Estimated ATEs of Contract Farming on Welfare Outcomes for Parametric and Nonparametric WTP Estimates

	(1) Parametric WTP			(2) Nonparametric WTP		
Variable	**ATE**		**(Std. Err.)**	**ATE**		**(Std. Err.)**
Income (US$)	117.056	***	(1.837)	119.233	***	(1.871)
Volatility of Income (Percent)	-0.159	***	(0.057)	-0.159	***	(0.057)
Income Per Capita (US$)	29.491	***	(1.627)	30.353	***	(1.674)
Volatility of Income Per Capita (Percent)	-0.164	***	(0.059)	-0.162	***	(0.058)
Income Per Adult Equivalent (US$)	40.773	***	(1.587)	42.415	***	(1.651)
Volatility of Income Per Adult Equivalent (Percent)	-0.165	***	(0.058)	-0.163	***	(0.058)
Income Net of CF Revenue (US$)	93.961		(1.669)	91.197		(1.620)
Volatility of Income Net of CF Revenue (Percent)	0.025		(0.061)	0.053		(0.128)
Duration of Hungry Season (Months)	-2.246	***	(0.734)	-1.988	**	(0.787)
Likelihood of Receiving a Formal Loan (Percent)	0.342	***	(0.055)	0.311	***	(0.063)

Note: The symbols ***, **, and * respectively denote significance at the 1, 5, and 10 percent levels. The acronym CF denotes contract farming. The results in column 2 are based off of the nonparametric lower-bound WTP estimate developed in section 3.3.

Table 12b. Synthesis of Estimated ATEs of Contract Farming on Income between Growth Areas and Regular Regions for Parametric and Nonparametric WTP Estimates

	(1) Regular Regions			(2) Growth Areas			(3) Significance of
Variable	**ATE**		**(Std. Err.)**	**ATE**		**(Std. Err.)**	**(1) - (2)**
				Parametric WTP			
Income (US$)	124.263	***	(2.612)	109.107	***	(2.533)	***
Income Per Capita (US$)	35.489	***	(2.306)	22.874	***	(2.258)	***
Income Per Adult Equivalent (US$)	46.696	***	(2.244)	34.238	***	(2.209)	***
				Nonparametric WTP			
Income (US$)	126.574	***	(2.660)	111.136	***	(2.581)	***
Income Per Capita (US$)	36.526	***	(2.373)	23.543	***	(2.324)	***
Income Per Adult Equivalent (US$)	48.578	***	(2.334)	35.617	***	(2.298)	***

Note: The symbols ***, **, and * respectively denote significance at the 1, 5, and 10 percent levels. The results in column 1 are for regions 3, 4, and 11 in figure 1. The results in column 2 are for regions 1, 5, and 22 in figure 1. The upper half of the table is based off of the parametric WTP estimate, and the lower half of the table is based off of the nonparametric lower bound WTP estimate developed in section 3.3.

Appendix

Table A1. Linear Probability Model Estimation Results of the Determinants of Negative WTP

Variable	Coefficient		(Std. Err.)	Coefficient		(Std. Err.)
	Exluding Income			Including Income		
	Dependent Variable: = 1 if WTP is Negative; = 0 Otherwise.					
Household Size	-0.049	***	(0.004)	-0.049	***	(0.004)
Dependency Ratio	0.422	***	(0.039)	0.422	***	(0.039)
Single	0.072	*	(0.042)	0.072	*	(0.042)
Female	0.098	*	(0.053)	0.098	*	(0.053)
Migrant	-0.042		(0.029)	-0.042		(0.029)
Age	0.012	***	(0.001)	0.012	*	(0.001)
Education	-0.002		(0.003)	-0.002		(0.003)
Experience	0.000		(0.001)	0.000		(0.001)
Member of Peasant Organization	-0.074	***	(0.018)	-0.074	***	(0.018)
Fady Days	-0.003	***	(0.000)	-0.003	***	(0.000)
Income				0.000		(0.000)
Working Capital	0.001		(0.001)	0.001		(0.001)
Assets	0.000		(0.001)	0.000		(0.001)
Landholdings	0.000		(0.000)	0.000		(0.000)
Intercept	-0.393	***	(0.043)	-0.393	***	(0.043)
Number of Observations	1178			1178		
Region Fixed Effects	Yes			Yes		
p-value (Joint Significance, All Coefficients)	0.000			0.000		
Pseudo *R*-square	0.465			0.465		

Note: Estimation results are probability-weighted. The symbols ***, **, and * respectively denote significance at the 1, 5, and 10 percent levels.

Table A2. Treatment Regression Estimation Results for Household Income Using Nonparametric WTP

	(1)			(2)		
Variable	**Coefficient**		**(Std. Err.)**	**Coefficient**		**(Std. Err.)**
	Treatment Regression					
	Dependent Variable: = 1 if Participates in Contract Farming; = 0 Otherwise			**Dependent Variable: Log of Income**		
Household Size	0.033		(0.021)	0.046	***	(0.016)
Dependency Ratio	-0.156		(0.212)	-0.093		(0.161)
Single	0.132		(0.205)	-0.159		(0.144)
Female	-0.491	**	(0.238)	-0.226		(0.174)
Migrant	0.087		(0.140)	0.008		(0.103)
Age	-0.020	***	(0.007)	0.010	**	(0.005)
Education	-0.007		(0.015)	0.069	***	(0.010)
Experience	0.011	*	(0.007)	-0.004		(0.004)
Member of Peasant Organization	0.518	***	(0.108)	0.030		(0.094)
Fady Days	-0.002		(0.002)	0.001		(0.001)
Working Capital	0.006		(0.005)	0.007	***	(0.002)
Assets	0.001		(0.003)	0.007	***	(0.002)
Landholdings	0.001	**	(0.000)	0.000		(0.000)
Contract Farming				1.038	***	(0.305)
WTP for Contract Farming	0.008	***	(0.002)			
Intercept	0.370		(0.267)	0.268		(0.281)
Number of Observations	1178					
Region Fixed Effects	Yes					
Log Pseudo-Likelihood	-1096.159					
p-value (Joint Significance of All Coefficients)	0.000					
p-value (Test of Independent Equations)	0.033					
R-square	-					

Note: The symbols ***, **, and * respectively denote significance at the 1, 5, and 10 percent levels. Results in the first column are marginal effects.

Table A3. Treatment Regression Estimation Results for Household Income Per Capita Using Nonparametric WTP

	(1)			(2)		
Variable	**Coefficient**		**(Std. Err.)**	**Coefficient**		**(Std. Err.)**
	Treatment Regression					
	Dependent Variable: = 1 if Participates in Contract Farming; = 0 Otherwise			**Dependent Variable: Log of Income Per Capita**		
Household Size	0.033		(0.021)	-0.133	***	(0.016)
Dependency Ratio	-0.161		(0.214)	-0.304	*	(0.162)
Single	0.122		(0.207)	0.052		(0.151)
Female	-0.485	**	(0.240)	-0.379	**	(0.180)
Migrant	0.083		(0.140)	0.016		(0.101)
Age	-0.020	***	(0.007)	0.009	**	(0.005)
Education	-0.006		(0.015)	0.071	***	(0.010)
Experience	0.011	*	(0.007)	-0.003		(0.004)
Member of Peasant Organization	0.518	***	(0.109)	0.048		(0.094)
Fady Days	-0.002		(0.002)	0.001		(0.001)
Working Capital	0.006		(0.005)	0.007	***	(0.002)
Assets	0.001		(0.003)	0.006	***	(0.002)
Landholdings	0.001	**	(0.000)	0.000		(0.000)
Contract Farming				0.933	***	(0.331)
WTP for Contract Farming	0.008	***	(0.002)			
Intercept	0.373		(0.268)	-0.228		(0.297)
Number of Observations	1178					
Region Fixed Effects	Yes					
Log Pseudo-Likelihood	-1095.322					
p-value (Joint Significance of All Coefficients)	0.000					
p-value (Test of Independent Equations)	0.086					
R-square	-					

Note: The symbols ***, **, and * respectively denote significance at the 1, 5, and 10 percent levels. Results in the first column are marginal effects.

Table A4. Treatment Regression Estimation Results for Household Income Per Adult Equivalent Using Nonparametric WTP

	(1)			(2)		
Variable	**Coefficient**		**(Std. Err.)**	**Coefficient**		**(Std. Err.)**
	Treatment Regression					
	Dependent Variable: = 1 if Participates in Contract Farming; = 0 Otherwise			**Dependent Variable: Log of Income Per Adult Equivalent**		
Household Size	0.033		(0.021)	-0.127	***	(0.016)
Dependency Ratio	-0.158		(0.213)	0.235		(0.159)
Single	0.122		(0.207)	0.053		(0.150)
Female	-0.485	**	(0.240)	-0.368	**	(0.179)
Migrant	0.083		(0.140)	0.022		(0.101)
Age	-0.020	***	(0.007)	0.008	*	(0.005)
Education	-0.006		(0.015)	0.071	***	(0.010)
Experience	0.011	*	(0.007)	-0.004		(0.004)
Member of Peasant Organization	0.519	***	(0.109)	0.052		(0.093)
Fady Days	-0.002		(0.002)	0.001		(0.001)
Working Capital	0.006		(0.005)	0.007	***	(0.002)
Assets	0.001		(0.003)	0.006	***	(0.002)
Landholdings	0.001	**	(0.000)	0.000		(0.000)
Contract Farming				0.940	***	(0.323)
WTP for Contract Farming	0.008	***	(0.002)			
Intercept	0.370		(0.268)	-0.197		(0.291)
Number of Observations	1178					
Region Fixed Effects	Yes					
Log Pseudo-Likelihood	-1094.555					
p-value (Joint Significance of All Coefficients)	0.000					
p-value (Test of Independent Equations)	0.077					
R-square	-					

Note: The symbols ***, **, and * respectively denote significance at the 1, 5, and 10 percent levels. Results in the first column are marginal effects.

Table A4. Treatment Regression Estimation Results for Household Income Net of CF Revenue Using Nonparametric WTP

	(1)			(2)		
Variable	**Coefficient**		**(Std. Err.)**	**Coefficient**		**(Std. Err.)**
	Treatment Regression					
	Dependent Variable: = 1 if Participates in Contract Farming; = 0 Otherwise			**Dependent Variable: Log of Income Net of Contract Farming Revenue**		
Household Size	0.031		(0.021)	0.057	***	(0.018)
Dependency Ratio	-0.152		(0.211)	-0.047		(0.183)
Single	0.153		(0.224)	-0.246		(0.200)
Female	-0.512	**	(0.251)	-0.088		(0.231)
Migrant	0.087		(0.141)	-0.003		(0.120)
Age	-0.020	***	(0.007)	0.013		(0.006)
Education	-0.007		(0.015)	0.075	***	(0.011)
Experience	0.011	*	(0.007)	-0.005		(0.005)
Member of Peasant Organization	0.512	***	(0.111)	-0.031		(0.133)
Fady Days	-0.002		(0.002)	0.001		(0.001)
Working Capital	0.006		(0.005)	0.007	***	(0.002)
Assets	0.001		(0.003)	0.007	***	(0.002)
Landholdings	0.001	**	(0.000)	0.000		(0.000)
Contract Farming				0.854		(0.521)
WTP for Contract Farming	0.007	***	(0.002)			
Intercept	0.391		(0.271)	-0.075		(0.454)
Number of Observations	1178					
Region Fixed Effects	Yes					
Log Pseudo-Likelihood	-1152.29					
p-value (Joint Significance of All Coefficients)	0.000					
p-value (Test of Independent Equations)	0.113					
R-square	-					

Note: The symbols ***, **, and * respectively denote significance at the 1, 5, and 10 percent levels. Results in the first column are marginal effects.

Table A5. Treatment Regression Estimation Results for Hungry Season Duration Using Nonparametric WTP

Variable	(1) Coefficient		(Std. Err.)	(2) Coefficient		(Std. Err.)
	Treatment Regression					
	Dependent Variable: = 1 if Participates in Contract Farming; = 0 Otherwise			Dependent Variable: Duration of Household Hungry Season		
Household Size	0.029		(0.021)	0.071	**	(0.036)
Dependency Ratio	-0.158		(0.211)	0.444		(0.388)
Single	0.110		(0.203)	-0.053		(0.361)
Female	-0.500	**	(0.234)	0.442		(0.430)
Migrant	0.055		(0.140)	0.079		(0.246)
Age	-0.020	***	(0.006)	0.010		(0.011)
Education	-0.006		(0.015)	-0.071	***	(0.024)
Experience	0.012	*	(0.006)	-0.023	**	(0.010)
Member of Peasant Organization	0.531	***	(0.110)	0.463	*	(0.257)
Fady Days	-0.002		(0.002)	-0.004		(0.002)
Income	0.004	**	(0.002)	-0.004	**	(0.002)
Working Capital	0.003		(0.003)	0.003		(0.003)
Assets	0.001		(0.003)	-0.012	***	(0.003)
Landholdings	0.000	**	(0.000)	0.000		(0.000)
Contract Farming				-1.988	**	(0.787)
WTP for Contract Farming	0.007	***	(0.002)			
Intercept	0.372		(0.268)	4.799	***	(0.749)
Number of Observations	1178					
Region Fixed Effects	Yes					
Log Pseudo-Likelihood	-1577.522					
p-value (Joint Significance of All Coefficients)	0.000					
p-value (Test of Independent Equations)	0.037					
R-square	-					

Note: The symbols ***, **, and * respectively denote significance at the 1, 5, and 10 percent levels. Results in the first column are marginal effects.

Table A6. Treatment Regression Estimation Results for the Likelihood of Receiving a Formal Loan

	(1)			(2)		
Variable	**Coefficient**		**(Std. Err.)**	**Coefficient**		**(Std. Err.)**
	Treatment Regression					
	Dependent Variable: = 1 if Participates in Contract Farming; = 0 Otherwise			**Dependent Variable: = 1 if Household Received a Formal Loan; = 0 Otherwise**		
Household Size	0.031		(0.021)	0.000		(0.005)
Dependency Ratio	-0.128		(0.209)	-0.020		(0.046)
Single	0.121		(0.191)	-0.017		(0.041)
Female	-0.488	**	(0.228)	0.028		(0.050)
Migrant	0.098		(0.138)	0.003		(0.035)
Age	-0.018	***	(0.007)	0.004	**	(0.002)
Education	-0.010		(0.015)	0.014	***	(0.004)
Experience	0.010		(0.007)	-0.003	*	(0.002)
Member of Peasant Organization	0.536	***	(0.110)	0.032		(0.029)
Fady Days	-0.003	*	(0.002)	0.000		(0.000)
Income	0.005	**	(0.002)	0.001		(0.001)
Working Capital	0.005		(0.005)	-0.002	**	(0.001)
Assets	0.000		(0.002)	-0.001		(0.000)
Landholdings	0.000	*	(0.000)	0.000	***	(0.000)
Contract Farming				0.311	***	(0.063)
WTP for Contract Farming	0.007	***	(0.002)			
Intercept	0.339		(0.267)	-0.312	***	(0.079)
Number of Observations	1178					
Region Fixed Effects	Yes					
Log Pseudo-Likelihood	-456.922					
p-value (Joint Significance of All Coefficients)	0.000					
p-value (Test of Independent Equations)	0.000					
R-square	-					

Note: The symbols ***, **, and * respectively denote significance at the 1, 5, and 10 percent levels. Results in the first column are marginal effects.