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Effects of marketing contracts and resource-providing contracts in the African small farm sector: Insights from oil palm production in Ghana

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ABSTRACT

Smallholder farmers in developing countries often suffer from high risk and limited market access. Contract farming may improve the situation under certain conditions. Several studies analyzed effects of contracts on smallholder productivity and income with mixed results. Most existing studies focused on one particular contract scheme. Contract characteristics rarely differ within one scheme, so little is known about how different contract characteristics may influence the benefits for smallholders. Here, we address this research gap using data from oil palm farmers in Ghana who participate in different contract schemes. Some of the farmers have simple marketing contracts, while others have resource-providing contracts where the buyer also offers inputs and technical services on credit. A comparison group cultivates oil palm without any contract. Regression models that control for selection bias show that resource-providing contracts increase farmers' input use and yield. Resource-providing contracts also incentivize higher levels of specialization and an increase in the scale of production. These effects are especially pronounced for small and medium-sized farms. In contrast, the marketing contracts have no significant effects on input use, productivity, and scale of production. The results suggest that resource-providing contracts alleviate market access constraints, while the marketing contracts do not.

1. Introduction

Participation of smallholder farmers in modern supply chains is an important element of rural economic development and poverty reduction. However, market access for smallholders is often limited due to weak infrastructure, high risk, and other types of market failures (Barrett et al., 2012; Miyata et al., 2009). Market failures lead to under-investment in farm inputs, technologies, and profitable high-value crops (Otsuka et al., 2016; Wang et al., 2014a). Small farms are often more affected by market failures than large farms, which can perpetuate and further aggravate existing inequalities (Minot and Sawyer, 2016; Ton et al., 2018). Contract farming is an institutional response to market failures, which can help reduce production and marketing risk and thus increase smallholder investment, productivity, and income (Eaton and Shepherd, 2001; Key and Runsten, 1999; Simmons et al., 2005; Wang et al., 2014b).

Various studies analyzed effects of contracts on farm production and household welfare (e.g., Key and Runsten, 1999; Mishra et al., 2018; Rao et al., 2012; Simmons et al., 2005; Tripathi et al., 2005). Recent review articles revealed that the results are mixed, which may be due to differences in terms of the commodities produced or the broader socioeconomic and institutional conditions (Bellemare and Bloem, 2018; Ton et al., 2018). Differences in contract characteristics may also play a role (Ochieng et al., 2017). One major difference in contract characteristics exists between simple marketing contracts that only offer a secure sales market, and resource-providing contracts that additionally provide credit, inputs, and other technical services. Marketing contracts and resource-providing contracts can have differential effects on farmers' market access, risk, investment, and production behavior, but a comparison of effects has rarely been performed. Most existing studies only observed one type of contract in one setting. Comparison across such case studies from different settings is difficult because of many possible confounding factors that one cannot easily control for.

A few studies examined contracts involving several commodities (Miyata et al., 2009; Narayanan, 2014; Simmons et al., 2005) or several companies (Ragasa et al., 2018), yet mostly without explicitly analyzing the effects of varying contract characteristics. Two exceptions are Mishra et al. (2016) and Ashraf et al. (2009). Mishra et al. (2016) investigated effects of contracts on smallholder seed producers in Nepal, suggesting that resource-providing contracts may have larger effects than simple marketing contracts. However, in their study the number of farmers operating under the different contract types was relatively small. Ashraf et al. (2009) used a randomized controlled trial (RCT) to compare effects of contracts with and without credit in the Kenyan horticultural sector. They found that the provision of credit as part of the contract increased farmers' participation rates but had no additional effect on income. Effects on farmers' cropping patterns and longer-term investment decisions were not analyzed, because the evaluation was conducted shortly after the RCT treatments.

We add to the research direction by evaluating and comparing the effects of marketing contracts and resource-providing contracts on farmers' input use, productivity, and longer-term cropping decisions in the palm oil sector of Ghana. In Ghana, as in several other countries of West Africa, oil palm recently gained in importance and is now one of the most important cash crops produced (Rhebergen et al., 2016). However, limited adoption of modern technologies and low productivity remain important challenges for the sector. Productivity increases are required to meet the rapidly rising demand for vegetable oil in West Africa. In comparison to other local crops, oil palm is relatively capital-intensive, especially for plantation establishment but also to pay for regular inputs. To overcome market limitations, increase production, and ensure stable supply, palm oil processing companies in Ghana have established various types of contractual arrangements with farmers.

We use survey data collected in Ghana in 2018 and different approaches to reduce issues of selection bias. The main research question is whether producing oil palm under a contract has effects on farmers' cropping patterns, investments, and yields and whether the effects of resource-providing contracts differ from those of simple marketing contracts. We analyze average effects and additionally also disaggregate by farm size to better understand distributional implications.

2. Conceptual Framework

Contract farming involves a contractual arrangement between a buyer – typically a processing company – and the farmer as a seller. Contracts specify prices and quantities of the commodity produced prior to the harvest, and possibly other details related to the production process. Contracts can be beneficial for both the farmer and the company, as they reduce marketing and procurement risks (Eaton and Shepherd, 2001; Key and Runsten, 1999; Otsuka et al., 2016). However, different types of contracts can have different effects.

One major difference in terms of contract characteristics exists between simple marketing contracts and resource-providing contracts. Farmers with a simple marketing contract have a secure sales market with a specified price. High risk in the small farm sector is a major impediment for technology adoption and more intensified production. Hence, a contract that reduces marketing risk may increase technology adoption, input use, and thus also yield and income (Anbarassan et al., 2016; Bellemare, 2012). Several empirical studies confirmed positive effects of marketing contracts on farm productivity and income (Andersson et al., 2015; Henningsen et al., 2015; Michelson, 2013; Rao et al., 2012). However, there are also other studies that found no significant effects of marketing contracts, suggesting that a secure sales market alone may be insufficient to overcome failures in credit and input markets (Hernández et al., 2007; Mwambi et al., 2016). Such failures in credit and input markets are explicitly addressed in resource-providing contracts, where the buying company also supplies inputs and technical advice to farmers, usually deducting the cost of these services from farmers' sales. Indeed, many empirical studies found that resource-providing contracts increase farmers' input use, yield, and specialization on the contracted crop (Bolwig et al., 2009; Champika and Abeywickrama, 2014; Maertens and Velde, 2017; Miyata et al., 2009; Ragasa et al., 2018; Warning and Key, 2002). However, depending on the situation, resource-providing contracts can also be associated with problems of side-selling (Otsuka et al., 2016).

Marketing contracts and resource-providing contracts can have different effects, especially in situations where technological upgrading requires larger investments and where access to credit and input markets is limited. Indeed, the available literature suggests that the effects of marketing contracts are more diverse and smaller in magnitude than the effects of resource-providing contracts (Otsuka et al., 2016). And studies that found positive effects of marketing contracts were often related to the vegetable sector (Andersson et al., 2015; Ashraf et al., 2009; Michelson, 2013; Rao et al., 2012), where investment requirements are low or moderate. In plantation crops – such as tea, cocoa, or oil palm – where the initial establishment costs are higher, simple marketing contracts may have smaller effects than resource-providing contracts, although a comparison under otherwise similar conditions has not been made before.

For oil palm in Ghana, we hypothesize that marketing contracts have smaller effects on input use and yield than resource-providing contracts, as oil palm is a capital-intensive crop and credit and input market failures are commonplace outside of contractual arrangements. We also hypothesize that resource-providing contracts may incentivize farmers to specialize more on oil palm at the expense of other cash crops for which no contracts are available. In the study region in Ghana, land is often not the most limiting factor. Farmers typically have more land available than what they can cultivate given their capital and labor constraints.

Hence, some of the farmers' land remains uncultivated. Against this background, resource-providing contracts, which help to ease farmers' capital constraints, may lead to more land being cultivated and a larger scale of production. The same effects are not expected for simple marketing contracts.

These hypotheses are tested empirically below. In addition to looking at average effects of marketing and resource-providing contracts, we will also carry out the analysis for different subsamples, distinguishing between small-, medium-, and large-scale farmers. Small farms usually suffer most from market access constraints, so we hypothesize that they may also benefit more from resource-providing contracts than large farms.

3. Survey and Sampling Design

3.1. Study Area and Contract Types

This study uses cross-sectional data from a survey of oil palm farmers conducted in Ghana in 2018. The survey covers the Central, Western, and Ashanti Regions in the southern parts of Ghana. Oil palm is native to West Africa and has been grown by local farmers on a small scale since long. Traditionally, farmers have milled the oil palm fruits at home, in order to use the oil for home consumption of for sales in local markets (Byerlee et al., 2017). However, the demand for vegetable oil has increased considerably during the last 20 years, both for direct consumption and for processing in the food and cosmetics industries, so that larger processing plants were gradually established. We identified four large palm oil processing companies in the study area in southern Ghana, namely Benso Oil Palm Plantation, Ghana Oil Palm Development Company, Norpalm Ghana Limited, and Twifo Oil Palm Plantation. Out of these four companies, we selected two based on differences in their contract characteristics and geographical proximity – both key criteria for meaningful evaluation and comparison of contract effects.

Table 1 provides an overview of the two selected companies and their contract characteristics. Benso Oil Palm Plantation (BOPP) is a subsidiary of Wilmar International Limited, whereas Twifo Oil Palm Plantation (TOPP) is owned by Unilever. Both companies operate a centrally managed, nucleus estate oil palm plantation. However, as the processing capacities are larger than what the nucleus estate plantations produce, both companies also contract smallholder oil palm producers.[1] BOPP is using simple marketing contracts, whereas TOPP is using resource-providing contracts. Both companies have been active in the region with the same types of contracts for more than 10 years. Hence, we are able to analyze possible short-term and longer-term effects on farmers' investment decisions and outcomes. The companies buy fresh oil palm fruit bunches from farmers without any quality differentiation.

Table 1: Company and contract characteristics

	Marketing contract (Western Region)	Resource-providing contract (Central Region)
Company name	Benso Oil Palm Plantation (BOPP)	Twifo Oil Palm Plantation (TOPP)
Company owner	Wilmar International Limited	Unilever
Location	Western Region	Central Region
Size of nucleus estate	4700 hectares	4300 hectares
Processing capacity	20 tons per hour	30 tons per hour
Contract	Verbal	Written
Resources provided on credit	None	Plot setup, agrochemicals, tools, labor
Average price per ton	335 Ghanaian Cedis (GHS)	310 Ghanaian Cedis (GHS)

The BOPP marketing contracts are agreements between the company and farmers in which only the price is fixed. Farmers harvest and sell from their own-established oil palm plots without receiving inputs or production-related services from the company. Even though the contracts are verbal in nature, farmers clearly perceive BOPP as a secure market, as they can always sell the quantities harvested to the company at the specified price. The company depends on farmers' regular sales to be able to operate at full processing capacity.

[1] Such combinations of nucleus estate and smallholder contract schemes are also observed in Southeast Asia's palm oil sector (Gatto et al., 2017).

The TOPP resource-providing contracts are long-term written agreements between the company and farmers. These contracts involve the establishment of new oil palm plots on the farmers' land. Farmers dedicate a particular piece of their land to the contract and are assisted by the company in the setup of the oil palm plantation. Farmers can also obtain labor services, tools and regular inputs – such as fertilizer and pesticides – from the company on credit, if they wish. However, after the plot is established farmers make their own decisions about input use and intensities. The credits obtained from the company are repaid through a fraction of the harvest. Farmers are obligated to sell all the fruit bunches harvested on the contracted plot to TOPP. Side-selling is sanctioned, but seems to be a rare phenomenon in this context because different processing companies do not procure in the same villages.

3.2. Sampling Design

The two companies with different types of contracts operate in different but neighboring regions of Ghana, namely the Western and Central Regions (Table 1). To keep transaction costs low, both companies cluster their procurement in certain villages. Within these villages, the companies accept all farmers willing to supply oil palm bunches on a regular basis into the contract scheme; that is, the companies do not use specific selection criteria. Farmers in these villages can choose between participating or not participating in the contract offered, but – as only one type of contract is offered in each village and region – they have no choice between the different contract types. We randomly selected contracted farmers in the procurement villages in both regions, as explained in more detail below.

In addition to the contracted farmers, we need a group of comparison farmers producing oil palm without any contract. While there are farmers in the same procurement villages in the Western and Central Regions that produce oil palm without a contract, many of them only have a few oil palms that they primarily grow and harvest for home consumption. Even if these non-contracted farmers are more commercially oriented, they made a deliberate decision not to participate in a contract scheme, which could easily lead to non-random selection problems in our impact evaluation. Similarly, sampling comparison farmers from other villages in the same regions could also lead to selection problems, because the companies did not select their procurement villages on a random basis. Against this background, we decided to sample the group of comparison farmers from a third region, namely the Ashanti Region, where farmers produce oil palm commercially, but where no contract scheme was yet operating at the time of the survey. Commercial oil palm farmers in the Ashanti Region sell their harvest on the spot market. Often, they also process the fruits manually in order to sell the palm oil on the spot market. While the fresh fruits are perishable, the processed palm oil has a longer shelf-life, which is an advantage when the output market is insecure.

We chose the Ashanti Region because it is very similar to the Central and Western Regions in terms of agroecological conditions. All three regions are located within the green belt that is particularly suitable for the cultivation of oil palm (Rhebergen et al., 2016). Table 2 shows that there are no systematic differences in temperature and rainfall between the three regions. While oil palm contracts did not exist in the Ashanti region in 2018, we knew from the local Ministry of Food and Agriculture (MoFA) that a company was planning to build a new oil palm processing facility and procure from a number of villages in this Region through marketing contracts. Farmers were not aware of these plans when we carried out the survey. But the information about the upcoming contract scheme helped us to select comparison villages and farmers that are similar to those in the two contract groups.

To select farmers for the survey, we used a two-stage sampling procedure. The first stage was the random selection of procurement or future procurement villages using village lists that we obtained from the two companies in the Central and Western Regions and from MoFA in the Ashanti Region. We cross-checked the completeness of these village lists together with local agricultural extension officers on the ground. We randomly selected nine villages each in the Central and Ashanti Regions. In the Western region, we randomly sampled 13 villages, because the average number of farmers per village participating in the resource-providing contract was lower than in the marketing contract. In the second sampling stage, we randomly selected commercial oil palm farmers in each of the 31 selected villages. In the Central and Western Regions, we randomly selected 75% of all contracted farmers. In the Ashanti Region, commercial oil palm farmers were selected randomly based on lists that we prepared together with the village chief.

Table 2: Regional characteristics

	Marketing contract (Western Region)	Resource-providing contract (Central Region)	Comparison (Ashanti Region)
Climate classification	Tropical savanna	Tropical savanna	Tropical savanna
Highest temperature	28.9°C	28.7°C	28.6°C
Lowest temperature	25.1°C	25.3°C	25.2°C
Mean temperature	27.2°C	27.2°C	27.0°C
Average annual rainfall	1268 mm	1249 mm	1246 mm

Note: Temperature and rainfall data are derived from the World Bank Climate Change Knowledge Portal and refer averages between 1991 and 2015. Temperature data refer to monthly averages.

The total sample includes 463 households. A breakdown by contract scheme and farm size is shown in Table 3. These households were interviewed, using a carefully prepared and pre-tested questionnaire programmed into tablet computers. The interviews captured structured data at the household level (general socioeconomic variables), the oil palm plot level (inputs, outputs, plot characteristics), and the farmer level (age, education etc.). Some of the farms have more than one oil palm plot. We captured data for all oil palm plots owned and managed by the farmer, so that the number of plot observations is somewhat higher than the number of household observations (Table 3).[2] In addition to the household interviews, we had prepared a village-level questionnaire that was administered with the village chief to capture additional information on village infrastructure, population, and other relevant village-level variables.

[2] For farmers in the resource-providing contract, only oil palm plots registered under this scheme were included.

Table 3: Number of observations by contract type and farm size

	Total	Marketing contract (Western Region)	Resource-providing contract (Central Region)	Comparison (Ashanti Region)
			Household observations	
Total sample	463	193	164	106
Small-scale (<10 acres)	182	86	51	45
Medium-scale (10–20 acres)	177	76	60	41
Larger-scale (>20 acres)	104	31	53	20
			Plot observations	
Total sample	551	225	205	121
Small-scale (<10 acres)	191	93	53	45
Medium-scale (10–20 acres)	211	88	78	46
Larger-scale (>20 acres)	149	44	74	31

Note: Farm size refers to the land available to farmers, which may be larger than the land actually cultivated.

4. Statistical Approaches

4.1. Outcome Variables

We want to analyze and compare the effects of marketing contracts and resource-providing contracts on farmers' short-term and longer-term production decisions. Short term production decisions are especially decisions related to input use, which is best captured at the plot level. The two most important external inputs in oil palm production are chemical fertilizer and herbicides. Nevertheless, many farmers in Ghana do not use these inputs on a regular basis. Therefore, rather than looking at input quantities, we measure whether or not farmers used any chemical fertilizer and herbicides on their oil palm plot during the 12 months prior to the survey with two separate dummy variables. In addition to the inputs used, we are interested in the effects of the contracts on crop productivity, which we measure in terms of oil palm yields per acre (fresh fruit bunches harvested during the 12 months prior to the survey).

Longer-term production decisions are related to the scale of production and the degree of specialization. Effects on such longer-term outcomes can be evaluated with our data, because the farmers in our sample had entered the contract schemes already more than 10 years ago. As mentioned, farmers in the study regions often have more land available than they actually cultivate, the difference mostly occurring due to capital and labor constraints. The oil palm contracts may reduce the capital and labor constraints, so the scale of production may possibly increase. We measure the scale of production as the land area that a farmer cultivates with commercial crops (those not primarily grown for home consumption) relative to the total land available to the household. Hence this variable ranges between zero and one. Crops cultivated primarily for home consumption are excluded from this calculation, because these are usually less affected by capital constraints, meaning that effects of oil palm contracts can hardly be expected.

Oil palm contracts reduce risk and could therefore also increase the farmers' level of specialization. We measure specialization as the proportion of the commercial crop area that a household cultivates with oil palm. This variable ranges between zero and one. As a second indicator, we count the number of cash crops other than oil palm that the household produces. This indicator of cash crop diversity can take non-negative integer numbers and is negatively related to specialization on oil palm. Hence, we would expect a positive effect of contracts on specialization and a negative effect on cash crop diversity.

4.2. Regression Models

The effects of marketing and resource-providing contracts on input use and yields in oil palm production are estimated at the plot level with models of the following type:

$$Y_{ihj} = \beta_0 + \beta_1 MC_i + \beta_2 RPC_i + \beta_3 C_i + \beta_4 C_h + \beta_5 C_j + \varepsilon_{ihj} \quad (1)$$

where Y_{ihj} is the outcome variable of interest on plot i of household h in village j. We estimate separate regressions for fertilizer use, herbicide use, and yield. *MC* and *RPC* are dummy variables for the marketing contract and the resource-providing contract. These are our main variables of interest. Positive coefficients for β_1 and β_2 would indicate that the contracts increase input use and yield. Our hypothesis that resource-providing contracts have larger effects than simple marketing contracts would imply $\beta_2 > \beta_1$.

C_i, C_h, and C_j in equation (1) are plot-level, household-level, and village-level control variables, and ε_{ihj} is a random error term clustered at the village level. At the plot level, we control for factors such as soil quality, plantation age, and irrigation, which may have independent effects on the outcome variables. At the household level, we control for socioeconomic characteristics of the farmer responsible for cultivating the plot, including gender, education, and experience in oil palm farming. We also use a dummy for whether or not the household is also involved in cocoa production. Cocoa is generally produced with higher input-intensities than oil palm in Ghana, which may possibly lead to spillover effects across crops within the same household. At the village level, we control for distance to input suppliers.

The effects of the contracts on the scale of production, specialization, and cash crop diversity are estimated at the household level with models of the following type:

$$S_{hj} = \gamma_0 + \gamma_1 MC_h + \gamma_2 RPC_h + \gamma_3 X_h + \gamma_4 X_j + u_{hj} \quad (2)$$

where S_{hj} is the outcome variable of interest for household h in village j. X_h and X_j are household-level and village-level controls, which are similar to those in equation (1) with only a few differences. For instance, we use socioeconomic characteristics of the household head, which may be the farmer cultivating oil palm plot i or also a different person. We also control for total land availability of the household. As current land availability may potentially be influenced by the contracts, we use land availability in 2008, when most of the contracted farmers were just entering a contract scheme. This historical land availability was obtained through recall questions during the survey.

At the village level, in addition to market access, we also control for local shocks that occurred during the five years prior to the survey, including droughts, floods or unusually heavy rainfall, or heavy pest and disease infestations affecting crop and livestock production. As such shocks are expected to influence farmers' cropping and investment decisions and could also be spatially correlated with participation in the different contract schemes, not controlling for shocks could result in omitted variable bias. Finally, we control for the average land rent in the village, which is an indicator of local land scarcity.

The models in equations (1) and (2) are estimated for the sample as a whole, with all plot and household observations, as well as separately with observations from the subsamples for the three farm size categories (small-, medium-, and large-scale farmers). We use ordinary least-squares (OLS) estimators for the models with continuous outcome variables and probit estimators for the input use models with binary outcome variables.

4.3. Dealing with Selection Bias

The main explanatory variables in our models, namely farmers' participation in marketing and resource-providing contracts, may be endogenous due to non-random self-selection into a contract scheme. Endogeneity would lead to correlation with the error term and biased estimates of the contract effects (Angrist and Pischke, 2008). We use various approaches to reduce issues of endogeneity and selection bias.

First, the sampling strategy, which was already described in section 3, is integral part of the identification strategy. The farmers with marketing contracts, resource-providing contracts, and without any contracts were sampled from three different regions. This helps to reduce issues of farmers' self-selection within each region. Moreover, the three regions are very similar in terms of climatic conditions and attractiveness for the palm oil industry to establish contract schemes with smallholders. Differences in terms of soil conditions, land scarcity, market access, and specific shocks, which may occur between and within regions, are controlled for in the model specifications (see equations 1 and 2 above). We also control for a number of observed farmer and household characteristics.

Second, to address issues of unobserved heterogeneity between farmers with and without contracts we use a variable that measures individual willingness-to-pay (WTP) to participate in a contract scheme as an additional covariate in the regression models. WTP was estimated based on a set of hypothetical contract offers. In the interviews, each respondent was 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)?" Depending on the answer (yes/no), the investment amount Z was increased or reduced. WTP is the highest amount, for which a "yes" answer was recorded. While the hypothetical contract offers were quite general, we still expect that the WTP estimates are correlated with unobserved characteristics such as the respondents' risk behavior and entrepreneurial attitudes.[3] Hence, including the WTP estimate as an additional covariate controls for relevant unobserved heterogeneity. The same approach was also used by Bellemare and Novak (2017) in a recent study of the effects of contract farming among smallholders in Madagascar.

As a third approach to test and control for endogeneity, we use instrumental variable (IV) estimators. As we have two potentially endogenous variables (*MC* and *RPC*), we need at least two instruments that are correlated with participation in a contract scheme but uncorrelated with the outcome variables. Participation in the marketing contract scheme is instrumented with a variable that measures the share of commercial oil palm producers relative to the total village population ('village share'). Palm oil companies are more likely to procure from villages with a high share of commercial oil palm producers, in order to keep transport and transaction costs low. Participation in the resource-providing contract scheme is instrumented with a dummy variable that equals one if the village chief cultivates oil palm commercially

[3] When farmers enter a new contract, they often do not know or fully understand the complete details of the agreement. Hence, our hypothetical contract offers are not so different from the actual offers that farmers may get in a new contract scheme. In the plot-level models (equation 1), we use the WTP estimate for the farmer managing the plot. For the household-level models (equation 2), we use the WTP estimate for the household head.

('village chief'). The village chief typically acts as a mediator between the company and the oil palm farmers in the village, and the contract scheme can hardly start in the village without the chief's approval. Hence, contracts are more likely to be initiated in a village when the village chief is a commercial oil palm farmer himself/herself.

In principle, the two identified instruments might also be correlated with the outcome variables. For instance, the share of commercial oil palm farmers in the village could be positively associated with local soil quality or market access, which could also influence input use, yields, and cropping portfolios. Similarly, the village chief being a commercial oil palm grower might possibly affect farmers' access to information, which could also lead to direct correlation with the outcome variables. We tested for such direct correlation using the subsample of comparison farmers, where no indirect effects through the contract pathway may occur. These tests for both instruments and all outcome variables are shown in Tables A1 and A2 in the Appendix. None of the correlation coefficients is statistically significant, which is an indication of instrument exogeneity. Tables A3-A5 in the Appendix show first-stage results of the plot-level and household-level IV models. As expected, the instruments are significantly correlated with participation in the contract schemes, so that all criteria for instrument validity seem to be fulfilled. It should be stressed that proving instrument validity is difficult, especially with cross-sectional data. However, as we use different approaches to deal with endogeneity, cautious causal inference should be in order, especially when the different approaches lead to the same conclusions.

5. Results

5.1. Descriptive Statistics

Table 4 shows selected welfare characteristics of households in the total sample and disaggregated by farm size to provide a better understanding of the socioeconomic situation of oil palm farmers in Ghana. The average household has a landholding of 18 acres, with small-scale farmers having about 6 acres and large-scale farmers around 40 acres. Average annual per capita expenditures are 2800 GHS, which is more than twice the national poverty line of 1314 GHS. Clearly, commercial oil palm farmers do not belong to the poorest of the poor in rural Ghana. Nevertheless, around 13% of the sample farmers live below the poverty line. The share of poor households is much higher among small-scale farmers (16%) than among large-scale farmers (7%).

Table 4: Household welfare characteristics for total sample and by farm size category

	Total sample	Small-scale	Medium-scale	Larger-scale
Land availability (in acres)	18.33	6.13	14.42	39.54
	(18.96)	(2.22)	(2.84)	(25.56)
Per capita expenditure (in GHS per year)	2800	2510	2841	3104
	(2084)	(1496)	(2168)	(2521)
Share of farmers below poverty line [a]	0.13	0.16	0.14	0.07
	(0.33)	(0.37)	(0.35)	(0.26)

Note: Mean values are shown with standard deviations in parentheses. [a] The national poverty line is 1314 GHS per year, equivalent to $1.83 per capita and day in purchasing power parity terms (Cooke et al., 2016).

Table 5 shows descriptive statistics of the outcome and control variables by contract type. For the outcome variables, we find significant differences especially between the households with resource-providing contracts and the other two groups. Differences between the households with simple marketing contracts and those without any contracts are less sizeable and partly statistically insignificant. For the control variables, we find significant differences between contract types for experience in oil palm farming, market access, average land rents, and willingness to participate in contracts. Interestingly, farmers without contracts have a higher WTP than contracted farmers. This is actually plausible, because those farmers holding a contract already benefit from reduced marketing risk. We do not observe differences between the groups in terms of farm size, gender, education, soil quality, and irrigation, supporting our argument that the farms and households with different contract status are similar in terms of many relevant characteristics.

Table 5: Descriptive statistics by contract type

	Mean			Difference		
	Marketing contract (MC)	Resource-providing contract (RPC)	No contract (NC)	MC-RPC	MC-NC	RPC-NC
Outcome variables						
Chemical fertilizer application (dummy)	0.07	0.20	0.03	***		***
	(0.02)	(0.03)	(0.02)			
Herbicide application (dummy)	0.44	0.64	0.50	***		**
	(0.03)	(0.03)	(0.05)			
Yield (t/acre)	3.10	6.65	3.82	***		***
	(0.15)	(0.40)	(0.70)			
Scale of production (0-1)	0.79	0.87	0.84	***	**	
	(0.01)	(0.01)	(0.02)			
Specialization (0-1)	0.53	0.58	0.50	*		***
	(0.02)	(0.02)	(0.02)			
Cash crop diversity (number)	1.20	1.29	1.74		***	***
	(0.06)	(0.07)	(0.12)			
Control variables						
Cocoa cultivation (dummy)	0.12	0.13	0.13			
	(0.02)	(0.02)	(0.03)			
Land availability (acres in 2008)	13.23	14.91	12.37			
	(0.93)	(1.31)	(1.50)			
Female household head (dummy)	0.15	0.20	0.15			
	(0.03)	(0.03)	(0.03)			
Education of household head (years)	7.65	6.86	7.03			
	(0.32)	(0.37)	(0.38)			
Experience of household head (years)	19.56	15.65	16.74	***	***	
	(0.61)	(0.74)	(0.77)			
Female farmer (dummy)	0.25	0.28	0.23			
	(0.03)	(0.03)	(0.04)			
Education of farmer (years)	7.52	7.10	7.16			
	(0.31)	(0.33)	(0.34)			
Experience of farmer (years)	20.23	15.32	17.20	***	***	*
	(0.58)	(0.66)	(0.73)			
Willingness to pay (in 500 GHS)	2.06	2.13	2.73		***	**
	(0.12)	(0.15)	(0.19)			
Number of palms per acre	68.85	63.96	63.10			
	(2.99)	(2.22)	(1.22)			
Age of palms (years)	12.89	9.33	14.87	***	***	***
	(0.45)	(0.06)	(0.43)			
Irrigation (dummy)	0.32	0.33	0.25			
	(0.03)	(0.03)	(0.04)			
Good soil (dummy)	0.66	0.73	0.73			
	(0.03)	(0.03)	(0.04)			
Market access (km)	0.85	1.12	0.12		***	***
	(0.15)	(0.14)	(0.05)			
Distance to input provider (km)	0.66	4.34	1.80	***	***	***
	(0.09)	(0.59)	(0.25)			
Average land rent (GHS per acre)	152.54	18.33	95.57	***	***	***
	(11.07)	(4.46)	(11.75)			
Shocks (number in last 5 years)	0.22	0.58	1.15	***	***	***
	(0.04)	(0.13)	(0.13)			

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

5.2. Regression Results

We compared all models with and without IVs to test the null hypothesis that the contract variables are exogenous. This null hypothesis could not be rejected in any of the models (Tables A6 and A7 in the Appendix), which suggests that the estimators without IVs are consistent and that the effects of the contracts estimated with these models do not suffer from selection bias. This is plausible given that the sampling framework used helped to reduce selection issues. Nevertheless, we also report the IV results next to the probit and OLS results. The IV estimates support the same conclusions, only that they are somewhat less efficient than the estimates without IVs.

Table 6 summarizes the estimated effects of contracts on the plot-level outcome variables (full model estimates are shown in Tables A8 and A9 in the Appendix). The results suggest that the marketing contract has no significant effects on input use and yield. This is quite different for the resource-providing contract where we observe positive and statistically significant effects on fertilizer use and yield. The resource-providing contract increases the probability of chemical fertilizer use by 18 percentage points. It also increases oil palm yield by 2.9 t/acre, which is a gain of 75% when compared to the mean yield of non-contracted farmers. The effect of the resource-providing contract on herbicide use is positive but not statistically significant. These results clearly suggest that the resource-providing contract contributes to more intensified production patterns and higher land productivity. This does not seem to be the case for the marketing contract.

Table 7 summarizes the estimated effects of the contracts on the household-level outcomes (full model estimates are shown in Table A10 in the Appendix). The marketing contract has no significant effect on the scale of production and on specialization in terms of the area share of oil palm. However, producing under the marketing contract reduces the number of other cash crops produced by 0.5 on average, suggesting that some specialization on oil palm occurs. In comparison, the resource-providing contract has statistically significant effects on all three household-level outcomes. It increases the scale of production by 4 percentage points and the share of the commercial area planted with oil palm by almost 10 percentage points. Producing under a resource-providing contract also reduces the number of other cash crops produced by 0.5 on average.

Table 6: Summary of contract effects on plot-level outcomes (total sample)

	Chemical fertilizer use (dummy)		Herbicide use (dummy)		Yield (t/acre)	
	Probit	IV probit	Probit	IV probit	OLS	IV
Marketing contract	0.0508	0.0202	-0.0117	-0.1323	-0.7664	0.0677
	(0.06)	(0.11)	(0.11)	(0.28)	(0.84)	(1.62)
Resource-providing contract	0.1797***	0.1462	0.1211	0.0952	2.9182***	2.4741
	(0.05)	(0.12)	(0.09)	(0.27)	(0.87)	(1.80)
Control variables included	Yes	Yes	Yes	Yes	Yes	Yes
WTP included	Yes	No	Yes	No	Yes	No
Observations	551	551	551	551	551	551

Note: Average marginal effects are shown with cluster-corrected standard errors in parentheses. WTP, willingness-to-pay. Full model results are shown in Tables A8 and A9 in the Appendix. * p<0.1, ** p<0.05, *** p<0.01.

Table 7: Summary of contract effects on household-level outcomes (total sample)

	Scale of production (0-1)		Specialization (0-1)		Cash crop diversity (number)	
	OLS	IV	OLS	IV	OLS	IV
Marketing contract	-0.0196	-0.0354	-0.0123	-0.0260	-0.5093***	-0.6662**
	(0.02)	(0.05)	(0.03)	(0.10)	(0.12)	(0.26)
Resource-providing contract	0.0417**	-0.0057	0.0961***	0.0157**	-0.5229***	-0.7189**
	(0.02)	(0.05)	(0.02)	(0.08)	(0.13)	(0.30)
Control variables included	Yes	Yes	Yes	Yes	Yes	Yes
WTP included	Yes	No	Yes	No	Yes	No
Observations	463	463	463	463	463	463

Note: Marginal effects are shown with cluster-corrected standard errors in parentheses. WTP, willingness-to-pay. Full model results are shown in Table A10 in the Appendix. * p<0.1, ** p<0.05, *** p<0.01.

These estimation results confirm that contracts can increase the intensity and productivity of production and also lead to higher investments and specialization on the contracted crop. However, as hypothesized, the effects can vary with the type of contract offered and are larger for the resource-providing contract than for the simple marketing contract. In fact, we did not observe any effects of the simple marketing contract on most of the outcome variables considered. It seems that the reduced marketing risk alone is insufficient to overcome problems of access to credit and input markets. In addition to the regular inputs (fertilizer and herbicides) analyzed here, farmers under the resource-providing contract also have much better access to high-quality planting material for oil palms, which is costly but important for vigorous plant growth and higher yields throughout the plantation cycle.

5.3. *Effects by Farm Size Category*

We now analyze the effects of the contracts separately for small-, medium-, and large-scale farmers. The results of the plot-level models are summarized in Table 8 (full model results are shown in Tables A11 and A12 in the Appendix). We do not find significant effects of the marketing contract on input use and yield for any of the farm size categories. However, we do observe positive and significant effects of the resource-providing contract.

Table 8: Summary of contract effects on plot-level outcomes by farm size category (subsample analyses)

		Chemical fertilizer use (dummy)	Herbicide use (dummy)	Yield (t/acre)
Marketing contract	Small-scale	0.0677	0.0716	-0.2379
		(0.08)	(0.10)	(0.69)
	Medium-scale	0.0485	-0.1448	0.1732
		(0.09)	(0.14)	(0.50)
	Large-scale	0.0337	0.0975	-2.0271
		(0.12)	(0.12)	(1.72)
Resource-providing contract	Small-scale	0.1909***	0.3231***	4.0295***
		(0.06)	(0.12)	(0.91)
	Medium-scale	0.1813**	-0.0454	4.3482***
		(0.08)	(0.13)	(0.53)
	Large-scale	0.1712*	0.1403	0.6007
		(0.01)	(0.11)	(2.18)
Control variables included		Yes	Yes	Yes
WTP included		Yes	Yes	Yes

Note: Average marginal effects are shown with cluster-corrected standard errors in parentheses. WTP, willingness-to-pay. Full model results are shown in Tables A11 and A12 in the Appendix. * p<0.1, ** p<0.05, *** p<0.01.

The resource-providing contract increases input use and yield, especially among small-scale farmers. For small-scale farmers, the probability of fertilizer and herbicide use is increased by 19 and 32 percentage points, respectively. These effects are larger than what we observed for the full sample in Table 6, where the effect on herbicide use was not statistically significant. The resource-providing contract increases the oil palm yield of small-scale farmers by about 4 t/acre, which means more than a doubling of yields when comparing to the mean yield of non-contracted farmers. The resource-providing contract also increases fertilizer use and yield among the medium-scale farmers, whereas for large-scale farmers the only significant effect is an increase in the use of fertilizer. These are interesting findings that support our hypothesis that credit and input market imperfections outside of contracts are more constraining for smallholders than for large-scale producers.

The results of the household-level models are summarized in Table 9 (full model results are shown in Table A13 in the Appendix). Surprisingly, the marketing contract seems to have a negative effect on the scale of production among small-scale farmers. At the same time, the marketing contract seems to incentivize small- and medium-scale farmers to reduce the number of other cash crops produced. For large-scale farmers, the marketing contract has no significant effects on the scale of production or on oil palm specialization.

Table 9: Summary of contract effects on household-level outcomes by farm size category (subsample analyses)

		Scale of production (0-1)	Specialization (0-1)	Cash crop diversity (number)
Marketing contract	Small-scale	-0.0497**	0.0601	-0.4599*
		(0.02)	(0.05)	(0.25)
	Medium-scale	-0.0033	-0.0113	-0.7148***
		(0.03)	(0.04)	(0.18)
	Large-scale	0.0563	-0.0846	-0.0242
		(0.07)	(0.07)	(0.24)
Resource-providing contract	Small-scale	0.0156	0.1284**	-0.4754**
		(0.02)	(0.05)	(0.22)
	Medium-scale	0.0426*	0.0887*	-0.8036***
		(0.02)	(0.04)	(0.18)
	Large-scale	0.0730	0.0310	-0.1705
		(0.06)	(0.07)	(0.24)
Control variables included		Yes	Yes	Yes
WTP included		Yes	Yes	Yes

Note: Marginal effects are shown with cluster-corrected standard errors in parentheses. WTP, willingness-to-pay. Full model results are shown in Table A13 in the Appendix. * p<0.1, ** p<0.05, *** p<0.01.

The resource-providing contract increases oil palm specialization among small- and medium-scale farmers. Among medium-scale farmers, we also observe a positive effect on the scale of production. The resource-providing contract has no effects on large-scale farmers.

In summary, the disaggregated analyses clearly show that the effects of contracts can vary not only by contract type but also by farm size category. Large-scale farmers are mostly unaffected by both types of contracts. In contrast, small- and medium-scale farmers benefit from the resource-providing contract in terms of higher investments, higher yields, and higher levels of specialization on the oil palm crop.

6. Conclusion

In this article, we have analyzed and compared the effects of marketing and resource-providing contracts on agricultural investments and productivity in the small farm sector of Ghana. Previous studies had evaluated the effects of contracts in different settings, but very few studies had compared the effects of different contract types in the same setting, as we have done here. Our results can contribute to better understand what type of contracts can be useful for smallholder farmers and for agricultural development in what situations. We have collected and used survey data of oil palm farmers in the southern parts of Ghana. A sampling framework specifically designed for this study has helped us to reduce issues of selection bias in the evaluation of contract effects. Furthermore, we have used IV models and also included WTP estimates as an additional control variable to deal with unobserved heterogeneity between contracted and non-contracted farmers. The results support two main conclusions.

The first conclusion is that contracts can reduce risks and other market failures and thus contribute to agricultural growth in the small farm sector, but that the actual results depend on the contract characteristics. Not all contracts are useful in every situation. We have found sizeable effects of the resource-providing contract on input use, oil palm yield, specialization, and the scale of production. In the resource-providing contract scheme, farmers have a secure market for their output. In addition, the contracting company offers various inputs, technologies, and technical services on credit. In contrast, we have found no significant effects of the simple marketing contract on input use or on any of the other outcome variables considered. We conclude that a secure output market alone is insufficient to increase farm investments and productivity in a setting with severe credit and input market failures. This is especially true for high-value crops – such as oil palm and other plantation crops – that require relatively large upfront investments.

A few previous studies showed that simple marketing contracts can contribute to productivity growth in the small farm sector (e.g., Henningsen et al., 2015; Rao et al., 2012). These studies referred to vegetables or other annual crops in situations where the required upfront investment was either low or where credits and inputs were accessible to farmers also when not offered as part of the contract. Other studies that referred to different crops and different countries did not find significant effects of simple marketing contracts (e.g., Hernández et al. 2007; Mwambi et al., 2016), possibly because the required investments for technological upgrading were larger, or credit and input market failures more severe, as in our case. For comparison: most studies that analyzed resource-providing contracts found positive effects on smallholder investments and productivity (e.g., Champika and Abeywickrama, 2014; Maertens and Velde, 2017; Ragasa et al., 2018). Our study with both marketing and resource-providing contracts examined and compared in the same setting and for the same crop helps to explain some of the impact heterogeneity observed in the previous literature.

The second main conclusion from our study is that the effects of contracts cannot only vary with contract characteristics, but also between different farm size categories. Resource-providing contracts seem to be particularly beneficial for small- and medium-scale farmers, whereas the effects of both types of contracts on large-scale farmers were mostly insignificant. These pro-poor distributional effects are welcome and can be explained by the fact that small- and medium-scale farmers often suffer most from imperfections in input and output markets. Hence, if these small- and medium-scale farmers have access to contracts that help reduce some of the market imperfections, they may benefit more than large-scale farmers, who often have better market access anyway.

Of course, the concrete findings are specific to the palm oil sector in Ghana and should not be generalized. In Ghana, small-scale farmers have access to contracts with palm oil companies, because the demand for palm oil is growing rapidly and companies cannot source sufficient quantities when relying on the supply of large-scale farmers alone. In many other situations, small-scale farmers find it more difficult to enter a contract scheme, because companies often prefer to deal with larger farms in order to keep transaction costs low. Especially for resource-providing contracts, side-selling can also be an issue and is not always easy to monitor and sanction when dealing with a large number of smallholders (Otsuka et al., 2016). Side-selling is not yet much of an issue in Ghana's palm oil sector, because the contracting companies buy fresh fruit bunches, whereas larger sales on the open market usually require own processing by farmers. Own processing is labor-intensive and needs to be done immediately after the harvest, because of the perishability of the fresh oil palm fruits. However, in spite of these specific conditions, the general findings that contract characteristics matter and that resource-providing contracts are more suitable to reduce market failures in the small farm sector than simple marketing contracts probably also hold in other situations.

In closing, two limitations of our study shall be mentioned. First, we used cross-section observational data to evaluate the effects of contracts. While we used different approaches to reduce issues of selection bias and obtained consistent results, possible endogeneity of contract participation remains a concern that is difficult to fully address with cross-section data. Studies with panel data or with experimental approaches in a more controlled setting could further strengthen the identification of causal effects. Second, the focus of our study was on the effects of contracts on farm investments, input intensity, and productivity. While these outcomes are important indicators of agricultural growth and development, they do not necessarily measure farm household welfare. Analyzing the effects of contracts on farm household livelihoods more explicitly would require other outcome variables, such as income, health, and nutrition. These are interesting directions for follow-up research.

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Appendix

Table A1: Correlations between instruments and plot-level outcome variables

	Chemical fertilizer	Herbicides	Yields per acre
Village share	0.0405	0.1011	-0.0697
Village chief	0.1075	-0.0329	-0.1161

Note: The correlation analysis only includes observations from the comparison group of farmers without any contract. None of the correlation coefficients is statistically significant at the 5% level.

Table A2: Correlations between instruments and household-level outcome variables

	Scale of Production	Specialization	Cash crop diversity
Village share	-0.0611	0.0721	-0.0131
Village chief	-0.0684	0.1829	-0.0886

Note: The correlation analysis only includes observations from the comparison group of farmers without any contract. None of the correlation coefficients is statistically significant at the 5% level.

Table A3: First-stage IV regressions of plot-level models (input use)

	Marketing contract		Resource-providing contract	
Gender of the farmer (dummy)	0.0880**	(0.04)	-0.0669	(0.05)
Education of the farmer (in years)	0.0044	(0.01)	-0.0001	(0.00)
Experience of the farmer (in years)	0.0088**	(0.00)	-0.0075**	(0.00)
Cocoa cultivation (dummy)	-0.0477	(0.06)	0.0358	(0.05)
Decision spraying(dummy)	-0.0862	(0.06)	0.1081	(0.09)
Good soil (dummy)	-0.0500	(0.05)	0.0318	(0.04)
Distance inputs (in km)	-0.0118*	(0.01)	0.0092	(0.01)
Village share (IV MC)	0.7757*	(0.46)	0.0467	(0.39)
Village chief (IV RPC)	-0.4261**	(0.20)	0.5306***	(0.18)
Constant	0.3341**	(0.23)	0.0416	(0.17)
Number of observations	551		551	

Note: Standard errors in parentheses. * p<0.1, ** p<0.05, *** p<0.01.

Table A4: First-stage IV regressions of plot-level models (oil palm yield per acre)

	Marketing contract		Resource-providing contract	
Gender of the farmer (dummy)	0.1016**	(0.05)	-0.0772	(0.05)
Education of the farmer (in years)	0.0045	(0.01)	0.0005	(0.01)
Experience of the farmer (in years)	0.0038*	(0.00)	-0.0017	(0.00)
Number of palms per acre	0.0007**	(0.00)	-0.0007*	(0.00)
Age of palms (in years)	0.0285***	(0.01)	-0.0314***	(0.01)
Irrigation (dummy)	-0.0194	(0.05)	0.0635	(0.05)
Good soil (dummy)	-0.0229	(0.049	0.0097	(0.03)
Market access (in km)	0.0209	(0.03)	-0.0091	(0.04)
Village share (IV MC)	0.6687*	(0.39)	0.1125	(0.28)
Village chief (IV RPC)	-0.4274**	(0.18)	0.5159***	(0.13)
Constant	-0.0760	(0.24)	0.4808***	(0.18)
Number of observations	551		551	

Note: Standard errors in parentheses. * p<0.1, ** p<0.05, *** p<0.01.

Table A5: First-stage IV regressions of household-level models (scale of production, specialization, cash crop diversity)

	Marketing contract		Resource-providing contract	
Gender of the household head (dummy)	0.0559*	(0.03)	-0.0203	(0.03)
Education of the household head (in years)	0.0070*	(0.00)	-0.0031	(0.00)
Experience of the household head (in years)	0.0075***	(0.00)	-0.0074***	(0.00)
Land availability household (in acres)	-0.0010	(0.00)	0.0054*	(0.00)
Land availability household (square term)	0.0000	(0.00)	-0.0000*	(0.00)
Market access (in km)	0.0532	(0.05)	-0.0227	(0.059
Average land charges village (in GHS per acre)	0.0020***	(0.00)	-0.0013*	(0.00)
Shocks	-0.1488***	(0.04)	0.0679	(0.04)
Village share (IV MC)	0.8380***	(0.30)	-0.0280	(0.30)
Village chief (IV RPC)	-0.4470***	(0.14)	0.5287***	(0.13)
Constant	0.0685	(0.15)	0.2579	(0.16)
Number of observations	463		463	

Note: Standard errors in parentheses. * p<0.1, ** p<0.05, *** p<0.01.

Table A6: Test for exogeneity of contract variables in plot-level models

	Chemical fertilizer	Herbicides	Yield
p-values	0.3982	0.2162	0.2935

Note: For the input-use models with binary outcome variables, A Wald test was used. For the yield model with a continuous outcome variable, a Wu-Hausman test was used.

Table A7: Wu-Hausman test for exogeneity of contract variables in household-level models

	Scale of production	Specialization	Cash crop diversity
p-values	0.4397	0.1034	0.8096

Table A8: Effects of contracts on chemical fertilizer and herbicide use (total sample)

	Chemical fertilizer		Herbicides	
	Probit	IV probit	Probit	IV probit
Marketing contract (dummy)	0.0508	0.0202	-0.0117	-0.1323
	(0.06)	(0.11)	(0.11)	(0.28)
Resource-providing contract (dummy)	0.1797***	0.1462	0.1211	0.0952
	(0.05)	(0.12)	(0.09)	(0.27)
Female farmer (dummy)	0.0567	0.0426	-0.0681	-0.0792
	(0.04)	(0.04)	(0.05)	(0.06)
Education of farmer (years)	0.0074**	0.0069***	0.0071	0.0084
	(0.00)	(0.00)	(0.00)	(0.01)
Experience of farmer (years)	0.0010	0.0006	-0.0101***	-0.0112***
	(0.00)	(0.00)	(0.00)	(0.00)
Willingness to pay (500 GHS)	0.0111		0.0097	
	(0.01)		(0.01)	
Cocoa cultivation (dummy)	0.0155	0.0187	0.0745	0.0673
	(0.06)	(0.06)	(0.07)	(0.07)
Decision spraying (dummy)	0.0102	0.0158	-0.0434	-0.0746
	(0.03)	(0.03)	(0.06)	(0.07)
Good soil (dummy)	-0.0521**	0.0406	0.0093	0.0115
	(0.03)	(0.03)	(0.04)	(0.05)
Distance to input provider (km)	-0.0046	-0.0057	0.0033	0.0020
	(0.00)	(0.00)	(0.00)	(0.00)
Number of observations	551	551	551	551
Wald chi2	54.98	25.02	37.90	27.31
P-value (joint significance)	0.0000	0.0029	0.0000	0.0012
Pseudo R-squared	0.1174		0.0575	

Note: Average marginal effects are shown with cluster-corrected standard errors in parentheses. * p<0.1, ** p<0.05, *** p<0.01

Table A9: Effects of contracts on oil palm yield in t/acre (total sample)

	OLS	IV
Marketing contract (dummy)	-0.7664	0.0677
	(0.84)	(1.62)
Resource-providing contract (dummy)	2.9182***	2.4741
	(0.87)	(1.80)
Female farmer (dummy)	0.0984	0.0852
	(0.46)	(0.46)
Education of farmer (years)	0.0342	0.0280
	(0.04)	(0.04)
Experience of farmer (years)	-0.0971***	-0.1015***
	(0.02)	(0.02)
Willingness to pay (500 GHS)	-0.0371	
	(0.10)	
Number of palms per acre	0.0274***	0.0263***
	(0.01)	(0.01)
Age of palms (years)	0.0910**	0.0465
	(0.04)	(0.04)
Irrigation (dummy)	-0.5267	-0.5312
	(0.44)	(0.44)
Good soil (dummy)	0.2739	0.2681
	(0.34)	(0.35)
Market access (km)	0.0254	0.0168
	(0.09)	(0.13)
Constant	2.3451**	2.8536*
	(1.09)	(1.56)
Number of observations	551	551
F-statistic/Wald chi2	17.01	86.85
P-value (joint significance)	0.0000	0.0000
R-squared	0.1431	0.1341

Note: Average marginal effects are shown with cluster-corrected standard errors in parentheses.
* p<0.1, ** p<0.05, *** p<0.01

Table A10: Effects of contracts on household-level outcome variables (total sample)

	Scale of production (0-1)		Specialization (0-1)		Cash crop diversity (number)	
	OLS	IV	OLS	IV	OLS	IV
Marketing contract	-0.0196	-0.0354	-0.0123	-0.0260	-0.5093***	-0.6662**
	(0.02)	(0.05)	(0.03)	(0.10)	(0.12)	(0.26)
Resource-providing contract	0.0417**	-0.0057	0.0961***	0.1575**	-0.5229***	-0.7189**
	(0.02)	(0.05)	(0.02)	(0.08)	(0.13)	(0.30)
Female household head (dummy)	-0.0398**	-0.0397**	0.0688*	0.0686**	-0.0385	-0.0265
	(0.02)	(0.02)	(0.03)	(0.03)	(0.12)	(0.10)
Education of household head (years)	0.0015	0.0014	-0.0031	-0.0026	0.0178	0.0178
	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.01)
Experience of household head (years)	-0.0024**	-0.0027***	0.0052***	0.0060***	-0.0007	-0.0011
	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.00)
Willingness to pay (500 GHS)	0.0025		-0.0017		0.0001	
	(0.00)		(0.01)		(0.03)	
Land availability household (acres)	-0.0051***	-0.0048***	-0.0092***	-0.0095***	0.0200***	0.0209***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.01)
Land availability (squared)	0.0000**	0.0000**	0.0001***	0.0001***	-0.0002***	-0.0002***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Market access (km)	-0.0037	-0.0026	-0.0020	-0.0016	0.0632***	0.0744***
	(0.00)	(0.00)	(0.01)	(0.01)	(0.02)	(0.02)
Average land rent (GHS/acre)	-0.0002**	-0.0002***	0.0002	0.0003	-0.0005	-0.0005
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Shocks	0.0132***	0.0122*	-0.0352***	-0.0385**	0.0870**	0.0689
	(0.00)	(0.01)	(0.01)	(0.02)	(0.04)	(0.06)
Constant	0.9234***	0.9605***	0.5377***	0.4955***	1.3791***	1.5092***
	(0.02)	(0.04)	(0.04)	(0.06)	(0.26)	(0.28)
Observations	463	463	463	463	463	463
F-statistic/Wald chi2	8.51	145.69	35.61	108.59	12.94	71.74
P-value (joint significance)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
R-squared	0.1299	0.1210	0.1661	0.1525	0.1150	0.1097

Note: Marginal effects are shown with cluster-corrected standard errors in parentheses. * p<0.1, ** p<0.05, *** p<0.01

Table A11: Effects of contracts on input use by farm size category (subsample analyses)

	Chemical fertilizer use (dummy)			Herbicide use (dummy)		
	Small-scale	Medium-scale	Large-scale	Small-scale	Medium-scale	Large-scale
Marketing contract	0.0677	0.0485	0.0337	0.0716	-0.1448	0.0975
	(0.08)	(0.09)	(0.12)	(0.10)	(0.14)	(0.12)
Resource-providing contract	0.1909***	0.1813**	0.1712*	0.3231***	-0.0454	0.1403
	(0.06)	(0.08)	(0.01)	(0.12)	(0.13)	(0.11)
Female farmer (dummy)	0.0731	0.0000	0.1039*	0.0530	-0.0897	-0.0826
	(0.05)	(0.04)	(0.06)	(0.07)	(0.10)	(0.13)
Education of farmer (years)	0.0124***	0.0131**	0.0002	0.0283***	0.0063	-0.0188*
	(0.00)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Experience of farmer (years)	0.0016	-0.0006	0.0017	-0.0092**	-0.0124***	-0.0098**
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Willingness to pay (500 GHS)	0.0095	-0.0035	0.0299*	0.0817***	0.0191	-0.0249
	(0.01)	(0.01)	(0.02)	(0.01)	(0.02)	(0.02)
Cocoa cultivation (dummy)	0.0683	0.0343	0.0215	0.2509*	0.1019	0.0235
	(0.09)	(0.05)	(0.09)	(0.13)	(0.06)	(0.15)
Decision spraying (dummy)	0.0076	-0.0525	0.0707	-0.1836*	0.0819	-0.0074
	(0.06)	(0.05)	(0.10)	(0.10)	(0.11)	(0.16)
Good soil (dummy)	-0.0374	-0.0320	-0.1220	-0.0314	0.0253	-0.0152
	(0.03)	(0.04)	(0.08)	(0.06)	(0.07)	(0.09)
Distance to input provider (km)	0.0018	-0.0149**	-0.0137*	-0.0071	0.0128	0.0009
	(0.00)	(0.01)	(0.01)	(0.01)	(0.01)	(0.00)
Number of observations	191	211	149	191	211	149
Wad chi2	51.58	45.96	72.43	251.61	66.57	17.61
P-value (joint significance)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0619
Pseudo R-squared	0.1517	0.2000	0.1416	0.1704	0.0968	0.0722

Note: Average marginal effects from probit models are shown with cluster-corrected standard errors in parentheses. * p<0.1, ** p<0.05, *** p<0.01

Table A12: Effects of contracts on oil palm yield (kg/acre) by farm size category (subsample analyses)

	Small-scale	Medium-scale	Large-scale
Marketing contract	-0.2379	0.1732	-2.0271
	(0.69)	(0.50)	(1.72)
Resource-providing contract	4.0295***	4.3482***	0.6007
	(0.91)	(0.53)	(2.18)
Female farmer (dummy)	0.6034	0.3702	-0.3727
	(0.86)	(1.00)	(1.18)
Education of farmer (years)	0.1126	0.0034	-0.0601
	(0.07)	(0.05)	(0.08)
Experience of farmer (years)	-0.0815*	-0.0913***	-0.1186***
	(0.04)	(0.02)	(0.04)
Willingness to pay (55 GHS)	0.0479	0.2158***	-0.2593
	(0.24)	(0.07)	(0.17)
Number of palms per acre	0.0152***	0.0503*	0.0290***
	(0.00)	(0.03)	(0.01)
Age of palms (years)	0.1306*	0.0585*	0.0709
	(0.07)	(0.03)	(0.06)
Irrigation (dummy)	-0.5090	-0.7795	-0.6718
	(0.72)	(0.53)	(0.89)
Good soil (dummy)	0.0636	0.6428	0.5616
	(0.78)	(0.46)	(0.76)
Market access (km)	0.0100	0.1733**	-0.2520
	(0.11)	(0.08)	(0.24)
Constant	0.9473	-0.3091	6.0200**
	(1.67)	(1.23)	(2.46)
Number of observations	191	211	149
F-statistic	41.33	13.01	5.85
P-value (joint significance)	0.0000	0.0000	0.0000
R-squared	0.1722	0.2730	0.1065

Note: Marginal effects from OLS models are shown with cluster-corrected standard errors in parentheses.
* p<0.1, ** p<0.05, *** p<0.01

Table A13: Effects of contracts on household-level outcomes by farm size category (subsample analyses)

	Scale of production (0-1)			Specialization (0-1)			Cash crop diversity (number)		
	Small-scale	Medium-scale	Large-scale	Small-scale	Medium-scale	Large-scale	Small-scale	Medium-scale	Large-scale
Marketing contract (dummy)	-0.0497**	-0.0033	0.0563	0.0601	-0.0113	-0.0846	-0.4599*	-0.7148***	-0.0242
	(0.02)	(0.03)	(0.07)	(0.05)	(0.04)	(0.07)	(0.25)	(0.18)	(0.24)
Resource-providing contract (dummy)	0.0156	0.0426*	0.0730	0.1284**	0.0887*	0.0310	-0.4754**	-0.8036***	-0.1705
	(0.02)	(0.02)	(0.06)	(0.05)	(0.04)	(0.07)	(0.22)	(0.18)	(0.24)
Female household head (dummy)	-0.0580*	-0.0064	-0.0221	0.0719	0.0150	0.0953*	0.0503	-0.0709	0.0059
	(0.03)	(0.03)	(0.06)	(0.06)	(0.05)	(0.05)	(0.19)	(0.29)	(0.16)
Education of household head (years)	0.0005	0.0022	-0.0001	-0.0033	-0.0033	0.0010	0.0201	0.0015	0.0222
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.02)	(0.02)
Experience of household head (years)	-0.0040**	-0.0006	-0.0029	0.0045**	0.0034	0.0072**	-0.0091	0.0065	-0.0018
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.01)	(0.01)
Willingness to pay (500 GHS)	-0.0032	0.0038	0.0032	0.0023	-0.0100	0.0075	-0.0297	0.0035	-0.0039
	(0.00)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.03)	(0.06)	(0.04)
Land availability (acres)	-0.0059	-0.0093**	-0.0043	-0.0289	-0.0454***	-0.0059*	-0.0819	-0.0036	0.0074
	(0.01)	(0.00)	(0.00)	(0.02)	(0.01)	(0.00)	(0.06)	(0.08)	(0.01)
Land availability (squared)	-0.0000	0.0001	0.0000	0.0009	0.0017***	0.0000*	0.0092*	0.0003	-0.0001
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Market access (km)	-0.0010	-0.0074	-0.0012	-0.0033	-0.0004	0.0002	0.0630	0.0303	0.0982***
	(0.00)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.04)	(0.04)	(0.03)
Average land rent (GHS per acre)	-0.0001	-0.0002***	-0.0004	0.0003**	-0.0000	0.0001	-0.0008	-0.0004	0.0000
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Shocks	0.0036	0.0194**	0.0251*	-0.0256*	-0.0292**	-0.0383*	0.0757	0.0463	0.1604**
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.08)	(0.03)	(0.07)
Constant	0.9882***	0.9248***	0.9022***	0.5633***	0.7382***	0.4578***	1.6180***	1.9384***	1.2112***
	(0.04)	(0.04)	(0.08)	(0.10)	(0.08)	(0.11)	(0.34)	(0.57)	(0.42)
Observations	182	177	104	182	177	104	182	177	104
F-statistic	9.24	10.94	2.91	11.49	22.39	4.62	4.53	21.55	6.29
P-value (joint significance)	0.0000	0.0000	0.0111	0.0000	0.0000	0.0005	0.0010	0.0000	0.0000
R-squared	0.1170	0.1379	0.1547	0.1587	0.2173	0.1404	0.1424	0.1090	0.1175

Note: Marginal effects from OLS models are shown with cluster-corrected standard errors in parentheses. * p<0.1, ** p<0.05, *** p<0.01