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New evidence regarding the effects of contract farming on agricultural labor use

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Abstract

Contract farming recently gained in importance in many developing countries. Various studies analyzed effects of contracting on productivity and income in the small farm sector. A few studies also looked at effects on agricultural labor use, suggesting that contracting tends to increase labor intensity, thus generating additional farm employment. An increase in the use of farm labor is plausible when contracting involves additional work in production, harvesting, and post-harvest handling. However, we argue that the opposite may also be true, namely when contracting involves labor-saving procedures and technologies. We use primary data from the oil palm sector in Ghana and show that farmers with a contract use significantly less labor per unit of land than farmers without a contract. We also analyze whose labor input is reduced. Household labor is reduced more than hired labor. Especially male household members reallocate time to off-farm employment. Contracts also reduce the likelihood of using child labor in farm production. This is the first study to show that contract farming reduces agricultural labor use in certain situations.

Keywords: Contract farming, oil palm, agricultural labor use, rural employment, gender, child labor

JEL codes: J23; J43; O13; Q12

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1. Introduction

Contract farming recently gained in importance in developing countries (Bellemare, 2018; Meemken and Bellemare, 2019; Otsuka et al., 2016). Many studies analyzed the effects of contracts on agricultural productivity and income in the small farm sector (e.g., Arouna et al., 2019; Ashraf et al., 2009; Barrett et al., 2012; Bellemare, 2012; Khan et al., 2019; Maertens et al., 2012; Mishra et al., 2016; Mishra et al., 2018; Ragasa et al., 2018; Rao et al., 2012; Ruml and Qaim, 2019; Simmons et al., 2005; Tripathi et al., 2005). Possible effects of contracts on agricultural labor use have received much less attention in the empirical literature. This is surprising, because employment is an important issue for sustainable rural development, especially in Africa where rural population growth is still quite large.

The general expectation is that contract farming increases agricultural labor use and employment, because contracting often involves high-value farm commodities that are labor-intensive (Bellemare, 2018; Khan et al., 2019; Narayanan, 2014; Otsuka et al., 2016). This expectation is consistent with a few empirical studies showing that contracting leads to additional labor use in production, harvesting, and post-harvest handling in some situations (Benali et al., 2018; Meemken and Bellemare, 2019; Neven et al., 2009; Rao and Qaim, 2013). However, we argue that these results cannot be generalized, because contracting can also involve the adoption of labor-saving technologies and procedures. Labor-reducing effects through contracts have not been shown previously in a small farm context. Here, we show that they exist using smallholder oil palm production in Ghana as an empirical example.

In particular, using data from a survey of farm households we investigate the effects of two types of contracts – namely marketing and resource-providing contracts – on labor use in oil palm production. While farmers without a contract do some of the post-harvest handling themselves, farmers with a contract sell the oil palm fruit bunches to the buying company immediately after harvest. Some of the contracted farmers also use labor-saving chemical inputs such as herbicides, thus further reducing the labor intensity. We evaluate the effects of

contracting on total labor use per unit of land. In addition, we differentiate between household and hired labor, and between male, female, and child labor. Differentiation is useful to better understand possible broader social implications. Endogeneity issues in the evaluation of effects are addressed with a control function approach and through including farmers' willingness-to-pay for certain contract features as an additional explanatory variable in the regressions.

Contract farming in the oil palm sector of Ghana is not a peculiar case. Many smallholders in Africa have traditionally produced palm oil for home consumption and local markets. However, demand for palm oil from domestic and international markets is growing, so that modern supply chains with new players and smallholder contract schemes are increasingly emerging (Byerlee et al., 2017). Similar trends are also observed in other crops traditionally grown by smallholders. Against this background, better understanding the labor market implications of contract farming is particularly important.

The rest of this article is structured as follows. The next section presents further details of trends in Africa's oil palm sector, based on which several concrete research hypotheses are developed. Section 3 describes the data collection and the statistical methods used to test the reseaech hypotheses. Section 4 presents the empirical results, while section 5 concludes.

2. Background and Hypotheses

2.1. Trends in Oil Palm Production and Marketing

Oil palm is native in West Africa and has been grown by smallholders for a long time for home consumption and local markets. Over the last few decades, international demand for palm oil has increased tremendously, but most of this demand was met by production growth in Southeast Asia, not Africa (Byerlee et al., 2017). The situation is now gradually changing. While in Southeast Asia, the expansion of oil palm is increasingly conflicting with environmental objectives, Africa still has more potential for production increases. In West Africa, oil palm has recently become one of the most important cash crops produced, and further growth is expected

in the future (Byerlee et al., 2017; Huddleston and Tonts, 2007; Rhebergen et al., 2016). The transformation of oil palm from a local semi-subsistence crop to a major cash crop is associated with a modernization of supply chains and the entry of large processing companies, which secure some of the supply from smallholders through contractual agreements.

Smallholder farmers continue to be the main producers of oil palm in West Africa. In Ghana, smallholder production accounts for 75 percent of total palm oil supply (Byerlee et al., 2017). Smallholder oil palm production in Ghana also employs over 2 million farm workers (Ministry of Food and Agriculture, 2011). However, the production conditions differ remarkably between traditional supply chains without contracts and modern supply chains with contracts. In traditional supply chains, farmers have no secure sales market. They harvest the fruit bunches and then pick the individual fruits out of the bunches, in order to sell to local customers or home-process to palm oil. Picking, processing, and finding a buyer are time-intensive operations, which are particularly performed by women. As the quantities traded in local markets are small and the fruits are perishable, harvesting typically takes place in a piecemeal fashion.

In contrast, farmers in modern supply chains with a contract have a secure sales market where prices are fixed annually. Contracted farmers harvest the bunches themselves, but instead of picking and processing the fruits, they sell the bunches to the buying companies at the farm gate. The companies have large mills where the fruit bunches are processed. This means that contracted farmers can harvest and sell larger quantities of fruit bunches at once.

In Ghana, two types of contracts exist in the oil palm sector, namely marketing and resource-providing contracts, as shown in Table 1. For both types of contracts, the harvest and sales conditions are as described above. However, the contracts differ in terms of the additional assistance provided for production inputs and technologies. While farmers with a marketing contract do not receive production assistance, farmers with a resource-providing contract can obtain chemical inputs, other production tools, and technical support on credit from the contracting company. As a result, farmers with a resource-providing contract often obtain higher

yields (Ruml and Qaim, 2019). On the other hand, they are also more likely to use chemical herbicides for weed control, which reduces labor demand, as the alternative is to control weeds manually. The lower part of Table 1 shows production and post-harvest handling steps for the different alternatives with and without contracts, also indicating typical gender responsibilities.

Table 1: Production and marketing characteristics in oil palm with and without contract

	Traditional, without contract	Marketing contract	Resource-providing contract
Buyer	Local customers, small processing mills	Processing company	Processing company
Product sold	Oil palm fruits, palm oil	Oil palm bunches	Oil palm bunches
Production assistance	None	None	Inputs, technologies, technical support on credit
Labor operations	Plot maintenance ♂ Input application ♂ Harvesting (piecemeal) ♀♂ Picking of fruits ♀ Processing (sometimes) ♀ Marketing ♀	Plot maintenance ♂ Input application ♂ Harvesting (at once) ♀♂	Plot maintenance ♂ Input application ♂ Harvesting (at once) ♀♂

Notes: ♂ indicates that operation if performed mostly by males. ♀ indicates that operation is performed mostly by females.

2.2. Research Hypotheses

Based on the differences between oil palm production and marketing conditions with and without contract, we develop a set of research hypotheses, which will be tested empirically further bellow. The first hypothesis is:

Hypothesis 1: Contract farming leads to a reduction in agricultural labor use.

When total labor input per unit of land is reduced, this can affect either household labor, or hired labor, or both. As picking fruits out of the bunches, processing, and marketing in traditional supply chains without contract are primarily performed by household labor, and these are the main operations falling away in the contract schemes, we further hypothesize:

Hypothesis 2: Household labor is reduced more than hired labor.

If household labor in oil palm production is saved, the labor time can be reallocated to other on-farm activities or also to off-farm employment (Davis et al., 2017). We expect a stronger reallocation to off-farm activities, as alternative crops are often less profitable than oil

palm. Furthermore, oil palm farmers in Ghana are relatively well educated, meaning that they may have access to more lucrative off-farm economic activities. Hence, we hypothesize:

Hypothesis 3: The reduction in agricultural labor use leads to a reallocation of household labor to off-farm employment.

In addition to differentiating between household and hired labor, we are also interested in the gender implications resulting from agricultural labor reduction and reallocation. The contracts in Ghana's oil palm sector do away with on-farm operations that are primarily performed by women (Table 1). In addition, especially the resource-providing contracts lead to more agrochemical applications, which is typically a male task in the local context. Hence, we hypothesize:

Hypothesis 4: Females are more affected than males by the reduction in agricultural labor use.

If hypothesis 4 is true, it will be interesting to see whether saved household female labor is also reallocated to off-farm employment. If women pursue off-farm economic activities, this is often associated with a gain in female financial autonomy and positive effects for family welfare and nutrition (Amugsi et al., 2016; Maertens and Swinnen, 2012). On the other hand, women often have limited access to off-farm employment due to cultural and educational constraints (Chrisendo et al., 2019). A reduction in female hired labor use through oil palm contracts may also have important social implications, as female agricultural laborers often belong to the most disadvantaged population groups in rural Africa (Fischer and Qaim, 2012; Maertens and Swinnen, 2012; Rao and Qaim, 2013).

Finally, we are interested in effects of contracts on child labor and youth labor in oil palm production. Children and adolescents are typically involved in all on-farm operations up to a certain extent, but especially in fruit picking and processing. Hence, we hypothesize:

Hypothesis 5: Contract farming leads to a reduction in child and youth labor.

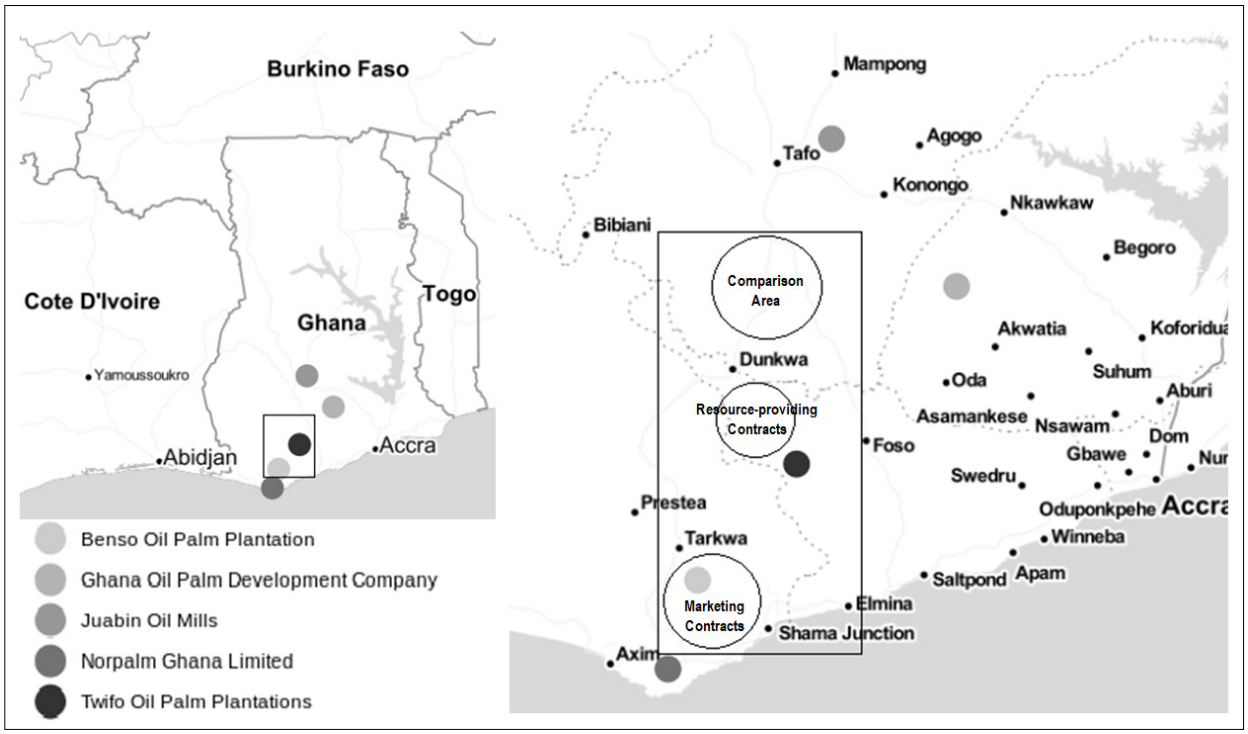
A reduction in child and youth labor may have positive effects on school attendance and educational attainments.

3. Materials and Methods

3.1. Farm Household Survey

This study uses cross-sectional survey data, collected between April and July 2018 in the South of Ghana, where five different processing companies are located that all contract smallholder oil palm farmers (Figure 1). Out of the five companies, we selected two that are located in neighboring regions relatively close to each other, namely Benso Oil Palm Plantation owned by Wilmar International in the Western Region and Twifo Oil Palm Plantation owned by Unilever in the Central Region. While Benso has simple marketing contracts with farmers, Twifo uses resource-providing contracts. From both company schemes, contracted oil palm farmers were selected randomly based on complete lists of villages and farmers involved. Comparison farmers were chosen in different locations in the Ashanti Region to reduce non-random selection issues and spillover effects that might bias the impact evaluation. The three neighboring regions included in the survey are shown in Figure 1.

Figure 1: Map of study area in Ghana



Source: Authors' own presentation using tools provided in Kahle and Wickham (2013).

All three regions are located in Ghana's green belt, which is classified as suitable for oil palm cultivation (Rhebergen et al., 2016). All three regions are similar in terms of rainfall and climate conditions (Table A1 in the Appendix). As contracts are expected to reduce agricultural labor use, farmers in regions with strong economic development and attractive off-farm employment opportunities may be particularly interested in producing oil palm under contract. Hence, comparing farmers in regions with notable differences in economic development could potentially confound the results. To avoid possible bias, we selected the comparison region such that rural unemployment rates and other indicators of economic development are very similar to those in the two contract farming regions (Table A1). Demographic structures in the three regions are also very similar in terms of ethnic and religious composition. Another indicator of similarity is that a new company contract scheme for oil palm was planned in the comparison region, but had not yet started at the time of the survey. When we collected the survey data, oil palm farmers in the comparison region were unaware of the upcoming contract scheme. We learned about the planned contract scheme from the local Ministry of Food and Agriculture (MoFA).

In total, we randomly selected 463 oil palm producing households from 31 villages in the three regions:[1] 193 from the Western Region with a marketing contract, 164 from the Central Region with a resource-providing contract, and 106 from the Ashanti Region without any contract. Personal interviews were carried out with the household heads in the local language, using a structured questionnaire developed for this purpose and programmed in tablet computers. The questionnaire captured information on the household structure, all income sources, the time spent by household members in various economic activities, and other socioeconomic details. Input-output details for oil palm production were captured at the plot level for all plots managed by the sample household. We use complete data for 524 oil palm plots, after excluding those that did not yet bear any fruits. In addition to the household interviews, we also conducted shorter

[1] We only sampled commercial oil palm producers, meaning that households with only a few palms for home consumption purposes and no commercial sales were not considered.

interviews with the chief in each of the villages, capturing information on village-level characteristics.

3.2. Regression Models

As discussed, we hypothesize that contract farming reduces agricultural labor use. This hypothesis is tested with a regression model of the following type:

$$Y_{ihj} = \beta_0 + \beta_1 MC_{ihj} + \beta_2 RPC_{ihj} + \beta_3 X_{ihj} + u_{ihj} \quad (1)$$

where Y_{ihj} is the agricultural labor use per acre on plot i, in household h, and village j. MC represents the marketing contract and RPC the resource-providing contract; these are dummy variables that take a value of one if the household and plot are part of the respective contract scheme and zero otherwise.[2] Thus, β_1 measures the effect of the marketing contract and β_2 the effect of the resource-providing contract. Hypothesis 1, stating that contract farming reduces agricultural labor use, is supported if β_1 and β_2 are both negative and statistically significant. We also control for other factors that may influence agricultural labor use, X_{ihj}, including plot, household, and village characteristics. u_{ihj} is a random error term that we cluster at the village level.

In order to test hypothesis 2, we estimate disaggregated models using household labor and hired labor as dependent variables. As there are some farmers that do not use both types of labor, the dependent variables in these disaggregated models include zero observations leading to corner solutions. This is accounted for by modeling two decisions for each type of labor as follows:

$$D_{ihj} = \propto_1 MC_{ihj} + \propto_2 RPC_{ihj} + \propto_3 X_{ihj} + \mu_{ihj} \qquad \mu_{ihj} \sim N(0,1) \quad (2)$$

$$Q_{ihj} = \gamma_1 MC_{ihj} + \gamma_2 RPC_{ihj} + \gamma_3 X_{ihj} + \varepsilon_{ihj} \qquad \varepsilon_{ihj} \sim N(0,\sigma^2) \quad (3)$$

where equation (2) models the binary decision whether or not to use household (hired) labor on oil palm plot *i*, and equation (3) models the decision how much household (hired) labor to use on

[2] *MC* and *RPC* are possibly endogenous, which could lead to biased estimates. We discuss endogeneity issues and how we address them further below.

the plot, conditional on the first decision being positive. Hence, D_{ihj} is a dummy and Q_{ihj} a continuous variable. The other variables are defined as above. Hypothesis 2, stating that household labor is reduced more through contracts than hired labor, is tested by estimating equations (2) and (3) separately for the use of household and family labor and then comparing the effects for MC_{ihj} and RPC_{ihj}.

Hypothesis 3 states that contract farming leads to a reallocation of household labor from farm to off-farm activities. This is tested with the following equations, which are estimated at the household level:

$$V_{hj} = \pi_1 MC_{hj} + \pi_2 RPC_{hj} + \pi_3 X_{hj} + \tau_{hj} \qquad \tau_{hj} \sim N(0,1) \qquad (4)$$

$$W_{hj} = \varphi_1 MC_{hj} + \varphi_2 RPC_{hj} + \varphi_3 X_{hj} + \delta_{hj} \qquad \delta_{hj} \sim N(0,\sigma^2) \qquad (5)$$

where V_{hj} is a dummy variable that takes a value of one if at least one member of household h works in off-farm employment, and zero otherwise, whereas W_{hj} is a continuous variable measuring the number of labor days worked in off-farm employment by all household members. Hypothesis 3 is supported if the coefficients π_1, π_2 and/or φ_1, φ_2 are positive and statistically significant.

Hypothesis 4 states that female labor in oil palm is reduced more than male labor through the contracts, which is tested by running the models in equations (1) to (5) separately for male and female labor and comparing the coefficients. Finally, hypothesis 5 – concerning the effects of contracts on the use of child and youth labor in oil palm – is tested by re-estimating the models in equations (2) and (3) with child and youth labor as dependent variables.

We use double hurdle specifications to estimate the models in equations (2)-(3) and (4)-(5). The double hurdle specification is suitable to estimate corner solution models with a binary first-stage decision and a continuous variable in the second stage (Burke, 2009; Cragg, 1971; Garcia, 2013). Double hurdle models were used recently in the agricultural economics literature to estimate labor market effects (Benali et al., 2018; Rao and Qaim, 2013). We test the double hurdle specification against the more specific tobit alternative using a likelihood ratio test. The

results reject the hypothesis that the tobit is a suitable specificastion in all cases, meaning that the double hurdle model is preferred (Table A2 in the Appendix).

3.3. Definition of Key Variables

The dependent variables in the different regression models are total agricultural labor use, as well as labor use by different categeries of laborers, including household and hired labor, male and female labor, and child and youth labor. All these variables are measured in labor days worked per acre of oil palm during the 12 months prior to the survey. Laborers are considered adult if they are 18 years or older. Youth labor includes persons between 15 and 17 years of age, and child labor refers to individuals that are 14 years or younger. Child and youth participation is only counted as labor when the individuals were actively involved in any of the agricultural operations. Activities such as delivering food or water to other laborers or simply accompanying family members without own active involvement is not counted as labor.

The key explanatory variables are the two dummies for particiation in marketing and resource-providing contracts, which were already explained above. In addition, we include a set of control variables. At the plot level, we control for soil quality, irrigation, the number of palms per acre, and the distance from the plot to the closest road that is accessible with a truck. At the household level, we control for the number of adult household members, which is a measure of the availability of household labor, and the total land size. As the current land size can be influenced by contracts, we use land availability in 2008, which is before most of the farmers in the study regions had any oil palm contracts. Total land size includes all plots available to the household for cultivation, regardless of whether or not the plots were actually cultivated in 2008. Furthermore, we control for socioeconomic characteristics of the oil palm farmer (age, sex, education, farming experience). In the household-level models, we control for the characteristics of the household head, which is not necessarily the same person as the oil palm farmer. Finally,

we control for distance to the closest market measured in km as a village-level variable; if the village has its own market the distance is set at zero.

3.4. Dealing with Endogeneity

We use the regression models explained above to evaluate the impact of marketing contracts and resource-providing contracts on labor use. However, farmers self-select into contract participation, so that the treatment variables may be endogenous. Farmers with low labor availability (or high opportunity costs of time) may be more likely to participate in contracts that reduce on-farm labor requirements, which could lead to issues of reverse causality. Moreover, there may be unobserved factors that are jointly correlated with contract participation and labor use decisions. Such types of endogeneity could lead to correlation of the contract dummy variables with the error terms and thus bias the estimation results.

Our sampling framework helps to reduce self-selection issues, because farmers with and without contracts were chosen in different regions. While the regions are similar in terms of agroecological and socioeconomic conditions (Table A1), they differ in the availability of contract schemes, thus providing a quasi-experimental setting. At the time of the survey, farmers in the comparison region did not have access to any of the contract schemes. Similarly, farmers in the two contracting regions only had access to one of the contract types.

In spite of the quasi-experimental setting, some level of endogeneity may still occur. We therefore use a control function approach with instrumental variables (IVs), which is also known as the two-stage residual inclusion approach (Terza et al., 2008). The control function approach addresses endogeneity, is more flexible than the standard IV model, and can also be used for non-linear models (Wooldridge, 2014). In the first stage, participation in a contract scheme is regressed on the full set of control variables and the instruments. In the second stage, labor use is regressed on contract participation and the control variables, as explained above in equations (1)

to (5), but additionally including residual terms from the first stage as explanatory variables. For the double hurdle models, the residual terms are included in both hurdles.

As we look at two different contract schemes (and the comparison group), we use a multinomial logit for the first stage. This produces two residual terms, one for each contract scheme. We calculate generalized residuals, which are normalized and have a conditional mean at zero (Wooldridge, 2015). If the residual terms are statistically insignificant in the second stage, the null hypothesis that participation in the contract schemes is exogenous cannot be rejected. In that case, the residuals are excluded for the particular model. However, if the residuals are significant, exogeneity has to be rejected and inclusion of the residual terms controls for endogeneity bias.

We use two instruments that are significantly correlated with participation in the two contract schemes but do not influence labor use through other mechanisms. Participation in the marketing contract is instrumented with the share of households in the village producing oil palm commercially ('village share'). Commercial oil palm production means that a household cultivates oil palm and sells at least some of the produce either in local markets or to a company under contract. The rationale for this instrument is that the company will prefer to contract in villages with many commercial oil palm farmers, as this can help to reduce transport and transaction costs. Participation in the resource-providing contract is instrumented with a dummy variable that takes a value of one if the chief of the respective village is a commercial oil palm farmer ('village chief'). The rationale for this instrument is that approval from the village chief is required before the company can contract farmers in a particular village under the resource-providing scheme. The village chief will likely be more obliging when commercially producing oil palm himself/herself.

Table A3 in the Appendix presents the first-stage IV regressions, which confirm that both instruments are significantly correlated with contract participation. At the same time, they are not significantly correlated with any of the outcome variables (Table A4). This is plausible in our

quasi-experimental setting. Given that the "treatment" and comparison regions and villages are similar, there is no reason to believe that the village-level share of commercial oil palm farmers or the types of crops grown by the village chief would affect individual labor use through mechanisms other than own contract participation. We conclude that the two instruments ae valid. In Table A5, we show results of the exogeneity tests for all models used in this study. Whenever, the exogeneity hypothesis is rejected, the residual terms are included when estimating the treatment effects.

While all criteria for instrument validity are fulfilled, instruments are rarely perfect. Therefore, we use an additional approach to reduce possible issues of endogeneity, namely we include the individual farmer's willingness-to-pay (WTP) for contracts as an additional control variable in those models where exogeneity of contract participation could not be rejected. WTP measures the farmer's subjective preference for producing under contract, which is likely correlated with a number of farmer characteristics, including unobserved ones such as risk aversion, time preferences, and entrepreneurial skills. Hence, controlling for WTP in the models will reduce possible issues caused by unobserved heterogeneity. Using WTP measures to address endogeneity is an approach that was recently used also in other studies evaluating the impacts of contracts and related marketing institutions (Bellemare, 2012; Bellemare and Novak, 2017; Meemken and Qaim, 2018; Verhofstadt and Maertens, 2014).

We derived the farmer's WTP for contracts through a simple experiment that was part of the survey questionnaire. In particular, we offered each farmer a set of hypothetical contract offers requiring varying amounts of initial investments. Respondents were asked: "Would you be willing to enter a contract agreement with a company for the establishment of one acre of oil palm that would increase your income but would necessitate an initial investment of *Z* Ghanaian Cedis (GHS)?" For each respondent, *Z* started at a low value and, if the answer was 'yes', was increased in follow-up questions. The highest value of *Z* for which the answer was 'yes'

represents the individual WTP, which we include as an additional control variable in our impact regressions.

4. Results

4.1. Descriptive Statistics

Table 2 shows descriptive statistics and mean difference tests for all outcome variables used in this study. The upper part of Table 2 shows labor use at the plot level. As expected, farmers with a contract use significantly less agricultural labor in oil palm production than farmers without a contract. This is true for both types of contracts, but the difference is especially large for the resource-providing contract. Farmers with a marketing contract use less than half, and farmers with a resource-providing contract only use about one-third of the labor that farmers without a contract use per acre of oil palm. Differences are primarily observed for household labor, including male and female, as well as child and youth labor. For hired labor, differences between plots with and without contracts are not statistically significant.

Table 2: Descriptive statistics of outcome variables

	Mean			Difference		
	Marketing contract (MC)	Resource-providing contract (RPC)	No contract (NC)	MC-RPC	MC-NC	RPC-NC
Plot-level variables (n=524)	*(n=222)*	*(n=186)*	*(n=119)*			
Agricultural labor use (in labor days per acre of oil palm)	34.78	26.86	78.06	***	***	***
	(2.16)	(1.87)	(7.24)			
Household labor (in labor days per acre of oil palm):	16.06	11.03	50.91	**	***	***
	(1.60)	(1.16)	(5.17)			
Male household labor	9.71	7.60	27.63		***	***
	(1.13)	(0.88)	(3.19)			
Female household	6.35	3.43	23.28	***	***	***
	(0.81)	(0.53)	(2.93)			
Child labor	0.23	0.11	4.08		***	***
	(0.13)	(0.04)	(1.39)			
Youth labor days per acre	0.50	0.29	3.28		***	***
	(0.26)	(0.09)	(0.96)			
Hired labor days (in labor days per acre of oil palm):	17.36	14.97	18.65			
	(1.73)	(1.82)	(3.68)			
Male hired labor	10.67	11.43	12.16			
	(1.14)	(1.22)	(2.41)			
Female hired labor	6.69	3.54	6.49	**		
	(0.87)	(1.02)	(1.77)			
Household-level variables (n=463)	*(n=193)*	*(n=164)*	*(n=106)*			
Days worked in off-farm employment (per household)	151.32	125.24	117.51			
	(12.63)	(13.50)	(15.84)			
Male days worked in off-farm employment	69.91	62.91	67.71			
	(9.39)	(10.48)	(11.65)			
Female days worked in off-farm employment	81.42	62.33	49.80		**	
	(9.41)	(9.61)	(10.20)			

Notes: Mean values are shown with standard errors in parentheses. * p<0.1, ** p<0.05, *** p<0.01.

The lower part of Table 2 shows the number of days worked in off-farm employment at the household level. For the total number of days worked in off-farm activities, no significant differences between households with and without contract are observed. However, gender disaggregation reveals that households with a marketing contract have more female off-farm labor days than households without any contract.

The differences in Table 2 cannot be interpreted as effects of contracts, as the plots and households also differ in terms of several other characteristics (Table A6 in the Appendix). The regression results presented below control for such differences in plot and household characteristics and for possible other confounding factors.

4.2. Effects of Contracts on Agricultural Labor Use

Table 3 shows the estimated effects of contract farming on agricultural labor use. Ordinary least squares (OLS) and control function estimates are shown with very similar results, which is to be expected given that the first-stage residuals are not statistically significant in this model. Contract farming reduces agricultural labor use, which holds true for both types of contracts and supports our research hypothesis 1. The marketing contract leads to a reduction of 43 labor days per acre of oil palm, which is equivalent to a 55 percent decrease when compared to the mean labor use of 78 days on oil palm plots without any contract. The resource-providing contract leads to a reduction of 48 labor days, equivalent to a 62 percent decrease. We find no statistically significant difference between the effects of both contracts.

Table 3: Effects of contracts on agricultural labor use (labor days per acre)

	(1)	(2)
	OLS	Control function
Marketing contract	-43.36***	-40.68***
	(7.89)	(8.37)
Resource-providing contract	-47.94***	-43.17***
	(6.17)	(6.30)
Control variables included	Yes	Yes
Residuals included	No	Yes
WTP included	Yes	No
Observations	524	524

Notes: Average effects are shown with village cluster-corrected standard errors in parentheses. Full regression results are shown in Table A7 in the Appendix. * p<0.1, ** p<0.05, *** p<0.01.

4.3. Effects of Contracts on Labor Reallocation and Employment

Table 4 shows the effects of contracts on labor reallocation and employment. These estimates are based on double hurdle models. The results in column (1) suggest that contracts reduce the likelihood of using household labor in oil palm production by 14 and 37 percentage points for marketing and resource-providing contracts, respectively. The results in column (2) further suggest that – for those who use household labor in oil palm production – the number of household labor days per acre is reduced by 16.3 and 23.5 for marketing and resource-providing contracts, respectively. These effects of contracts on household labor use are much stronger than the effects on hired labor use in oil palm production (columns 3 and 4 of Table 4). Table 5 shows unconditional marginal effects combining the results from both hurdles. It becomes obvious that both types of contracts significantly reduce the use of household labor, but not of hired labor, which supports our research hypothesis 2.

Table 4: Effects of contracts on labor reallocation and employment

	Household labor		Hired labor days		Off-farm employment	
	(1)	(2)	(3)	(4)	(5)	(6)
	Decision	Quantity	Decision	Quantity	Decision	Quantity
	0-1	Days per acre	0-1	Days per acre	0-1	Days per household
Marketing contract	-0.14**	-16.28***	-0.18***	-0.51	0.06	81.96***
	(0.06)	(5.81)	(0.05)	(5.91)	(0.04)	(22.93)
Resource-providing contract	-0.37***	-23.50***	0.00	1.25	-0.01	54.12**
	(0.05)	(4.90)	(0.05)	(3.29)	(0.04)	(24.55)
Control variables included	Yes	Yes	Yes	Yes	Yes	Yes
Residuals included	Yes	Yes	Yes	Yes	No	No
WTP included	No	No	No	No	Yes	Yes
Observations	524	381	524	422	463	249

Notes: Marginal effects from double hurdle models are shown with village cluster-corrected standard errors in parentheses. Marginal effects of the second hurdle (quantity) are conditional on the first hurdle being passed. Full results are shown in Table A8 and A9 in the Appendix.
* p<0.1, ** p<0.05, *** p<0.01.

Table 5: Effects of contracts on labor reallocation and employment (unconditional marginal effects)

	Household labor (days per acre)	Hired labor (days per acre)	Off-farm employment (days per household)
Marketing contract	-16.43***	-3.77	61.10***
	(4.63)	(5.30)	(22.84)
Resource-providing contract	-27.15***	1.07	25.37
	(4.37)	(2.85)	(19.12)
Control variables included	Yes	Yes	Yes
Observations	524	463	524

Notes: Unconditional marginal effects are shown with village cluster-corrected standard errors in parentheses. Full results are shown in Table A10 in the Appendix. * p<0.1, ** p<0.05, *** p<0.01.

What do households do with the household labor time saved per acre of oil palm? The results in Table 4 suggest that some of the labor saved is reallocated to off-farm economic activities. While contracting has no effect on the likelihood of working off-farm, it significantly increases the number of household labor days in off-farm employment.[3] These results support our research hypothesis 3. Interestingly, however, the effect on off-farm employment is bigger for the marketing contract than for the resource-providing contract, even though the resource-providing contract leads to somewhat larger labor savings per acre of oil palm. This puzzle can be explained by differences in household livelihood strategies. Farmers with a marketing contract use the labor saved primarily to increase their off-farm income. In contrast, households with a resource-providing contract specialize more on commercial farming and expand their total oil palm area, so that the labor saved per acre of land does not necessarily imply an equally large reduction in the total household time spent in agriculture.

4.4. Gender and Age Disaggregation for Household Labor

Table 6 presents disaggregated results for male and female household labor and for child and youth labor. These results are also based on double hurdle models. Both types of contracts significantly reduce male and female household labor use per acre of oil palm. The effects of both contracts on male and female labor are similar in magnitude (the differences are not

[3] Note that the effects of contracts on the number of labor days in off-farm employment cannot be compared directly to the effect on the number of days worked in oil palm, because the former is measured per household while the latter is measured per acre of oil palm.

statistically significant). Our research hypothesis 4 stated that female labor is more affected than male labor. This hypothesis is not supported by the empirical results.

Table 6: Effects of contracts on household labor use, by gender and age

	Male labor		Female labor		Child labor		Youth labor	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Decision	Quantity	Decision	Quantity	Decision	Quantity	Decision	Quantity
	0-1	Days per acre	0-1	Days per acre	0-1	Days per acre	0-1	Days per acre
Marketing contract	-0.14***	-12.34***	-0.13**	-7.51***	-0.07**	-32.33	-0.10**	-2.97
	(0.04)	(3.21)	(0.07)	(2.56)	(0.03)	(30.23)	(0.04)	(8.23)
Resource-providing	-0.33***	-13.77***	-0.43***	-11.63***	-0.13***	-71.05	-0.10**	-13.21
contract	(0.05)	(3.68)	(0.07)	(2.79)	(0.02)	(95.56)	(0.05)	(29.06)
Control variables included	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Residuals included	Yes	No	Yes	Yes	Yes	No	Yes	Yes
WTP included	No	Yes	No	No	No	Yes	No	No
Observations	524	343	524	270	524	46	524	58

Notes: Marginal effects from double hurdle models are shown with village cluster-corrected standard errors in parentheses. The marginal effects of the second hurdle (quantity) are conditional on the first hurdle being passed. Full results are shown in Tables A11 and A12 in the Appendix. Unconditional marginal effects are shown in Table A13. * p<0.1, ** p<0.05, *** p<0.01.

The first-hurdle results in columns (5) and (7) of Table 6 further suggest that the likelihood of using child and youth labor in oil palm production is reduced by 7 to 13 percentage points through the contracts. The second-hurdle estimates (columns 6 and 8) also have negative signs and are quite large in absolute terms, especially for child labor. However, these second-hurdle estimates are not statistically significant, which is probably due to the small number of households using child and youth labor and the resulting inflation of the standard errors. The unconditional marginal effects (Table A13) show a significant reduction in child labor at least for the resource-providing contract, which supports our research hypothesis 5 at least to some extent. A larger sample might possibly lead to more significant effects.

Table 7 shows gender-disaggregated effects of the contracts on participation in off-farm employment. For male household members, the likelihood of off-farm employment is not significantly affected, but both contracts increase the number of off-farm labor days of male household members considerably. For female household members, the marketing contract increases the likelihood of off-farm employment by 11 percentage points, even though the effects of both contracts on the number of off-farm labor days of female household members are statistically insignificant. Overall, these results indicate that the reallocation of household labor

from farm to off-farm employment is more pronounced for male than female household members. And the reallocation to off-farm employment is stronger for the marketing contract than for the resource-providing contract, which is in line with the aggregated results above.

Table 7: Effects of contracts on off-farm employment, by gender

	Male labor		Female labor	
	(1)	(2)	(3)	(4)
	Decision	Quantity	Decision	Quantity
	0-1	Days per household	0-1	Days per household
Marketing contract	-0.06	104.68***	0.11**	-15.52
	(0.05)	(33.89)	(0.05)	(46.01)
Resource-providing contract	-0.05	82.85**	-0.02	69.59
	(0.04)	(37.14)	(0.05)	(57.47)
Control variables included	Yes	Yes	Yes	Yes
Residuals included	No	No	No	Yes
WTP included	Yes	Yes	Yes	No
Observations	463	151	463	130

Notes: Marginal effects from double hurdle models are shown with village cluster-corrected standard errors in parentheses. The marginal effects of the second hurdle (quantity) are conditional on the first hurdle being passed. Full results are shown in Tables A14 and A15 in the Appendix. Unconditional marginal effects are show in Table A16. * p<0.1, ** p<0.05, *** p<0.01.

4.5. Gender Disaggregation for Hired Labor

Table 8 provides gender-disaggregated results for hired labor. Here, we see notable differences for the two contract types. The marketing contract reduces the likelihood of using hired male labor by 15 percentage points, whereas it has no significant effect on the use of female hired labor. In contrast, the resource-providing contract reduces the likelihood of using female hired labor by 19 percentage points and has no significant effect on male hired labor. The unconditional marginal effects, which are shown in Table A19 in the Appendix, suggest that the resource-providing contract reduces hired female labor use by 3.4 days per acre of oil palm. This means that female agricultural laborers may potentially suffer from deteriorating employment opportunities through resource-providing contracts.

Table 8: Effects of contracts on hired labor use, by gender

	Male labor		Female labor	
	(1)	(2)	(3)	(4)
	Decision	Quantity	Decision	Quantity
	0-1	Days per acre	0-1	Days per acre
Marketing contract	-0.15**	1.89	0.10	0.88
	(0.06)	(2.67)	(0.09)	(1.80)
Resource-providing contract	0.08	-1.33	-0.19**	-2.37
	(0.05)	(2.09)	(0.09)	(2.81)
Control variables included	Yes	Yes	Yes	Yes
Residuals included	Yes	No	No	No
WTP included	No	Yes	Yes	Yes
Observations	524	401	524	214

Notes: Marginal effects from double hurdle models are shown with village cluster-corrected standard errors in parentheses. The marginal effects of the second hurdle (quantity) are conditional on the first hurdle being passed. Full results are shown in Tables A17 and A18 in the Appendix. Unconditional marginal effects are shown in Table A19. * p<0.1, ** p<0.05, *** p<0.01.

5. Conclusion

While effects of contract farming on labor use and employment were rarely analyzed in previous research, the few studies that exist suggested that contracting increases labor demand for agricultural production, harvesting, and post-harvest handling (Benali et al., 2018; Khan et al., 2019; Meemken and Bellemare, 2019; Narayanan, 2014; Neven et al., 2009; Rao and Qaim, 2013). We have provided new evidence showing that the opposite may also be true. Using survey data from the oil palm sector in Ghana, we have shown that contracts reduce total agricultural labor use per acre. The reduction is mainly observed for household labor. For hired labor, we did not identify significant effects.

Furthermore, we have shown that some of the household labor saved in oil palm production is reallocated to off-farm economic activities. Especially households with a marketing contract increase the number of labor days in off-farm emplyoment considerably. These results are in contrast to Otsuka et al. (2016) and Bellemare (2018), who argued that contract farming reduces off-farm income opportunities for farm households. Clearly, the effects depend on the context. Previous studies mostly looked at contracts for horticultural crops, which are labor-intensive and where the contracts led to additional production and post-harvest operations in order to meet specific quality requirements. This is different for oil palm contracts in Ghana. The contracts in Ghana are not associated with special quality requirements. Instead,

labor-intensive post-harvest handling, which is necessary when selling in traditional markets, falls away when selling under contract. The contracting companies pick up the oil palm fruit bunches as harvested without any on-farm processing.

While the concrete results presented here should not be generalized, the finding that contract farming can reduce agricultural labor use under certain conditions certainly holds more broadly. Due to the rising international demand for palm oil, supply chains are being modernized in many African countries. New types of processing technologies and contract schemes are gaining in importance. Similar market trends are also observed for other crops traditionally grown by African smallholders.

In addition to evaluating the effects of contract farming on total labor use, we also disaggregated the analysis by gender and age. Many of the traditional post-harvest operations in oil palm are performed by women, so we had hypothesized that contracts would reduce female labor more than male labor. This hypothesis was not supported by the empirical data. At least for household labor, reductions in male and female labor time were found to be similar in magnitude. Only for hired female labor, we found a decreasing effect through resource-providing contracts. Some gendered substitution of operations in oil palm seems to occur in the sense that a reduction in hired female labor for post-harvest operations is compensated by a slight increase in hired male labor for the application of agrochemicals. Disaggregation by age revealed that contracts significantly reduce the likelihood of using child and youth labor in oil palm.

We argue that more research on the labor market effects of contract farming is needed, as this is an under-researched topic and the effects can differ remarkably depending on the particular context. Creation of decent agricultural and non-agricultural employment is key for sustainable rural development, especially in Africa where rural population growth is still quite substantial.

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Appendix

New evidence regarding the effects of contract farming on agricultural labor use

Table A1: Regional characteristics

	Western Region (Marketing contract)	Central Region (Resource-providing contract)	Ashanti Region (Comparison)
Area classification	Tropical savanna climate	Tropical savanna climate	Tropical savanna climate
Highest temperature (monthly average)	28.86°C	28.66°C	28.63°C
Lowest temperature (monthly average)	25.09°C	25.30°C	25.22°C
Mean temperature	27.16°C	27.19°C	26.97°C
Average annual rainfall	1268.03 mm	1248.53 mm	1245.79 mm
Gross income per capita (GNI)	3782 GHS	3634 GHS	3598 GHS
Human development index (HDI)	0.609	0.541	0.603
Employment to population ratio	66.3	66.1	64.8
Rural unemployment rates	3.8%	4.1%	4.6%

Notes: Temperature and rainfall data are derived from the World Bank Climate Change Knowledge Portal and refer to monthly averages between 1991 and 2015. Mean temperature and average annual rainfall are calculated based on monthly averages. GNI and HDI are derived from the Global Data Lab 2017. Employment rates are derived from the Ghana Statistical Service, 2013.

Table A2: Likelihood-ratio tests to test the tobit model against the more general double hurdle specification

	Prob > chi2
Household labor days, per acre	0.0000
Male household labor days, per acre	0.0000
Female household labor days, per acre	0.0000
Child labor days, per acre	0.0000
Youth labor days, per acre	0.0000
Hired labor days, per acre	0.0000
Male hired labor days, per acre	0.0000
Female hired labor days, per acre	0.0000
Household days in off-farm employment	0.0000
Male days in off-farm employment	0.0000
Female days in off-farm employment	0.0000

Table A3: First-stage regressions

	For labor use models		For off-farm employment models	
	Marketing contract	Resource-providing contract	Marketing contract	Resource-providing contract
Adult household members	-0.00	0.52***	-0.01	0.15
	(0.12)	(0.16)	(0.12)	(0.13)
Education (in years)	0.05	0.03	0.04	0.02
	(0.04)	(0.04)	(0.04)	(0.04)
Experience (in years)	0.03	-0.02	0.04**	-0.03
	(0.02)	(0.02)	(0.02)	(0.02)
Female (dummy)	1.00***	0.22	0.10	-0.02
	(0.37)	(0.41)	(0.47)	(0.48)
Age (in years)	-0.01	0.07***	0.01	0.05***
	(0.01)	(0.02)	(0.01)	(0.01)
Land availability (in acres, in 2008)	-0.02*	-0.01		
	(0.01)	(0.01)		
Good soil (dummy)	-0.18	0.03		
	(0.32)	(0.41)		
Irrigation (dummy)	0.10	0.54		
	(0.34)	(0.42)		
Number of palms	0.01	0.00		
	(0.01)	(0.01)		
Age of palms (in years)	0.14***	-0.35***		
	(0.03)	(0.07)		
Distance to road (walking minutes)	0.01	-0.01		
	(0.01)	(0.01)		
Market access (km)	1.08***	0.94***	0.82***	0.85***
	(0.31)	(0.31)	(0.29)	(0.29)
Village chief (IV)	-1.22***	3.73***	-0.82**	3.04***
	(0.33)	(0.56)	(0.32)	(0.46)
Village share (IV)	10.83***	9.35***	11.41***	9.74***
	(1.47)	(1.61)	(1.47)	(1.52)
Constant	-4.51***	-6.45***	-3.35***	-7.03***
	(1.10)	(1.49)	(0.84)	(1.04)
Number of observations	524		463	
Prob>chi2	0.0000		0.0000	
Pseudo R2	0.4968			

Notes: Coefficient estimates from multinomial logit models are shown with standard errors in parentheses. The socioeconomic characteristics refer to the farmer for the plot-level analyses, and to the household head for the household-level analyses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table A4: Correlations between instruments and outcome variables

	Village share	Village chief
n=119		
Labor intensity, in days per acre	-0.0139	0.1235
	(0.7303)	(0.1807)
Household labor days, per acre	-0.0179	-0.0188
	(0.4198)	(0.1693)
Male household labor days, per acre	-0.1013	-0.0808
	(0.6110)	(0.2909)
Female household labor days, per acre	0.1009	0.0720
	(0.3842)	(0.2027)
Youth labor days, per acre	-0.1155	0.0182
	(0.3114)	(0.5981)
Child labor days, per acre	-0.0355	0.0354
	(0.6277)	(0.0889)
Hired labor days, per acre	0.1045	-0.0724
	(0.7993)	(0.8549)
Male hired labor days, per acre	0.1148	-0.0463
	(0.9369)	(0.8782)
Female hired labor days, per acre	0.0729	-0.1109
	(0.5234)	(0.5548)
n=106		
Household days for off-farm employment	-0.0768	-0.1251
	(0.4337)	(0.2021)
Male days for off-farm employment	-0.1174	-0.1430
	(0.2306)	(0.1435)
Female days for off-farm employment	0.0148	-0.0309
	(0.8805)	(0.7531)

Notes: Correlation coefficients are shown with *p*-vales in parentheses. Only comparison group farmers without contracts are included, as we want to test whether the instruments are correlated with the outcome variables through mechanisms other than contract participation.

Table A5: Test results for exogeneity of contract participation

	First hurdle	Second hurdle
Labor intensity, in days per acre	Exogeneity not rejected	
Household labor days, per acre	Exogeneity rejected	Exogeneity rejected
Male household labor days, per acre	Exogeneity rejected	Exogeneity not rejected
Female household labor days, per acre	Exogeneity rejected	Exogeneity rejected
Child labor days, per acre	Exogeneity rejected	Exogeneity not rejected
Youth labor days, per acre	Exogeneity rejected	Exogeneity rejected
Hired labor days, per acre	Exogeneity rejected	Exogeneity rejected
Male hired labor days, per acre	Exogeneity rejected	Exogeneity not rejected
Female hired labor days, per acre	Exogeneity not rejected	Exogeneity not rejected
Household days for off-farm employment	Exogeneity not rejected	Exogeneity not rejected
Male days for off-farm employment	Exogeneity not rejected	Exogeneity not rejected
Female days for off-farm employment	Exogeneity not rejected	Exogeneity rejected

Notes: The null hypothesis that contract participation is exogenous was tested based on the statistical significance of the residual terms in the second-stage regressions of the control function approach.

Table A6: Descriptive statistics of control variables

	Mean			Difference		
	Marketing contract (MC)	Resource-providing contract (RPC)	No contract (NC)	MC-RPC	MC-NC	RPC-NC
Number of adult household members	2.72	2.91	2.70			
	(0.09)	(0.09)	(0.12)			
Education of the farmer (in years)	7.91	7.42	7.28			
	(0.30)	(0.34)	(0.36)			
Experience of the farmer (in years)	20.12	15.70	17.38	***	***	
	(0.58)	(0.71)	(8.14)			
Female farmer (dummy)	0.26	0.26	0.22			
	(0.03)	(0.03)	(0.04)			
Willingness-to-pay (in 500 GHS)	2.08	2.05	2.72		***	***
	(0.13)	(0.15)	(0.19)			
Age of the farmer (in years)	52.18	55.78	49.43	***	**	***
	(0.76)	(0.88)	(1.01)			
Total land availability 2008 (in acres)	13.27	15.20	12.88			
	(0.93)	(1.30)	(1.47)			
Good soil (dummy)	0.67	0.72	0.73			
	(0.03)	(0.03)	(0.04)			
Irrigation (dummy)	0.32	0.30	0.27			
	(0.03)	(0.03)	(0.04)			
Number of palms	68.84	63.73	63.05			
	(3.02)	(2.39)	(1.24)			
Age of the palms (in years)	14.96	9.30	12.94	***	***	***
	(0.43)	(0.06)	(0.45)			
Distance to road (walking minutes)	13.03	7.97	14.36	***		***
	(1.20)	(0.98)	(1.46)			
Market access (km)	0.90	1.10	0.09		***	***
	(0.14)	(0.13)	(0.04)			

Notes: Mean values are shown with standard errors in parentheses. Good soil is a dummy variable that equals one for the most suited soils for oil palm cultivation. The suitability of the soil types was ranked with the MoFA, and an answer set of 5 types of soil was available for the farmer to choose from. Irrigation is a dummy variable that equals one if the plot is irrigated. GHS = Ghanaian Cedis. Distance to the next road is measured from the plot location to the next road that is accessible by car/truck. * p<0.1, ** p<0.05, *** p<0.01.

Table A7: Effects of contracts on agricultural labor use (full results)

	OLS	Control function
Marketing contract	-43.36***	-40.68***
	(7.89)	(8.37)
Resource-providing contract	-47.94***	-43.17***
	(6.17)	(6.30)
Adult household members	3.63	3.60
	(2.16)	(2.12)
Education (in years)	-0.21	-0.24
	(0.77)	(0.78)
Experience (in years)	-0.12	-0.09
	(0.20)	(0.20)
Age (in years)	-0.45**	-0.48**
	(0.21)	(0.22)
Female (dummy)	8.43	8.62
	(7.72)	(7.78)
Willingness-to-pay (in 500 GHS)	0.50	
	(1.08)	
Land availability (in acres, in 2008)	0.11	0.09
	(0.27)	(0.27)
Good soil (dummy)	-2.42	-2.34
	(5.70)	(5.50)
Irrigation (dummy)	-2.18	-2.07
	(2.34)	(2.41)
Number of palms	0.16***	0.17***
	(0.03)	(0.03)
Age of palms (in years)	0.51	0.64
	(0.39)	(0.48)
Distance to a road (walking minutes)	-0.08	-0.08
	(0.13)	(0.13)
Market access (in km)	-0.22	1.06
	(0.45)	(1.57)
Constant	75.48***	73.45***
	(14.92)	(15.55)
Residuals included	No	Yes
Observations	524	524
F Statistic	21.91	7.79
Prob > F	0.0000	0.0000
R-squared	0.2046	0.2065

Notes: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table A8: Double hurdle results – household labor reallocation and hired labor use

	Household labor days per acre of oil palm		Hired labor days per acre of oil palm		Household labor days in off-farm employment	
	Decision	Quantity	Decision	Quantity	Decision	Quantity
Marketing contract	-0.68**	-0.56***	-0.75***	-0.02	0.17	0.31***
	(0.30)	(0.19)	(0.21)	(0.28)	(0.12)	(0.08)
Resource-providing contract	-1.77***	-0.81***	0.01	0.06	-0.04	0.21**
	(0.26)	(0.14)	(0.20)	(0.15)	(0.12)	(0.09)
Adult household members	0.20***	0.15***	-0.15**	-0.03	0.16***	0.08**
	(0.05)	(0.05)	(0.07)	(0.05)	(0.05)	(0.03)
Education (in years)	-0.04**	-0.02	0.06***	0.00	0.02*	0.01
	(0.02)	(0.01)	(0.01)	(0.02)	(0.01)	(0.01)
Experience (in years)	0.01*	0.02*	-0.03***	0.01	-0.01	-0.00
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Female (dummy)	-0.51***	-0.08	0.61***	0.38***	0.25	0.11
	(0.17)	(0.13)	(0.12)	(0.15)	(0.18)	(0.14)
Willingness-to-pay (in 500 GHS)					-0.01	-0.03
					(0.03)	(0.02)
Age (in years)	-0.06***	-0.01***	0.02***	0.00	-0.02***	-0.00
	(0.01)	(0.01)	(0.00)	(0.01)	(0.01)	(0.01)
Land availability (in acres, in 2008)	-0.03***	-0.02**	0.03***	0.01***	-0.00	0.00
	(0.01)	(0.01)	(0.01)	(0.00)	(0.00)	(0.00)
Good soil (dummy)	-0.09	-0.24	-0.04	0.01		
	(0.15)	(0.19)	(0.17)	(0.10)		
Irrigation (dummy)	-0.44***	-0.04	0.01	0.12		
	(0.12)	(0.13)	(0.17)	(0.10)		
Number of palms	-0.00	0.01**	-0.00**	0.00***		
	(0.00)	(0.00)	(0.00)	(0.00)		
Age of palms (in years)	0.02	0.00	-0.01	-0.00		
	(0.02)	(0.01)	(0.01)	(0.02)		
Distance to road (walking minutes	-0.01	-0.00	0.00	-0.00		
	(0.01)	(0.00)	(0.00)	(0.00)		
Market access (km)	0.18***	0.12*	-0.11**	-0.06	0.03	-0.06*
	(0.06)	-0.01***	(0.05)	(0.06)	(0.02)	(0.03)
Constant	4.93***	3.37***	0.21	1.69***	0.67*	4.89***
	(0.48)	(0.48)	(0.44)	(0.52)	(0.39)	(0.31)
Residuals included	Yes	Yes	Yes	Yes	No	Yes
Observations	524	381	524	422	463	249
Prob>chi2	0.0000		0.0000		0.0000	
Pseudo R2	0.0947		0.0455		0.0170	

Notes: Cluster corrected standard errors in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table A9: Marginal effects – household labor reallocation and hired labor use

	Household labor days per acre of oil palm		Hired labor days per acre of oil palm		Household labor days in off-farm employment	
	Decision	Quantity	Decision	Quantity	Decision	Quantity
Marketing contract	-0.14**	-16.28***	-0.18***	-0.51	0.06	81.96***
	(0.06)	(5.81)	(0.05)	(5.91)	(0.04)	(22.93)
Resource-providing contract	-0.37***	-23.50***	0.00	1.25	-0.01	54.12**
	(0.05)	(4.90)	(0.05)	(3.29)	(0.04)	(24.55)
Adult household members	0.04***	4.38***	-0.04**	-0.67	0.06***	20.79**
	(0.01)	(1.57)	(0.02)	(1.12)	(0.02)	(8.43)
Education (in years)	-0.01**	-0.60	0.01***	0.10	0.01*	1.60
	(0.00)	(0.39)	(0.00)	(0.36)	(0.01)	(3.13)
Experience (in years)	0.00	0.44*	-0.01***	0.21	-0.00	-0.18
	(0.00)	(0.23)	(0.00)	(0.14)	(0.00)	(1.65)
Female (dummy)	-0.11***	-2.35	0.14***	8.04**	0.10	29.80
	(0.04)	(3.90)	(0.03)	(3.32)	(0.07)	(37.10)
Willingness-to-pay (in 500 GHS)					-0.01	-8.60
					(0.01)	(6.24)
Age (in years)	-0.01***	-0.39***	0.01***	0.07	-0.01***	-0.09
	(0.00)	(0.15)	(0.00)	(0.12)	(0.00)	(1.39)
Land availability (in acres, in 2008)	-0.01***	-0.53**	0.01***	0.16***	-0.00	1.21
	(0.00)	(0.22)	(0.00)	(0.06)	(0.00)	(0.80)
Good soil (dummy)	-0.02	-6.96	-0.01	0.23		
	(0.03)	(5.49)	(0.04)	(2.10)		
Irrigation (dummy)	-0.09***	-1.26	0.00	2.48		
	(0.02)	(3.83)	(0.04)	(1.95)		
Number of palms	-0.00	0.20**	-0.00**	0.07**		
	(0.00)	(0.10)	(0.00)	(0.03)		
Age of palms (in years)	0.01	0.02	-0.00	-0.03		
	(0.00)	(0.28)	(0.00)	(0.35)		
Distance to road (walking minutes)	-0.00	-0.07	0.00	-0.07		
	(0.00)	(0.14)	(0.00)	(0.08)		
Market access (km)	0.04***	3.37*	-0.02*	-1.19	0.01	-14.49*
	(0.01)	(2.01)	(0.01)	(1.34)	(0.01)	(8.55)
Residuals included	Yes	No	Yes	Yes	No	Yes
Observations	524	381	524	422	463	249

Notes: Cluster corrected standard errors in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table A10: Unconditional marginal effects – household labor reallocation and hired labor use

	Household labor days per acre of oil palm	Hired labor days per acre of oil palm	Household labor days in off-farm employment
Marketing contract	-16.43***	-3.77	61.10***
	(4.63)	(5.30)	(22.84)
Resource-providing contract	-27.15***	1.07	25.37
	(4.37)	(2.85)	(19.12)
Adult household members	4.50***	-1.22	26.89***
	(1.26)	(1.01)	(7.19)
Education (in years)	-0.66*	0.33	3.22
	(0.34)	(0.31)	(2.60)
Experience (in years)	0.42**	0.05	-0.98
	(0.20)	(0.14)	(1.27)
Female (dummy)	-4.20	9.37***	41.06
	(3.24)	(3.15)	(25.68)
Willingness-to-pay (in 500 GHS)			-6.00
			(4.90)
Age (in years)	-0.57***	0.17*	-2.00**
	(0.13)	(0.10)	(0.96)
Land availability (in acres, in 2008)	-0.55***	0.25***	0.32
	(0.20)	(0.06)	(0.44)
Good soil (dummy)	-6.15	0.03	
	(4.70)	(1.67)	
Irrigation (dummy)	-3.00	2.10	
	(3.05)	(1.98)	
Number of palms	0.16**	0.05*	
	(0.08)	(0.03)	
Age of palms (in years)	0.12	-0.07	
	(0.24)	(0.32)	
Distance to road (walking minutes	-0.09	-0.03	
	(0.11)	(0.07)	
Market access (in km)	3.57**	-1.46	-5.27
	(1.57)	(1.14)	(5.06)
Observations	524	524	524

Notes: Cluster corrected standard errors in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table A11: Double hurdle results – household labor use**,** by gender and age

	Male household labor		Female household labor		Child household labor		Youth household labor	
	Decision	Quantity	Decision	Quantity	Decision	Quantity	Decision	Quantity
Marketing contract	-0.62***	-0.68***	-0.43**	-0.49***	-0.52**	-0.72	-0.65**	-1.65***
	(0.19)	(0.16)	(0.21)	(0.16)	(0.25)	(0.87)	(0.26)	(0.44)
Resource-providing contract	-1.48***	-0.76***	-1.40***	-0.76***	-1.04***	-1.57***	-0.63**	0.80
	(0.23)	(0.19)	(0.23)	(0.18)	(0.15)	(0.42)	(0.31)	(0.54)
Adult household members	0.25***	0.10**	0.29***	0.04	0.01	0.08	0.04	0.08
	(0.06)	(0.05)	(0.06)	(0.07)	(0.07)	(0.19)	(0.03)	(0.15)
Education (in years)	-0.01	-0.03*	-0.03*	-0.00	-0.05*	0.00	-0.05**	0.01
	(0.02)	(0.02)	(0.02)	(0.02)	(0.03)	(0.04)	(0.03)	(0.04)
Experience (in years)	0.01	0.01	-0.01	0.03***	-0.00	-0.00	-0.01	0.03*
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.01)	(0.02)
Gender (dummy)	-1.42***	-0.28	0.38**	0.36**	-0.34	0.07	-0.42	0.43
	(0.13)	(0.22)	(0.18)	(0.15)	(0.27)	(0.70)	(0.28)	(0.33)
Willingness-to-pay (in 500 GHS)		-0.03				-0.14		
		(0.04)				(0.15)		
Age (in years)	-0.05***	-0.01***	-0.02***	-0.01**	-0.00	-0.06**	0.01	0.02
	(0.01)	(0.00)	(0.01)	(0.01)	(0.01)	(0.02)	(0.01)	(0.02)
Land availability (in acres, in 2008)	-0.02***	-0.02	-0.01***	-0.02**	-0.01	-0.03***	-0.01	-0.02**
	(0.00)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Good soil (dummy)	-0.08	-0.19	0.06	-0.20	0.43**	0.30	0.26	0.25
	(0.15)	(0.20)	(0.10)	(0.17)	(0.18)	(0.54)	(0.17)	(0.37)
Irrigation (dummy)	-0.42***	-0.06	-0.14	0.07	0.49***	-0.29	0.23	-0.34
	(0.11)	(0.11)	(0.18)	(0.17)	(0.19)	(0.41)	(0.19)	(0.38)
Number of palms	-0.00	0.00	0.00	0.00	0.00***	0.00	0.00	0.01
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.00)	(0.01)
Age of palms (in years)	0.03**	-0.01	0.02	0.00	0.00	0.11***	0.03**	0.13***
	(0.01)	(0.01)	(0.02)	(0.01)	(0.02)	(0.03)	(0.01)	(0.04)
Distance to road (walking min.)	-0.01**	-0.00	-0.01***	0.01	-0.00	-0.02	-0.01	-0.00
	(0.00)	(0.00)	(0.00)	(0.01)	(0.01)	(0.01)	(0.01)	(0.00)
Market access (km)	0.19***	0.00	0.16**	0.13**	-0.08	0.50***	-0.17	1.11***
	(0.05)	(0.03)	(0.06)	(0.06)	(0.06)	(0.12)	(0.11)	(0.29)
Constant	3.96***	3.61***	1.45***	2.61***	-0.76	3.95***	-0.98*	-2.49
	(0.61)	(0.54)	(0.45)	(0.45)	(0.58)	(1.12)	(0.55)	(1.84)
Residuals included	Yes	No	Yes	Yes	Yes	No	Yes	Yes
Observations	524	343	524	270	524	46	524	58
Prob>chi2	0.0000		0.0000		0.0000		0.0014	
Pseudo R2	0.1112		0.1040		0.1803		0.1411	

Notes: Cluster corrected standard errors in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table A12: Marginal effects – household labor use**,** by gender and age

	Male household labor		Female household labor		Child household labor		Youth household labor	
	Decision	Quantity	Decision	Quantity	Decision	Quantity	Decision	Quantity
Marketing contract	-0.14***	-12.34***	-0.13**	-7.51***	-0.07**	-32.33	-0.10**	-2.97
	(0.04)	(3.21)	(0.07)	(2.56)	(0.03)	(30.23)	(0.04)	(8.23)
Resource-providing contract	-0.33***	-13.77***	-0.43***	-11.63***	-0.13***	-71.05	-0.10**	-13.21
	(0.05)	(3.68)	(0.07)	(2.79)	(0.02)	(95.56)	(0.05)	(29.06)
Adult household members	0.06***	1.83**	0.09***	0.67	0.00	3.42	0.01	1.33
	(0.01)	(0.91)	(0.02)	(1.10)	(0.01)	(12.50)	(0.01)	(3.37)
Education (in years)	-0.00	-0.56*	-0.01**	-0.07	-0.01*	0.22	-0.01**	-0.25
	(0.01)	(0.30)	(0.00)	(0.28)	(0.00)	(1.84)	(0.00)	(0.58)
Experience (in years)	0.00	0.18	-0.00	0.40***	-0.00	-0.14	-0.00	0.28
	(0.00)	(0.15)	(0.00)	(0.14)	(0.00)	(0.71)	(0.00)	(0.63)
Gender (dummy)	-0.32***	-5.12	0.12**	5.57**	-0.04	3.24	-0.07	4.81
	(0.02)	(4.04)	(0.05)	(2.26)	(0.04)	(30.17)	(0.04)	(11.28)
Willingness-to-pay (in 500 GHS)		-0.58				-6.37		-0.04
		(0.78)				(13.61)		(1.17)
Age (in years)	-0.01***	-0.22***	-0.01***	-0.22**	-0.00	-2.52	0.00	0.31
	(0.00)	(0.08)	(0.00)	(0.10)	(0.00)	(4.45)	(0.00)	(0.85)
Land availability (in acres, in 2008)	-0.01***	-0.28	-0.00***	-0.25**	-0.00	-1.33	-0.00	-0.38
	(0.00)	(0.18)	(0.00)	(0.11)	(0.00)	(1.93)	(0.00)	(0.67)
Good soil (dummy)	-0.02	-3.39	0.02	-3.08	0.06**	13.72	0.04	7.13
	(0.03)	(3.56)	(0.03)	(2.65)	(0.02)	(32.73)	(0.03)	(15.17)
Irrigation (dummy)	-0.09***	-1.08	-0.04	1.02	0.06***	-12.90	0.04	-4.27
	(0.02)	(2.05)	(0.05)	(2.59)	(0.02)	(25.51)	(0.03)	(11.07)
Number of palms	-0.00	0.07	0.00	0.07	0.00***	0.06	0.00	0.21
	(0.00)	(0.06)	(0.00)	(0.05)	(0.00)	(0.48)	(0.00)	(0.51)
Age of palms (in years)	0.01**	-0.16	0.01	0.01	0.00	4.91	0.01**	1.97
	(0.00)	(0.24)	(0.01)	(0.14)	(0.00)	(7.43)	(0.00)	(3.24)
Distance to road (walking min.)	-0.00*	-0.00	-0.00***	0.09	-0.00	-0.74	-0.00	-0.16
	(0.00)	(0.08)	(0.00)	(0.09)	(0.00)	(1.30)	(0.00)	(0.35)
Market access (km)	0.04***	0.04	0.05**	1.93**	-0.01	22.72	-0.03	5.07
	(0.01)	(0.50)	(0.02)	(0.91)	(0.01)	(37.17)	(0.02)	(9.65)
Residuals included	Yes	No	Yes	Yes	Yes	No	Yes	Yes
Observations	524	343	524	270	524	46	524	58

Notes: Cluster corrected standard errors in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table A13: Unconditional marginal effects – household labor use**,** by gender and age

	Male household labor	Female household labor	Child household labor	Youth household labor
Marketing contract	-11.34***	-6.52***	-1.83	-76.93
	(2.46)	(1.82)	(1.21)	(360.96)
Resource-providing contract	-15.40***	-13.31***	-3.84***	-27.60
	(2.74)	(2.03)	(1.15)	(147.52)
Adult household members	2.23***	1.69**	0.11	4.18
	(0.67)	(0.68)	(0.31)	(20.47)
Education (in years)	-0.46**	-0.17	-0.08	-3.34
	(0.21)	(0.21)	(0.06)	(16.73)
Experience (in years)	0.17	0.21**	-0.01	-0.34
	(0.11)	(0.11)	(0.04)	(2.19)
Gender (dummy)	-8.76***	5.13***	-0.50	-20.56
	(3.11)	(1.59)	(0.84)	(106.78)
Willingness-to-pay (in 500 GHS)	-0.43		-0.18	
	(0.58)		(0.21)	
Age (in years)	-0.34***	-0.23***	-0.08**	0.74
	(0.08)	(0.08)	(0.04)	(3.49)
Land availability (in acres, in 2008)	-0.29**	-0.22***	-0.05**	-1.08
	(0.14)	(0.08)	(0.02)	(5.08)
Good soil (dummy)	-2.82	-1.64	1.15*	22.45
	(2.85)	(1.84)	(0.64)	(106.58)
Irrigation (dummy)	-2.27	0.05	0.49	9.06
	(1.54)	(1.90)	(0.43)	(53.24)
Number of palms	0.05	0.05	0.01	0.26
	(0.04)	(0.03)	(0.01)	(1.12)
Age of palms (in years)	-0.01	0.10	0.14*	4.79
	(0.17)	(0.07)	(0.08)	(21.57)
Distance to road (walking min.)	-0.03	0.01	-0.03	-0.42
	(0.06)	(0.06)	(0.02)	(2.07)
Market access (km)	0.70*	1.87***	0.50**	10.03
	(0.39)	(0.58)	(0.25)	(38.77)
Observations	524	524	524	524

Notes: Cluster corrected standard errors in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table A14: Double hurdle results – off-farm employment

	Male off-farm employment		Female off-farm employment	
	Decision	Quantity	Decision	Quantity
Marketing contract	-0.18	0.45***	0.35**	-0.06
	(0.16)	(0.13)	(0.16)	(0.18)
Resource-providing contract	-0.15	0.36**	-0.06	0.27
	(0.13)	(0.15)	(0.17)	(0.22)
Adult household members	0.07	0.05	0.20***	-0.00
	(0.05)	(0.05)	(0.04)	(0.04)
Education (in years)	0.03*	0.00	0.00	0.01
	(0.02)	(0.02)	(0.02)	(0.01)
Experience (in years)	-0.00	0.00	-0.02***	0.01
	(0.01)	(0.01)	(0.01)	(0.01)
Gender (dummy)	-0.81***	0.02	0.84***	-0.06
	(0.16)	(0.28)	(0.17)	(0.13)
Willingness-to-pay (in 500 GHS)	0.02	-0.06*	-0.03	
	(0.04)	(0.03)	(0.04)	
Age (in years)	-0.03***	0.00	-0.00	-0.01
	(0.01)	(0.01)	(0.01)	(0.01)
Land availability (in acres, in 2008)	-0.00	0.00	0.00	-0.00
	(0.00)	(0.00)	(0.00)	(0.00)
Market access (in km)	-0.01	-0.09**	0.04	-0.12**
	(0.03)	(0.04)	(0.04)	(0.05)
Constant	0.71*	4.56***	-0.88**	5.58***
	(0.37)	(0.31)	(0.41)	(0.37)
Residuals included	No	No	No	Yes
Observations	463	151	463	130
Prob>Chi2	0.0005		0.0000	
Pseudo R2	0.0351		0.0315	

Notes: Cluster corrected standard errors in parentheses. * p < 0.1, ** p < 0.05, *** p < 0.01.

Table A15: Marginal effects – off-farm employment

	Male off-farm employment		Female off-farm employment	
	Decision	Quantity	Decision	Quantity
Marketing contract	-0.06	104.68***	0.11**	-15.52
	(0.05)	(33.89)	(0.05)	(46.01)
Resource-providing contract	-0.05	82.85**	-0.02	69.59
	(0.04)	(37.14)	(0.05)	(57.47)
Adult household members	0.02	12.69	0.06***	-0.83
	(0.02)	(11.32)	(0.01)	(10.83)
Education (in years)	0.01*	0.73	0.00	2.25
	(0.01)	(4.12)	(0.01)	(3.35)
Experience (in years)	-0.00	0.63	-0.01***	2.29
	(0.00)	(2.55)	(0.00)	(2.04)
Gender (dummy)	-0.26***	5.12	0.26***	-14.61
	(0.05)	(64.40)	(0.05)	(34.82)
Willingness-to-pay (in 500 GHS)	0.01	-14.52*	-0.01	
	(0.01)	(8.21)	(0.01)	
Age (in years)	-0.01***	0.66	-0.00	-2.34
	(0.00)	(1.67)	(0.00)	(1.60)
Land availability (in acres, in 2008)	-0.00	0.58	0.00	-0.05
	(0.00)	(0.77)	(0.00)	(0.61)
Market access (km)	-0.00	-20.45**	0.01	-31.15**
	(0.01)	(10.13)	(0.01)	(14.33)
Residuals included	No	No	No	Yes
Observations	463	151	463	130

Notes: Cluster corrected standard errors in parentheses. * p < 0.1, ** p < 0.05, *** p < 0.01.

Table A16: Unconditional marginal effects – off-farm employment

	Male off-farm employment	Female off-farm employment
Marketing contract	19.34	23.14
	(18.77)	(16.64)
Resource-providing contract	14.56	14.52
	(16.10)	(17.97)
Adult household members	9.36**	15.84***
	(4.55)	(3.61)
Education (in years)	2.52	0.99
	(2.04)	(2.25)
Experience (in years)	0.04	-1.12
	(1.32)	(0.92)
Gender (dummy)	-58.80***	62.33***
	(21.94)	(15.80)
Willingness-to-pay (in 500 GHS)	-3.26	-2.34
	(3.93)	(2.92)
Age (in years)	-1.69**	-1.00
	(0.76)	(0.61)
Land availability (in acres, in 2008)	0.11	0.34
	(0.27)	(0.41)
Market access (km)	-6.80	-5.62*
	(4.94)	(2.98)
Observations	463	463

Notes: Cluster corrected standard errors in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table A17: Double hurdle results – hired labor use**,** by gender

	Male hired labor		Female hired labor	
	Decision	Quantity	Decision	Quantity
Marketing contract	-0.57**	0.13	0.29	0.07
	(0.22)	(0.18)	(0.28)	(0.14)
Resource-providing contract	0.31	-0.09	-0.56**	-0.19
	(0.20)	(0.14)	(0.28)	(0.23)
Adult household members	-0.12**	-0.03	-0.12**	0.10
	(0.05)	(0.06)	(0.05)	(0.06)
Education (in years)	0.06***	0.01	0.03**	-0.01
	(0.01)	(0.02)	(0.02)	(0.02)
Experience (in years)	-0.02*	0.00	-0.01	0.01
	(0.01)	(0.01)	(0.01)	(0.01)
Gender (dummy)	0.84***	0.43***	-0.08	0.27*
	(0.13)	(0.10)	(0.17)	(0.15)
Willingness-to-pay (in 500 GHS)		-0.02	-0.03	-0.01
		(0.04)	(0.04)	(0.04)
Age (in years)	0.02***	0.01	0.02***	-0.01
	(0.01)	(0.00)	(0.01)	(0.01)
Land availability (in acres, in 2008)	0.02*	0.01**	0.02***	0.00
	(0.01)	(0.00)	(0.01)	(0.00)
Good soil (dummy)	-0.06	-0.00	0.19	-0.07
	(0.16)	(0.09)	(0.17)	(0.19)
Irrigation (dummy)	0.13	0.14	0.10	0.09
	(0.13)	(0.09)	(0.17)	(0.10)
Number of palms	-0.00	0.00***	-0.00	0.00***
	(0.00)	(0.00)	(0.00)	(0.00)
Age of palms (in years)	-0.00	-0.01	-0.01	0.00
	(0.01)	(0.01)	(0.02)	(0.02)
Distance to road (walking min.)	0.00	-0.00	0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)
Market access (km)	-0.09	-0.06**	-0.00	0.01
	(0.06)	(0.03)	(0.04)	(0.03)
Constant	-0.34	1.48***	-1.35**	1.73***
	(0.47)	(0.34)	(0.54)	(0.47)
			0.29	0.07
Residuals included	Yes	No	No	No
Observations	524	401	524	214
Prob>chi2	0.0000		0.0000	
Pseudo R2	0.0495		0.0581	

Notes: Cluster corrected standard errors in parentheses. * p < 0.1, ** p < 0.05, *** p < 0.01.

Table A18: Marginal effects – hired labor use**,** by gender

	Male hired labor		Female hired labor	
	Decision	Quantity	Decision	Quantity
Marketing contract	-0.15**	1.89	0.10	0.88
	(0.06)	(2.67)	(0.09)	(1.80)
Resource-providing contract	0.08	-1.33	-0.19**	-2.37
	(0.05)	(2.09)	(0.09)	(2.81)
Adult household members	-0.03**	-0.44	-0.04**	1.21
	(0.01)	(0.82)	(0.02)	(0.78)
Education (in years)	0.02***	0.12	0.01**	-0.08
	(0.00)	(0.28)	(0.01)	(0.22)
Experience (in years)	-0.00*	0.04	-0.00	0.10
	(0.00)	(0.11)	(0.00)	(0.12)
Gender (dummy)	0.22***	6.26***	-0.03	3.45*
	(0.03)	(1.80)	(0.06)	(2.07)
Willingness-to-pay (in 500 GHS)		-0.36	-0.01	-0.08
		(0.58)	(0.01)	(0.52)
Age (in years)	0.01***	0.09	0.01***	-0.10
	(0.00)	(0.07)	(0.00)	(0.08)
Land availability (in acres, in 2008)	0.00*	0.09**	0.01***	0.02
	(0.00)	(0.04)	(0.00)	(0.05)
Good soil (dummy)	-0.02	-0.04	0.06	-0.85
	(0.04)	(1.30)	(0.06)	(2.41)
Irrigation (dummy)	0.03	2.09	0.03	1.20
	(0.03)	(1.30)	(0.06)	(1.19)
Number of palms	-0.00	0.06**	-0.00	0.05***
	(0.00)	(0.02)	(0.00)	(0.01)
Age of palms (in years)	-0.00	-0.13	-0.00	0.04
	(0.00)	(0.19)	(0.01)	(0.25)
Distance to road (walking min.)	0.00	-0.03	0.00	0.01
	(0.00)	(0.06)	(0.00)	(0.03)
Market access (in km)	-0.02	-0.94**	-0.00	0.13
	(0.02)	(0.45)	(0.01)	(0.43)
Residuals included	Yes	No	No	No
Observations	524	401	524	214

Notes: Cluster corrected standard errors in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table A19: Unconditional marginal effects – hired labor use**,** by gender

	Male hired labor	Female hired labor
Marketing contract	-0.49	1.59
	(2.40)	(0.97)
Resource-providing contract	0.05	-3.37**
	(1.62)	(1.45)
Adult household members	-0.76	-0.00
	(0.72)	(0.32)
Education (in years)	0.32	0.10
	(0.22)	(0.10)
Experience (in years)	-0.03	0.01
	(0.10)	(0.07)
Gender (dummy)	7.93***	1.09
	(1.77)	(1.03)
Willingness-to-pay (in 500 GHS)	-0.28	-0.15
	(0.46)	(0.21)
Age (in years)	0.15**	0.05
	(0.06)	(0.04)
Land availability (in acres, in 2008)	0.13**	0.11***
	(0.05)	(0.02)
Good soil (dummy)	-0.25	0.46
	(0.92)	(1.22)
Irrigation (dummy)	2.13*	0.94
	(1.23)	(0.84)
Number of palms	0.04**	0.02***
	(0.02)	(0.01)
Age of palms (in years)	-0.11	-0.02
	(0.18)	(0.14)
Distance to road (walking min.)	-0.02	0.02
	(0.05)	(0.02)
Market access (km)	-1.05**	0.05
	(0.44)	(0.22)
Observations	524	524

Notes: Cluster corrected standard errors in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.