Smallholder Participation in Contract Farming and Food Security*

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Abstract

Contract farming has frequently been shown to increase the income of participating households. Whether contract farming increases other aspects of household welfare, however, remains unclear. Using a 1,200-household data set from Madagascar and the results of a contingent valuation experiment aimed at eliciting respondent's willingness to pay to participate in contract farming, we show that for the average household, participating in contract farming (i) reduces the duration of the hungry season experienced by the household by about 10 days and (ii) increases the likelihood that the household's hungry season will end by almost 20 percent in any given month. Further, we find that these effects are even more pronounced for households with a larger number of children and for households with a larger number of female children, who often bear a disproportionate share of the burden of food insecurity.

Keywords: Contract Farming, Outgrower Schemes, Grower-Processor Contracts, Agricultural Value Chains, Food Security

JEL Classification Codes: L24, O13, O14, Q12

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1 Introduction

Although the benefits of economic specialization have been widely understood since the publication of Adam Smith's (1776, 1976) *Wealth of Nations* if not earlier, a persistent lack of specialization is the main factor enabling economic underdevelopment in most of the world's poorest countries. In those countries, whose economies remain largely agrarian, the transition from subsistence to commercial agriculture – from many nonspecialized smallholder farmers producing small quantities of several crops for home consumption to fewer specialized large farms producing large quantities of one or two cash crops – has so far proven elusive.

One of the first steps in the transition from subsistence to commercial agriculture is the emergence of an intermediate agribusiness sector between the agricultural and manufacturing sectors. The institution that is perhaps the most emblematical of such an agro-industrial sector is contract farming, the economic institution wherein a processing firm contracts the production of commercial crops out to smallholder farmers. In one of the earliest studies of contract farming in economics, Grosh (1994) noted that the institution can resolve several market failures that result from risk and uncertainty, imperfect factor markets, and reluctance to adopt new technology. Since then, contract farming has been studied in many countries and for many crops, and the institution is often hailed by policy makers as a tool for rural poverty alleviation.

But does participation in agricultural value chains really make people better off? Although there is an important literature exploring the effects of participation in contract farming on household income or some variant thereof (Porter and Phillips-Howard, 1997; Singh, 2002; Warning and Key, 2002; Simmons, 2005; Maertens and Swinnen, 2009; Minten et al., 2009; Miyata et al., 2009; Rao and Qaim, 2011; Barrett et al., 2012; Bellemare, 2012; Michelson, 2013; Narayanan, 2014),[1] we study whether participation in contract farming improves food security. This question is important for two reasons. First, because the hungry season coincides with those weeks and months before households get cash for their crops at harvest, it is not immediately obvious that the households involved in contract farming can or will save the extra income from contract farming (Dupas and Robinson,

[1] A notable exception is Dedehouanou et al. (2013), who look at the impact of contracting on the subjective well-being of farmers in Senegal.

2013), and there is value in knowing whether income gains translate into other gains.[2] Second, self-control problems are more common among the poor (Banerjee and Mullainathan, 2010), and so it is likewise not immediately obvious that the cash a household receives at harvest will necessarily be spent on necessities like food.

Using a sample of 1,200 households and more than ten contracted crops across six regions of Madagascar, we look at whether participation in contract farming appears to decrease the length of the hungry season – defined here as the period during which people eat fewer than three meals per day – experienced by households. Because a household's decision to participate in contract farming is likely to be jointly determined with the duration of the hungry season experienced by the same household, we use the results of a field experiment in which the household head's willingness to pay (WTP) to participate in a hypothetical contract farming arrangement that would increase the household's income by 10 percent was elicited. This WTP variable is used in an effort to identify the causal effect of contract farming on the duration of the hungry season in a selection-on-observables research design (Angrist and Pischke, 2009).

Our results first suggest that participation in contract farming decreases the duration of the hungry season by about ten days for the average household in our data. Moreover, our results suggest that participation in contract farming increases the likelihood that a household's hungry season will end at any given time by almost 20 percent. In addition, our findings indicate that the beneficial effects of participation in contract farming are more pronounced (i) the greater the number of children and (ii) the greater the number of female children in a participant household. This is important because children – especially girls – often bear a disproportionate share of the burden of longer hungry seasons given unequal intrahousehold allocations of food, calories, and nutrients. Longer hungry seasons can cause wasting, stunting, and a number of other health problems.

The rest of this paper is organized as follows. In section 2, we discuss our estimation and identification strategies. Section 3 presents the data and some descriptive statistics. In section 4, we present and discuss our empirical results. Section 5 concludes.

[2] The contracts we study in this paper take place during the main agricultural season in Madagascar. Consequently, it is always the case in the data that people get paid for their contracted crops immediately after the hungry season ends.

2 Empirical Framework

This section first presents the estimation strategy we use in order to study the impact of participation in contract farming on the duration of the hungry season experienced by the households in our data. Then, because the duration of the hungry season experienced by a household is endogenous to its participation in contract farming, we explain the details of the identification strategy we rely on in order to make a causal statement about the impact of participation in contract farming on the duration of the hungry season experienced by the households in our data.

2.1 Estimation Strategy

The core equation we estimate in this paper is

$$y_i = \alpha + \underline{\beta}\underline{x}_i + \gamma D_i + \epsilon_i, \tag{1}$$

where $y \geq 0$ is the duration of the hungry season experienced by household i in months, $\underline{x}$ is a vector of control variables,[3] D is a variable equal to one if household i participates in contract farming and equal to zero otherwise, and ϵ is an error term with mean zero.

We are primarily interested in the coefficient γ which, if D were exogenous to y, would be the average treatment effect (ATE) of participating in contract farming on the duration of the hungry season, or

$$\gamma = E(y_i|D_i = 1) - E(y_i|D_i = 0). \tag{2}$$

However, since D is endogenous to y because households participation in contract farming is not assigned at random, we estimate the following version of equation 1:

$$y_i = \alpha + \underline{\beta}\underline{x}_i + \gamma D_i + \underline{\delta}\,\underline{w} + \epsilon_i, \tag{3}$$

where $\underline{w}$ is a vector of dummy variables that capture our respondents' answers to an experimental question aimed at eliciting WTP to participate in a hypothetical contract farming agreement. Our claim is that this WTP proxies for each respondent's marginal utility of participating in contract farming, which in turn controls for a number of unobservable characteristics

[3] Underlines are used throughout this paper to denote vectors.

which explain selection into contract farming. We thus attempt to identify the ATE of participating in contract farming on the duration of the hungry season using the method of selection on observables, in which a coefficient is identified because the RHS variables (here, $\underline{x}$ and $\underline{w}$) account for selection into a given treatment (here, D).

2.2 Identification Strategy

As discussed, we rely on a selection-on-observables identification strategy in order to estimate the causal impact of participation in contract farming on the duration of the hungry season. This section first explains the experimental setup that we used to elicit WTP for contract farming. It then explains how WTP for contract farming purges the error term, ϵ, of its correlation with the variables on the RHS of equation 3.

2.2.1 Experimental Setup

The contingent valuation (CV) experiment used in this paper is the same as the experiment used in Bellemare (2012). Each respondent in our data was asked whether he would participate in a contract farming agreement that would raise his income by 10 percent in exchange for an investment of \$12.50, \$25.00, \$37.50, \$50, \$62.50, or \$75.00. The size of investment was determined at random by the throw of a die. So for each respondent, the data include a random dollar amount and a "Yes" or "No" answer to whether the respondent would participate in a contract farming agreement that would increase his income by 10 percent in exchange of an initial investment equal to the random dollar amount.

The vector $\underline{w}$ in equation 3 captures respondent answers to the CV experiment. For example, a respondent who rolls a five on the die throw would be asked whether he'd like to participate in a contract farming agreement that would raise his income by 10 percent, but would cost \$62.50. If he answered "Yes," his $\underline{w}$ vector would be equal to $(0, 0, 0, 0, 1, 0)$. A respondent who rolls a four on the die throw would be asked whether he'd like to participate in a contract farming agreement that would raise his income by 10 percent, but would cost \$50.00. If he answered "No," his $\underline{w}$ vector would be equal to $(0, 0, 0, 0, 0, 0)$. The identifying assumption thus made here is that a respondent's response to the contingent valuation question is correlated with his WTP to participate in contract farming, and so the vector $\underline{w}$ serves

as a proxy for a respondent's marginal utility from participating in contract farming.

2.2.2 Identification

How does a proxy for a respondent's marginal utility from participating in contract farming help identify the causal impact of participation in contract farming on the duration of the hungry season? Recall that there are three sources of statistical endogeneity:

1. Unobserved heterogeneity,
2. Reverse causality, and
3. Measurement error.

We look at each of these in turn in the remainder of this section.

Unobserved heterogeneity refers to the problem of omitted variables such as a respondent's preferences for risk and ambiguity, his entrepreneurial ability, his technical ability, and his preferences in general, all of which can compromise the identification the ATE if they happen to be correlated with any of the variables on the RHS of equation 1. In this application, a great deal of this unobserved heterogeneity can be captured by differences in a respondent's marginal utility for contract farming. Take for example a respondent who is price risk averse (Bellemare et al., 2013). Such a respondent might prefer to participate in contract farming because contract farming arrangements typically insure growers against price risk. Alternatively, a respondent who is very entrepreneurial might have little to no use for contract farming given that she has her own micro-enterprise. Such a respondent might prefer not to participate in contract farming because of the opportunity cost of time associated with being in a grower-processor contract. In all such cases where a respondent's marginal utility of participating in contract farming varies because of some omitted variable, the variation in WTP measure captures the variation in respondent marginal utility, which should largely obviate concerns about unobserved heterogeneity between respondents.

Reverse causality refers to the statistical endogeneity problem that arises from the fact that the dependent variable might cause the variable of interest. In this case, the expected welfare impacts one expects to derive from contract farming – including a shorter hungry season – might induce one

to participate in contract farming, which would compromise the identification of the ATE. This could definitely be a concern in our application given that people might enter contract farming arrangements in the hope that the additional income they derive from their participation in contract farming will go toward shortening the hungry season experienced by their household. It should be the case, however, that a respondent who participates in contract farming with the goal of shortening the hungry season experience of his household should have a higher marginal utility of participating in contract farming. Our WTP measure controls for this issue much the same as it did for other changes in preferences, which should obviate concerns about reverse causality.

Finally, measurement error refers to the statistical endogeneity problem that arises from there being measurement error in whether a household participates in contract farming. This is highly unlikely to be a problem in our application given that there is no obvious advantage or disadvantage to misreporting whether one participates in contract farming or not. In addition, the sample was choice-based, i.e., the survey team aimed for a sample in which half the respondents participated in contract farming and half did not, and the survey frame was established with village chiefs, who know who participated in contract farming and who did not. This sampling strategy thus served as a consistency check on whether people truly did participate in contract farming.

In sum, our identification strategy allows us to rule out a number of sources of bias which plague the identification of a causal effect in this context. Because we are dealing with observational data, however, it is impossible to rule out all sources of statistical endogeneity with certainty. As a result, we caution the reader against interpreting our estimate of γ as causal, although it can certainly be interpreted as suggestive that participation in contract farming decreases the duration of the hungry season experienced by grower households.

3 Data and Descriptive Statistics

The data were collected between July and December of 2008 for a study of contract farming that was commissioned by the Economic Development Board of Madagascar (EDBM) on behalf of the World Bank. The data include six regions, with two communes from each region. Three of these

regions were chosen because of the relatively high prevalence of contract farming; the other three regions were chosen because EDBM views them as high-priority "growth areas." Within each region, the two communes with the highest density of contract farming were surveyed. The data for the communes were available in the 2007 commune census data (Moser, 2008).

Within each of the 12 communes, two lists were generated: one list of all households that participated in contract farming, and a second list of all households that did not participate in contract farming. Then, 50 households were randomly selected from the list of households that participated in contract farming, and 50 were randomly selected from the list of households that did not participate in contract farming. Probability weights are used through out this paper to bring the estimation sample as close to a random sample of the population as possible.

For each household, data were collected at the household, plot, crop, and contract level. Table 1 contains a list of all variables used in this analysis along with a description of how each variable was constructed. Descriptive statistics for our sample are found in table 2. In the interest of brevity, we do not discuss each variable in turn, focusing instead on our dependent variable, our variable of interest, and our WTP measure; the interested reader can find a discussion of these descriptive statistics in Bellemare (2012). First, the average household in our sample experienced a hungry season that lasted 3.5 months. Second, approximately half of the surveyed households participate in contract farming. Lastly, table 2 displays the results of the contingent evaluation experiment. This is a proxy for each respondent's WTP to enter into the hypothetical contract farming agreement described in the previous section. Though there is an unexpected increase in the proportion willing to invest US$25 versus US$12.50 that is purely due to chance, the proportion of farmers willing to invest monotonically decreases as the size of the necessary hypothetical investment increases for the remainder of the hypothetical investment amounts.

4 Empirical Results

In this section we begin by presenting nonparametric evidence on the relationship between participation in contract farming and duration of the hungry season experienced by households. This nonparametric evidence does not account for the endogeneity of the decision to participate in contract farming.

Thus, we then present parametric evidence using a selection-on-observables methodology, as explained in section 2. We then consider treatment heterogeneity by looking at whether the number of children in the household is associated with different effects of contract farming, and we present the results of robustness checks. Finally, we discuss the limitations of our approach.

4.1 Nonparametric Evidence

We begin with nonparametric evidence on the relationship between contract farming and the duration of the hungry season in order to establish whether such a relationship exists. Kaplan-Meier estimates of the survival function are displayed in figure 1, which shows that contract farming participants exit the hungry season earlier than non-participants across the entire conditioning domain.

Similarly, figure 2 displays the Epanechnikov kernel density estimates of the distribution of the duration of the hungry season for households that engage in contract farming and households that do not. Again, the households that participate in contract farming experience a shorter hungry season, which once again appears to be true across the entire conditioning domain.

Together these figures suggest that there is a relationship between whether one participates in contract farming and the duration of the hungry season one's household experiences, though it is impossible to tell whether that relationship is more than mere correlation at this point. We investigate whether that relationship appears causal in the next section.

4.2 Parametric Evidence

We now estimate the relationship between participation in contract farming and the duration of the hungry season experienced by the household using the estimation and identification strategies presented in section 2. Specifically, we account for the endogenous choice to participate in contract farming by using a proxy variable for the respondent's marginal utility of participation in contract farming. We do so by using each respondent's responses to a contingent valuation question aimed at eliciting respondent WTP to participate in contract farming.

Tables 3 and 4 present the ordinary least squares (OLS), Cox proportional hazards ("Cox" in the empirical results), and survival time regression

("Survival" in the empirical results) estimates of the duration of the hungry season experienced by the household using all control variables and the sampling weights discussed in section 3. The estimates in table 3 use the six vectors of WTP measurement to proxy for the respondent's marginal utility of participating in contract farming.

As a first robustness check, the estimates in table 4 use a nonparametric version of each respondent's WTP to participate in contract farming. That nonparametric WTP measure assigns as a lower bound on a respondent's WTP the precise dollar value of the random bid received by each respondent if the respondent said "Yes" to that bid, and which assigns a WTP of zero if the respondent said "No" to that bid. So for example, a respondent who would (not) agree to pay \$50 to participate in a hypothetical contract farming arrangement that would increase his household income by 10 percent is assigned a WTP of \$50 (\$0), since in each case, that is the lower bound on what we know to be that respondent's WTP.

The OLS estimates in table 3 show that households that participate in contract farming experience a hungry season that is 0.28 months (i.e., 8.5 days) shorter than households that do not participate in contract farming. The average household that does not participate in contract farming experiences a 3.8 month hungry season. This implies that contract farming decreases the average length of the hungry season by 7.3 percent. Additionally, we see that female-headed households have a longer hungry season, on average. These households experience a 0.73 month (i.e., 22-day) increase in the duration of the hungry season. This is an average increase of 19.3 percent in the duration of the hungry season. As expected, households with heads who are younger, more educated, and have more agricultural experience have a shorter hungry season. Finally, households that have higher income and more assets experience a shorter hungry season.

Note first that a negative sign in the OLS estimates indicates that the household experiences a shorter hungry season. A positive sign in the Cox proportional hazards models and survival time regressions indicates the household is more likely to exit the hungry season at any given time. The Cox proportional hazards and survival time regression estimates show that participation in contract farming increases the likelihood that the household's hungry season will end at any given time by 17 and 19 percent, respectively. Female headed households are more likely to remain in the hungry season at any given time, and households with a more educated head and those that are wealthier are more likely to exit the hungry season at any given time.

Our results are thus largely consistent across estimators.

Similarly, the results in table 4, which shows the results of the OLS, Cox proportional hazards model, and survival time regressions for the case where the nonparametric lower bound on WTP described above is used to control for selection into contract farming, are similar in sign, magnitude, and significance to those in table 3.

4.3 Treatment Heterogeneity

We now turn to possible treatment heterogeneity by the number and gender of children in the household. Tables 5 and 6 display the results of OLS, Cox proportional hazards models, and survival time regressions with interaction terms between participation in contract farming and the number and gender of children in the household.

The first column of table 5 suggests that participation in contract farming is especially effective in reducing the duration of the hungry season the more children there are in the household. For households that participate in contract farming, each additional child is associated with a 0.19-month (i.e., 5.8-day) reduction in the duration of the hungry season.

Likewise, in the second and third columns of table 5, the Cox proportional hazards model and survival time regression estimates show that for each additional child in the household, contract farming increases the probability of exiting the hungry season by 6 and 7 percent, respectively.

Table 6 goes a step further by showing how contract farming differentially affects households with different numbers of male and female children. Table 6 unbundles the results in table 5 and suggests that the result for children in table 5 is mainly driven by the effects on households with female children. That is, contract farming reduces the duration of the hungry season by 0.22 months for each additional girl, while the relationship is insignificant for the number of boys. Moreover, contract farming increases the likelihood of exiting the hungry season by 12 to 14 percent for each additional female child.

4.4 Robustness Checks

In this section, we scrutinize our core findings to determine whether our results are robust to two additional regression estimators. To do so, we estimate two additional versions of the OLS results in table 3: one estimating

a quantile (i.e., median) regression, and one estimating the robust regression specification suggested by Rousseeuw and Leroy (1987).

The quantile regression estimates indicate that for the average household, engaging in contract farming reduces the duration of the hungry season by 0.31 months, or 9.3 days. This is very close to the OLS estimate in table 3, and the quantile regression estimate in table 7 has a higher level of confidence. Consistent with the OLS regression results in table 3, the quantile regression results in table 7 show that households with a head who is younger, more educated, and has more agricultural experience have a shorter hungry season. Households with a higher income and more assets also experience a shorter hungry season. The one result that is not corroborated by the quantile regression estimates is that for female-headed households.

The Rousseeuw and Leroy (1987) robust regression estimates indicate that for the average household, engaging in contract farming reduces the duration of the hungry season by 0.26 months, or 7.7 days. Again, this is close to the OLS estimate in table 3 and again, this has a higher level of confidence than the OLS estimate. Consistent with the OLS results in table 3, the remainder of the second column in table 7 are practically identical to those in the first column.

4.5 Limitations

Lest nonexpert readers think our results are the definitive word on the relationship between participation in contract farming and food security, we wish to highlight two important limitations of our results.

First, while we have proxied for a very important source of endogeneity by using the responses to a contingent valuation question to estimate respondent WTP to participate in contract farming, any proxy variable is by definition imperfect. This is especially true in this case, where we only have partial information about each respondent's WTP, and where the best we can do is to assign a lower bound on each respondent's WTP. As such, our results are only an attempt at making a causal statement, and not a causal statement *per se*, about the relationship between participation in contract farming and food security.

Second, our dependent variable, which is itself a proxy for food insecurity, is far from ideal. Food insecurity is notoriously difficult to measure (Maxwell, 1996; Barrett, 2010), and different measures of food insecurity can paint different pictures (Maxwell et al., 2014). Ideally, more precise measures of

food insecurity such the average number of calories consumed by individuals in a household, the BMI of respondents, or weight-for-age z-score of their children would have been more accurate measures food insecurity.

5 Concluding Remarks

In this paper, we have looked at the relationship between contract farming and food security by looking at whether participating in contract farming led to decreases in the duration of the hungry season experienced by the household in our data.

Our results show that participating in contract farming reduces the duration of the hungry season by about 10 days for the average household. This is an important result because even though published research has shown that contract farming increases the income of participating farmers (Porter and Phillips-Howard, 1997; Singh, 2002; Warning and Key, 2002; Simmons, 2005; Maertens and Swinnen, 2009; Minten et al., 2009; Miyata et al., 2009; Rao and Qaim, 2011; Barrett et al., 2012; Bellemare, 2012; Michelson, 2013; Narayanan, 2014), there has so far been no attempt at studying whether contract farming leads to improvements in food security. Moreover, household with more children, in particular those households with female children, tend to benefit more from contract farming. This is an important result as children, particularly female children, bear the largest burden of food insecurity, the consequences of which include stunting, wasting, listlessness, and cognitive impairment.

From a behavioral perspective, our results suggest that smallholders in Madagascar save the additional income they receive from participating in contract farming in order to spend it on food in the months leading to the harvest. From a policy perspective, they suggest that policies that facilitate the development of agricultural value chains, beyond their direct effect on the incomes of those who participate as growers, can also have indirect effect on those same growers' food security.

References

[1] Angrist, Joshua D., and Jörn-Steffen Pischke (2009), *Mostly Harmless Econometrics*, Princeton: Princeton University Press.

[2] Banerjee, Abhijit V., and Sendhil Mullainathan (2010), "The Shape of Temptation: Implications for the Economic Lives of the Poor," NBER Working Paper.

[3] Barrett, Christopher B. (2010), "Measuring Food Insecurity," *Science* 327(12 February 2010): 825-828.

[4] Barrett, Christopher B., Maren Elise Bachke, Marc F. Bellemare, Hope C. Michelson, Sudha Narayanan, and Thomas F. Walker (2012), "Smallholder Participation in Contract Farming: Comparative Evidence from Five Countries," *World Development* 40(4): 715-730.

[5] Bellemare, Marc F. (2012), "As You Sow, So Shall You Reap: The Welfare Impacts of Contract Farming," *World Development* 40(7): 1418-1434.

[6] Bellemare, Marc F., Christopher B. Barrett, and David R. Just (2013), "The Welfare Impacts of Commodity Price Volatility: Evidence from Rural Ethiopia," *American Journal of Agricultural Economics* 95(4): 877-899.

[7] Dedehouanou, Senakpon F.A., Johan Swinnen, and Miet Maertens (2013), "Does Contracting Make Farmers Happy? Evidence from Senegal," *Review of Income and Wealth* 139(S1): S138-S160.

[8] Dupas, Pascaline, and Jonathan Robinson (2013), "Savings Constraints and Microenterprise Development: Evidence from a Field Experiment in Kenya," *American Economic Journal: Applied Economics* 5(1): 163-192.

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

[10] Lancaster, Tony (1992), *The Econometric Analysis of Transition Data*, Cambridge: Cambridge University Press.

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

[12] Maxwell, Daniel G. (1996), "Measuring Food Insecurity: The Frequency and Severity of 'Coping Strategies'," *Food Policy* 21(3): 291-303.

[13] Maxwell, Daniel G., Bapu Vaitla, and Jennifer Coates (2014), "How do Different Indicators of Household Food Security Compare?," *Food Policy* forthcoming.

[14] Michelson, Hope C. (2013), "Small Farmers, NGOs, and a Walmart World: Welfare Effects of Supermarkets Operating in Nicaragua," *American Journal of Agricultural Economics* 95(3): 628-649.

[15] 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.

[16] Miyata, Sachiko, Nicholas Minot, and Dinghuan Hu (2009), "Impact of Contract Farming on Income: Linking Small Farmers, Packers, and Supermarkets in China," *World Development* 37(11): 1781-1790.

[17] Naryananan, Sudha (2014), "Profits from Participation in High-Value Agriculture: Evidence of Heterogeneous Benefits in Contract Farming Schemes in Southern India," *Food Policy* 44: 142-157.

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

[19] Rao, Elizaphan J.O., and Matin Qaim (2011), "Supermarkets, farm household income, and poverty: Insights from Kenya," *World Development* 39(5): 784–796.

[20] Rousseeuw, Peter J., and Annick M. Leroy (1987), *Robust Regression and Outlier Detection*, New York: Wiley.

[21] 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.

[22] Singh, Sukhpal (2002), "Contracting Out Solutions: Political Economy of Contract Farming in the Indian Punjab," *World Development* 30(9): 1621–1638.

[23] Stephens, Emma C., and Christopher B. Barrett (2011), "Incomplete Credit Markets and Commodity Marketing Behavior," *Journal of Agricultural Economics* 62(1): 1-24.

[24] 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.

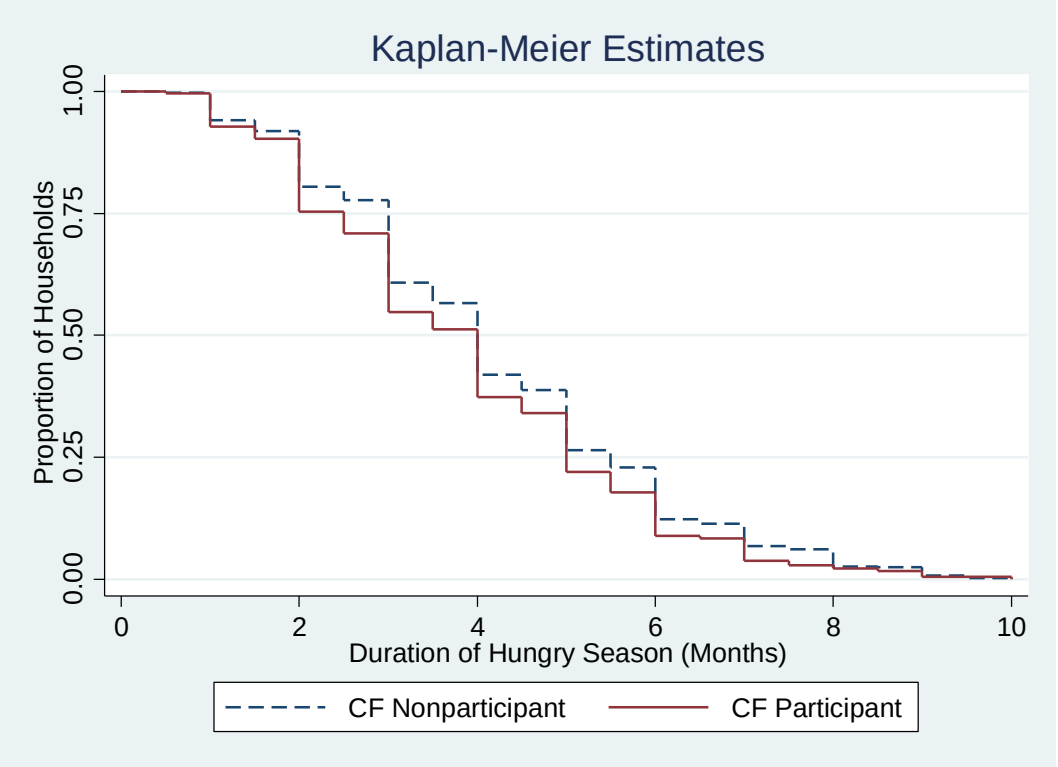

Figure 1. Nonparametric Survival Plot for the Duration of the Hungry Season by Participation Status.

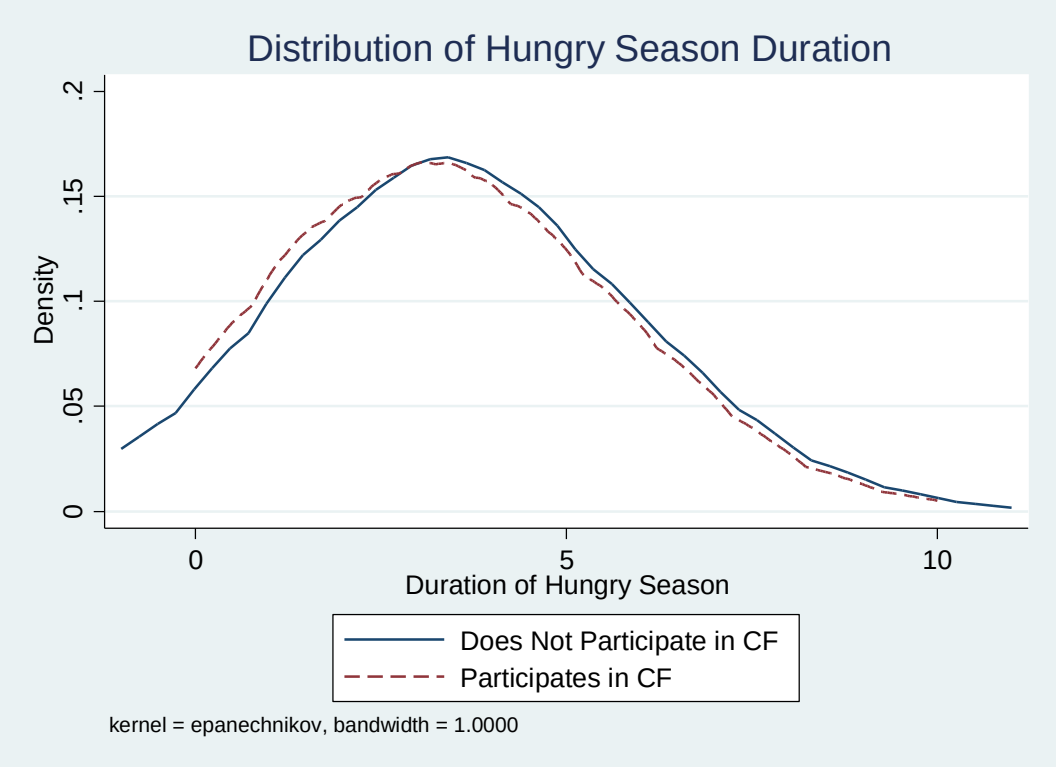

Figure 2. Kernel Density Estimate of the Distribution of the Duration of the Hungry Season by Participation Status.

Table 1. Variable Descriptions

Variable	Description
Duration of the Hungry Season	Number of months the last hungry season lasted. For households who experience two hungry seasons, this measures the total duration.
Contract Farming Participant	Equal to 1 if the household participates in contract farming and equal to 0 otherwise.
Household Size	Number of individuals in the household
Dependency Ratio	Number of individuals younger than 15 or older than 65 as a proportion of the total number of individuals in the household
Household Head Single	Equal to 1 if the household head is single and equal to 0 otherwise.
Household Head Female	Equal to 1 if the household head is female and equal to 0 otherwise.
Household Head Migrant	Equal to 1 if the household head migrated to the village from elsewhere and equal to 0 otherwise.
Household Head Age	Age of the household head in years.
Household Head Education	Education of the household head in years
Household Head Agricultural Experience	Agricultural experience of the household head in years
Household Head Member of a Farm Organization	Equal to 1 if the household head is a member of a farmer organization and equal to 0 otherwise.
Number of Taboo Days	Number days per year for which agricultural work is forbidden by religion
Household Income	Household income from animal sales, wages, nonfarm businesses, and agriculture in 100,000 Ariary
Household Working Capital	Household working capital (i.e., agricultural equipment and tools) in 100,000 Ariary
Household Assets	Household assets (i.e., house, TV, radio, bicycle, bank account, livestock, jewelry, and businesses) in 100,000 Ariary
Household Landholdings	Landholdings of the household measured in ares (1 are = 0.01 hectares, or 100 square meters)
Yes to $12.50 Investment Dummy	Equal to 1 if the household head received $12.50 as his bid and said "Yes" to the hypothetical
Yes to $25.00 Investment Dummy	Equal to 1 if the household head received $25.00 as his bid and said "Yes" to the hypothetical
Yes to $37.50 Investment Dummy	Equal to 1 if the household head received $37.50 as his bid and said "Yes" to the hypothetical
Yes to $50.00 Investment Dummy	Equal to 1 if the household head received $50.00 as his bid and said "Yes" to the hypothetical
Yes to $62.50 Investment Dummy	Equal to 1 if the household head received $62.50 as his bid and said "Yes" to the hypothetical
Yes to $75.00 Investment Dummy	Equal to 1 if the household head received $75.00 as his bid and said "Yes" to the hypothetical
Nonparametric Willingness to Pay	Willingness to pay estimate obtained by multiplying each respondent's random bid by his answer to the hypothetical question

Table 2. Descriptive Statistics

Variable	Mean (Std. Err.)
Duration of Hungry Season	3.507***
	(0.076)
Contract Farming Participant	0.498***
	(0.016)
Household Size	5.571***
	(0.075)
Dependency Ratio	0.449***
	(0.008)
Household Head Single	0.124***
	(0.011)
Household Head Female	0.088***
	(0.010)
Household Head Migrant	0.125***
	(0.011)
Household Head Age	43.274***
	(0.431)
Household Head Education	5.682***
	(0.106)
Household Head Agricultural Experience	20.621***
	(0.433)
Household Head Member of a Farm Organization	0.222***
	(0.014)
Number of Days When Agricultural Work Is Taboo	22.204***
	(1.105)
Household Income	19.531***
	(1.506)
Household Working Capital	4.440***
	(0.522)
Household Assets	13.965***
	(0.876)
Household Landholdings	145.569***
	(10.138)
Yes to $12.50 Investment	0.132***
	(0.011)
Yes to $25.00 Investment	0.179***
	(0.013)
Yes to $37.50 Investment	0.157***
	(0.012)
Yes to $50.00 Investment	0.133***
	(0.011)
Yes to $62.50 Investment	0.069***
	(0.009)
Yes to $75.00 Investment	0.066***
	(0.008)

Nonparametric Willingness to Pay	27.908***
	(0.766)
Observations	1,178

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 3. Estimation Results for the OLS, Cox Proportional Hazards, and Survival Time Regression Specifications Using Responses to the Contingent Valuation Experiment as Controls

Variable	(1) OLS	(2) Cox	(3) Survival
Dependent Variable: Duration of the Hungry Season (Months)			
Contract Farming Participant	-0.277*	0.166***	0.188***
	(0.145)	(0.063)	(0.071)
Household Size	0.052	-0.013	-0.015
	(0.036)	(0.015)	(0.017)
Dependency Ratio	0.517	-0.226	-0.247
	(0.366)	(0.158)	(0.181)
Single	-0.126	0.042	0.068
	(0.343)	(0.147)	(0.167)
Female	0.732*	-0.323*	-0.390*
	(0.402)	(0.175)	(0.202)
Migrant	0.064	0.014	0.009
	(0.219)	(0.101)	(0.115)
Age	0.021**	-0.003	-0.003
	(0.009)	(0.004)	(0.005)
Education	-0.068***	0.022**	0.026**
	(0.022)	(0.010)	(0.011)
Agricultural Experience	-0.029***	0.005	0.004
	(0.010)	(0.004)	(0.005)
Member of a Farmer Organization	0.091	-0.095	-0.125
	(0.183)	(0.088)	(0.100)
Number of Taboo Days for Agricultural Work	-0.003	0.000	0.000
	(0.002)	(0.001)	(0.001)
Income	-0.004**	0.000	0.000
	(0.002)	(0.001)	(0.002)
Working Capital	0.002	0.006***	0.007***
	(0.003)	(0.002)	(0.002)
Assets	-0.013***	0.004***	0.005***
	(0.003)	(0.001)	(0.002)
Landholdings	-0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)
Yes to $12.50 Investment	0.218	-0.033	-0.027
	(0.217)	(0.095)	(0.107)
Yes to $25.00 Investment	-0.396*	0.106	0.127
	(0.226)	(0.091)	(0.104)
Yes to $37.50 Investment	-0.388*	0.126	0.147
	(0.211)	(0.097)	(0.111)
Yes to $50.00 Investment	-0.205	-0.018	-0.017
	(0.243)	(0.112)	(0.128)
Yes to $62.50 Investment	-0.142	0.004	0.006
	(0.299)	(0.136)	(0.158)
Yes to $75.00 Investment	0.151	-0.226	-0.234
	(0.342)	(0.169)	(0.186)
Constant	3.793***	-	-4.152***
	(0.456)		(0.256)

Observations	1,178	1,045	1,045
District Fixed Effects	Yes	Yes	Yes
p-value (Joint Significance of Investment Dummies)	0.075	0.338	0.364
R-squared	0.206	-	-

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 4. Estimation Results for the OLS, Cox Proportional Hazards, and Survival Time Regression Specifications Using Nonparametric Willingness to Pay as a Control

Variable	(1) OLS	(2) Cox	(3) Survival
Dependent Variable: Duration of the Hungry Season (Months)			
Contract Farming Participant	-0.279*	0.159**	0.180**
	(0.144)	(0.062)	(0.070)
Household Size	0.051	-0.010	-0.012
	(0.036)	(0.015)	(0.017)
Dependency Ratio	0.564	-0.263*	-0.296
	(0.365)	(0.159)	(0.183)
Single	-0.090	0.045	0.075
	(0.338)	(0.147)	(0.167)
Female	0.727*	-0.344*	-0.419**
	(0.398)	(0.176)	(0.205)
Migrant	0.036	0.028	0.023
	(0.217)	(0.102)	(0.117)
Age	0.023**	-0.005	-0.005
	(0.009)	(0.004)	(0.005)
Education	-0.068***	0.021**	0.025**
	(0.022)	(0.010)	(0.012)
Agricultural Experience	-0.032***	0.006	0.006
	(0.010)	(0.004)	(0.005)
Member of a Farmer Organization	0.109	-0.105	-0.140
	(0.184)	(0.087)	(0.099)
Number of Taboo Days for Agricultural Work	-0.003	0.000	0.000
	(0.002)	(0.001)	(0.001)
Income	-0.004**	0.000	0.000
	(0.002)	(0.001)	(0.002)
Working Capital	0.002	0.006***	0.007***
	(0.003)	(0.002)	(0.002)
Assets	-0.013***	0.004***	0.005***
	(0.003)	(0.001)	(0.002)
Landholdings	-0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)
Willingness to Pay (Nonparametric)	-0.002	-0.001	-0.001
	(0.003)	(0.001)	(0.002)
Constant	3.598***	-	-3.977***
	(0.443)		(0.251)
Observations	1,178	1,045	1,045
District Fixed Effects	Yes	Yes	Yes
R-squared	0.197	-	-

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 5. Estimation Results for the OLS, Cox Proportional Hazards, and Survival Time Regression Specifications Exploring Treatment Heterogeneity I

Variable	(1) OLS	(2) Cox	(3) ST Regression
Dependent Variable: Duration of the Hungry Season (Months)			
Contract Farming Participant	0.210	0.009	0.004
	(0.253)	(0.109)	(0.125)
Contract Farming Participant*Number of Children	-0.191**	0.060*	0.070*
	(0.082)	(0.034)	(0.039)
Number of Children	0.172	-0.053	-0.060
	(0.121)	(0.050)	(0.057)
Household Size	0.007	0.002	0.002
	(0.059)	(0.028)	(0.032)
Dependency Ratio	0.255	-0.168	-0.187
	(0.583)	(0.231)	(0.259)
Single	-0.164	0.056	0.085
	(0.349)	(0.150)	(0.171)
Female	0.765*	-0.330*	-0.399*
	(0.406)	(0.176)	(0.204)
Migrant	0.066	0.006	-0.002
	(0.219)	(0.102)	(0.115)
Age	0.024**	-0.004	-0.004
	(0.010)	(0.004)	(0.005)
Education	-0.068***	0.022**	0.026**
	(0.022)	(0.010)	(0.012)
Agricultural Experience	-0.029***	0.004	0.003
	(0.010)	(0.004)	(0.005)
Member of a Farmer Organization	0.087	-0.088	-0.115
	(0.180)	(0.086)	(0.097)
Number of Taboo Days for Agricultural Work	-0.003	0.000	0.001
	(0.002)	(0.001)	(0.001)
Income	-0.004**	0.000	0.000
	(0.002)	(0.001)	(0.002)
Working Capital	0.002	0.005***	0.007***
	(0.003)	(0.002)	(0.002)
Assets	-0.013***	0.004***	0.005***
	(0.003)	(0.001)	(0.001)
Landholdings	-0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)
Yes to $12.50 Investment	0.197	-0.028	-0.022
	(0.217)	(0.095)	(0.107)
Yes to $25.00 Investment	-0.415*	0.107	0.126
	(0.227)	(0.091)	(0.104)
Yes to $37.50 Investment	-0.372*	0.124	0.144
	(0.211)	(0.098)	(0.112)
Yes to $50.00 Investment	-0.196	-0.004	0.000
	(0.238)	(0.108)	(0.124)
Yes to $62.50 Investment	-0.142	0.011	0.014
	(0.291)	(0.136)	(0.157)

Yes to $75.00 Investment	0.194	-0.245	-0.258
	(0.341)	(0.171)	(0.188)
Constant	3.592***		-4.078***
	(0.487)		(0.271)
Observations	1,178	1,045	1,045
District Fixed Effects	Yes	Yes	Yes
R-squared	0.213	-	-

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 6. Estimation Results for the OLS, Cox Proportional Hazards, and Survival Time Regression Specifications Exploring Treatment Heterogeneity II

Variable	(1) OLS	(2) Cox	(3) ST Regression
Dependent Variable: Duration of the Hungry Season (Months)			
Contract Farming Participant	0.206	-0.005	-0.013
	(0.254)	(0.109)	(0.125)
Contract Farming Participant*Female Children	-0.215*	0.118**	0.137**
	(0.120)	(0.054)	(0.061)
Contract Farming Participant*Male Children	-0.163	0.015	0.018
	(0.120)	(0.048)	(0.054)
Female Children	0.214	-0.067	-0.076
	(0.133)	(0.056)	(0.063)
Male Children	0.129	-0.026	-0.028
	(0.141)	(0.057)	(0.065)
Household Size	0.007	-0.002	-0.003
	(0.059)	(0.028)	(0.032)
Dependency Ratio	0.258	-0.196	-0.223
	(0.584)	(0.231)	(0.258)
Single	-0.167	0.058	0.088
	(0.348)	(0.148)	(0.169)
Female	0.766*	-0.336*	-0.406**
	(0.406)	(0.175)	(0.202)
Migrant	0.061	-0.001	-0.009
	(0.221)	(0.102)	(0.116)
Age	0.024**	-0.004	-0.004
	(0.010)	(0.004)	(0.005)
Education	-0.067***	0.023**	0.027**
	(0.023)	(0.010)	(0.012)
Agricultural Experience	-0.029***	0.004	0.003
	(0.010)	(0.004)	(0.005)
Member of a Farmer Organization	0.084	-0.096	-0.123
	(0.179)	(0.086)	(0.098)
Number of Taboo Days for Agricultural Work	-0.003	0.000	0.001
	(0.002)	(0.001)	(0.001)
Income	-0.004**	0.001	0.001
	(0.002)	(0.001)	(0.002)
Working Capital	0.002	0.005***	0.006***
	(0.003)	(0.002)	(0.002)
Assets	-0.013***	0.004***	0.005***
	(0.003)	(0.001)	(0.001)
Landholdings	-0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)
Yes to $12.50 Investment	0.191	-0.025	-0.017
	(0.216)	(0.095)	(0.106)
Yes to $25.00 Investment	-0.420*	0.104	0.122
	(0.226)	(0.091)	(0.104)
Yes to $37.50 Investment	-0.366*	0.122	0.143
	(0.212)	(0.098)	(0.111)

Yes to $50.00 Investment	-0.193	-0.015	-0.012
	(0.238)	(0.108)	(0.125)
Yes to $62.50 Investment	-0.138	-0.003	-0.003
	(0.290)	(0.137)	(0.159)
Yes to $75.00 Investment	0.193	-0.250	-0.265
	(0.342)	(0.171)	(0.189)
Constant	3.586***	-	-4.069***
	(0.486)		(0.271)
Observations	1,178	1,045	1,045
District Fixed Effects	Yes	Yes	Yes
R-squared	0.213	-	-

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 7. Robustness Checks on the Core Results

Variable	(1) Quantile	(2) Robust
Dependent Variable: Duration of the Hungry Season (Months)		
Contract Farming Participant	-0.306**	-0.255**
	(0.147)	(0.121)
Household Size	0.023	0.040
	(0.035)	(0.029)
Dependency Ratio	0.331	0.364
	(0.354)	(0.291)
Single	0.275	0.114
	(0.347)	(0.285)
Female	0.095	0.290
	(0.396)	(0.326)
Migrant	-0.034	0.070
	(0.227)	(0.187)
Age	0.022**	0.024***
	(0.011)	(0.009)
Education	-0.040*	-0.049**
	(0.023)	(0.019)
Agricultural Experience	-0.022**	-0.026***
	(0.011)	(0.009)
Member of a Farmer Organization	-0.092	-0.037
	(0.180)	(0.148)
Number of Taboo Days for Agricultural Work	-0.002	-0.003
	(0.003)	(0.002)
Income	-0.008***	-0.006***
	(0.002)	(0.002)
Working Capital	0.002	0.002
	(0.004)	(0.003)
Assets	-0.011***	-0.012***
	(0.003)	(0.002)
Landholdings	0.000	-0.000
	(0.000)	(0.000)
Yes to $12.50 Investment	0.217	0.191
	(0.246)	(0.202)
Yes to $25.00 Investment	-0.489**	-0.419**
	(0.229)	(0.188)
Yes to $37.50 Investment	-0.248	-0.269
	(0.231)	(0.190)
Yes to $50.00 Investment	-0.480**	-0.356*
	(0.242)	(0.199)
Yes to $62.50 Investment	-0.158	-0.185
	(0.313)	(0.257)
Yes to $75.00 Investment	-0.285	-0.191
	(0.298)	(0.245)
Constant	3.999***	3.751***
	(0.472)	(0.388)
Observations	1,178	1,178

District Fixed Effects	Yes	Yes
R-squared	-	0.200

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1