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Ruml, Anette; Qaim, Matin

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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

Anette Ruml [a],[*], Matin Qaim [b],[1]

[a] *German Institute for Global and Area Studies, Neuer Jungfernstieg 21, 20354 Hamburg, Germany*
[b] *University of Goettingen, 37083 Goettingen, Germany*

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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 simple marketing contracts do not in this context.

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, Minot, & Hu, 2009). Market failures lead to under-investment in farm inputs, technologies, and profitable high-value crops (Otsuka, Nakano, & Takahashi, 2016; Wang, Wang, & Delgado, 2014). Small farms are often more affected by market failures than large farms, which can perpetuate and further aggravate existing inequalities (Minot & Sawyer, 2016; Ton, Vellema, Desiere, Weituschat, & D'Haese, 2018). Contract farming is an institutional response to market failures, as contracts can help reduce production and marketing risk and thus increase

smallholder investment, productivity, and income (Eaton & Shepherd, 2001; Key & Runsten, 1999; Simmons, Winters, & Patrick, 2005; Wang, Moustier, & Loc, 2014).

Various studies analyzed effects of contracts on farm production and household welfare (e.g., Key & Runsten, 1999; Mishra, Kumar, Joshi, & D'Souza, 2018; Rao, Brümmer, & Qaim, 2012; Simmons et al., 2005; Tripathi, Singh, & Singh, 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 & Bloem, 2018; Ton et al., 2018). Differences in contract characteristics may also play a role (Ochieng, Veettil, & Qaim, 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 (Mighell & Jones, 1963). 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 between such case studies from

* Corresponding author at: University of Goettingen, Heinrich-Dueker-Weg 12, 37073 Goettingen, Germany.

E-mail addresses: anette.ruml@giga-hamburg.de (A. Ruml), mqaim@uni-goettingen.de (M. Qaim).

[1] Address: University of Goettingen, Platz der Goettinger Sieben 5, 37073 Goettingen, Germany.

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, Lambrecht, & Kufoalor, 2018), yet mostly without explicitly analyzing the effects of varying contract characteristics. Two exceptions are Mishra, Kumar, Joshi, and D'Souza (2016) and Ashraf, Giné, and Karlan (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 this 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 statistical approaches to reduce potential 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 disaggregate by farm size to better understand distributional implications.

2. Background and hypotheses

2.1. Potential effects of marketing and resource-providing contracts

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 & Shepherd, 2001; Key & 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. Price uncertainty and hold-up issues can further act as an entry barrier for smallholder farmers (Herath &

Weersink, 2009). Hence, a contract that reduces marketing risk may increase technology adoption, input use, and thus also yield and income (Anbarassan, Chandrasekaran, Raman, & Karthick, 2016; Bellemare, 2012). Several empirical studies confirmed positive effects of marketing contracts on farm productivity and income (Andersson, Chege, Rao, & Qaim, 2015; Henningsen, Mpeta, Adem, Kuzilwa, & Czekaj, 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, Reardon, & Berdegué, 2007; Mwambi, Oduol, Mshenga, & Saidi, 2016). Such failures in credit and input markets are explicitly addressed through 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, Gibbon, & Jones, 2009; Champika & Abeywickrama, 2014; Maertens & Velde, 2017; Miyata et al., 2009; Ragasa et al., 2018; Warning & 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). Findings about positive effects of marketing contracts are 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.

2.2. Oil palm farming and contracts in Ghana

Oil palm is native to West Africa and has been traditionally grown by local farmers on a small scale. These farmers typically harvest in small amounts, due to a lack of large buyers, and sell oil palm fruits to small mills and local consumers, or manually process palm oil (Byerlee, Falcon, & Naylor, 2017). With the increasing demand for vegetable oil during the last 20 years, the Ghanaian oil palm sector gradually commercialized and the area dedicated to oil palm substantially increased (Rhebergen et al., 2016). However, despite the agroecological suitability for oil palm cultivation and the large areas currently cultivated, productivity levels remain low and far behind South East Asian suppliers. Low adoption rates of modern technologies and the fragmentation of the market, with little coordination among supply chain actors, are the main obstacles for productivity growth (Rhebergen, Fairhurst, Whitbread, Giller, & Zingore, 2018). In the future, the Ghanaian oil palm sector will continue to grow in order to meet the rising demand. A particular focus should be on increasing crop yields, as further expanding the oil palm area is often associated with a loss in tropical rainforests and related negative externalities for climate and biodiversity protection (Qaim, Sibhatu, Siregar, & Grass, 2020).

Contract farming has the potential to stimulate yield and productivity growth in the oil palm sector, as it coordinates transactions along supply chain actors and provides a secure sales market for farmers. Reduced market risk through contracts could increase farmers' investments in inputs and technologies. How-

ever, it remains to be tested whether a secure sales market alone is sufficient for farmers to overcome potential capital constraints. Access to formal credit is difficult in Ghana, as most farmers do not have formal land titles that they could use as collateral. Resource-providing contracts could possibly be more suitable in this context, as they involve credit and technology options for farmers without requiring formal land titles as collateral.

Currently, five large palm oil processing companies are located in the study area in southern Ghana. These companies cultivate own plantations and additionally purchase oil palm bunches from smallholder farmers through contract schemes. Out of the five 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.[2] BOPP is using simple marketing contracts, whereas TOPP is using resource-providing contracts.

The BOPP marketing contracts are agreements between the company and farmers, in which an annual fixed price and regular pick-ups of the harvested produce are specified. 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.

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. The assistance includes the planting material, tools, machinery, and agrochemical inputs provided on credit. The average costs for the plantation setup and the first few years of maintenance until the palms are starting to bear fruits are estimated at around 1600 US dollars per hectare. However, the credit is not a fixed amount of money, as farmers decide themselves which inputs to use and how much. Farmers are charged an annual interest rate of 11.5% on the individual credit amount taken. Credit repayment and interest rate payments occur through the company paying contracted farmers only for three-quarters of the fruit bunches harvested until the credit is fully redeemed (i.e., one-quarter of the harvest is kept by the company without compensation). In addition to the plantation setup, farmers can also obtain labor services, tools, and regular inputs – such as fertilizer and pesticides – on credit from the company throughout the entire contract duration. These additional credits are also deducted from the farmers' subsequent sales. It is important to mention that farmers themselves are the ones making decisions about input use on their plots, that is, the company only sells inputs on credit as specifically ordered by each farmer. Farmers are obligated to sell all the fruit bunches harvested on the contracted plot to TOPP. Side-selling is forbidden and punished, but seems to be a rare phenomenon in this context because different processing companies do not procure in the same villages.

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2 Such combinations of nucleus estate and smallholder contract schemes are also observed in Southeast Asia's palm oil sector (Gatto, Wollni, Asnawi, & Qaim, 2017; Qaim et al., 2020).

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 ha	4300 ha
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)

Both companies have been active in the region with the same types of contracts for more than 10 years. Most farmers in the marketing contract scheme joined in the late-1990s and early-2000s. The resource-providing contract scheme started with plot setups between 2007 and 2008. Hence, we are able to analyze possible short-term and longer-term effects on farmers' investment decisions and productivity outcomes. The companies buy fresh oil palm fruit bunches from farmers without any quality differentiation.

2.3. Research hypotheses

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 benefit more from resource-providing contracts than large farms.

3. Sampling design

The two companies with different types of contracts operate in different but neighboring regions of Ghana, namely the Western and Central Regions (Fig. 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
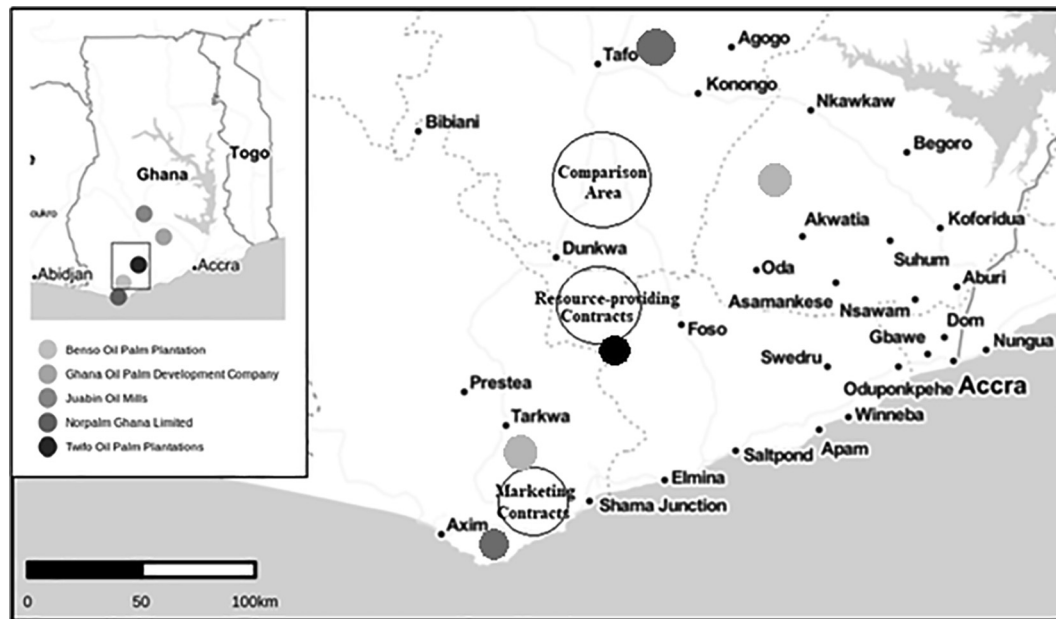
Fig. 1. Map of study area in Ghana Source: Authors' own presentation using tools provided in Kahle and Wickham (2013).

Table 2
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.

the different contract types.[3] 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. Within the procurement villages in the Western and Central Regions only few noncontracted farmers produce oil palm, because the majority of oil palm producers self-selected into contract farming. The few remaining households have a few oil palms that they primarily grow and harvest for home consumption. Even if these noncontracted 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 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. In the north of this region, currently one contract farming scheme exists (Fig. 1). In the south of the Ashanti Region, farmers produce oil palm commercially without a contract, because they are outside of the catchment areas' of the current schemes. Thus, they sell their harvested oil palm fruits or manually processed 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.

Comparing farmers with different types of contracts and without contracts in three different regions raises concerns, because contract differences are perfectly correlated with possible regional differences. We considered this problem in our sampling framework and chose three regions that are very similar in terms of their agroecological and socioeconomic conditions (Table 2). All three regions are located within the green belt that is particularly suitable for the cultivation of oil palm (Rhebergen et al., 2016). Also, we knew from the local Ministry of Food and Agriculture (MoFA) that an additional company was planning to build a new oil palm processing facility and procure from a number of villages in the south of the Ashanti 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.

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[3] Moving to another region in order to get access to a different contract type is not a realistic option for farmers, as they could not easily get land for cultivation in other communities. For the companies it matters where the farmers have their land, as the companies pick up the harvest from the plantations of contracted farmers.

To select farmers for the survey within each of the regions, 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 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, oil palm farmers were selected randomly based on complete lists that we prepared together with the village chiefs.

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 pretested 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 farmers, so that the number of plot observations is somewhat larger than the number of household observations (Table 3).[4] In addition to the household interviews, we had prepared a village-level questionnaire that was administered with the village chiefs to capture additional information on village infrastructure, population, and other relevant village-level variables.

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 oil palm specialization. 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:

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

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 explanatory 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 sex, 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:

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

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

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[4] 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.

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 endogeneity

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 & Pischke, 2008). We use various approaches to reduce issues of endogeneity and selection bias.

First, the sampling frame, which was described in section 3, is integral part of our identification strategy. The farmers with marketing contracts, resource-providing contracts, and without any contracts were sampled from three different regions, which helps to reduce issues of farmers' self-selection within each region. Moreover, as explained above, the three regions are very similar in terms of agroecological and socioeconomic conditions and their 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 carry out analyses with subsamples of farmers in all three regions – those closer and further away from the borders with the other regions – in order to test whether the main results are robust to regional variation.

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 decreased. 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.[5] 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. We chose both instruments according to the companies' reported procedures to select villages in which they offer contracts. 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. As such, the instrument is a measure of transaction costs. Due to the agroecological comparability across regions, a high share of oil palm producing households within the village is not correlated with the suitability for oil palm cultivation, and does thus not directly influence the outcome variables.

Participation in the resource-providing contract scheme is instrumented with a dummy variable that equals one if the village chief cultivates oil palm commercially ('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 and can benefit from the scheme himself/herself.[6]

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

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[5] 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.

[6] We selected one instrument for each type of contract. However, both instruments are included in the first-stage regressions for both contracts (see Tables A3-A5 in the Online Appendix).

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 Online Appendix. None of the correlation coefficients is statistically significant, which is an indication of instrument exogeneity. Tables A3-A5 in the Online 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 support the same conclusions.

5. Results

5.1. Descriptive statistics

Table 4 shows selected 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, market-oriented 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 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 households with simple marketing contracts and 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 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, sex, education, soil quality, and irrigation, confirming that the farms and households with different contract status are similar in terms of many key characteristics.

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 Online 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 frame used helped to reduce individual 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 Online 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. Thus, reduction in risk through the secure sales market is insufficient, and credit market failures need to be addressed directly in a capital-intensive crop sector.

Table 7 summarizes the estimated effects of the contracts on the household-level outcomes (full model estimates are shown in Table A10 in the Online 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.

These estimation results confirm that contracts can increase input intensity and productivity and also lead to higher investments and specialization on the contracted crop. However, as hypothesized, the effects can vary with the type of contract 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 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 Online 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.

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

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
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. $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.

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 in Table A13 in the Online 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

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 Online Appendix. ***$p < 0.01$.

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 Online Appendix. **$p < 0.05$, ***$p < 0.01$.

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 Online Appendix. *$p < 0.1$, **$p < 0.05$, ***$p < 0.01$.

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 Online Appendix. *$p < 0.1$, **$p < 0.05$, ***$p < 0.01$.

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.

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 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.

5.4. Robustness checks with regional subsamples

One of the concerns in our impact analysis is that we compare farmers with and without contracts in different regions, so that it is not entirely clear whether observed differences in the outcome variables are due to differences in contract types and/or regional conditions. As discussed, we paid particular attention to choose three regions that are very similar. Of course, differences in terms unobserved conditions are possible, but based on the available data and own field observations we argue that such differences can occur to the same extent within and between the three regions, so that a systematic bias is unlikely. Nevertheless, some robustness checks with subsamples from within each region may be useful. We choose two subsamples in each of the three regions, namely (i) observations from villages located most closely to the other region borders and (ii) observations from the villages located furthest away from the other region borders. For these subsamples we re-estimate the regression models and obtain results that are similar to the ones estimated above with the full sample.

The plot-level results of the regional subsample regressions are shown in Table 10. As before, we do not find any statistical evidence that the marketing contract leads to changes in input use or oil palm yield, whereas the resource-providing contract increases the likelihood of using chemical inputs and also contributes to substantially higher yields. For the farmers furthest away from the other region borders, the effects of the resource-providing contracts on chemical input use are not statistically significant, which may be due to the smaller subsample. However, the effect on yield for this subsample is even larger than for the full sample, suggesting that the resource-providing contract affects production decisions and productivity.

The household-level results for the regional subsamples are shown in Table A14 in the Online Appendix. These results are also similar to the full sample results, namely that the resource-providing contract increases the scale of production and farmers' specialization on oil palm, whereas the resource-providing contract does not.[7] Overall, these robustness checks support the main conclusions and suggest that the findings are not driven by regional differences, providing further confidence in the identification strategy.

6. Conclusion

In this article, we have analyzed and compared the effects of marketing contracts 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 a better understanding of what type of contracts can be useful for smallholder farmers and for agricultural development in what type of situations.

We have collected and used survey data of oil palm farmers in the southern parts of Ghana. A sampling frame 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.[8]

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 & Abeywickrama, 2014; Maertens & 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

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[7] In the villages furthest away from the region borders, the marketing contract even seems to decrease the level of specialization on oil palm (Table A14).

[8] When only interpreting the lack of effects of the marketing contract one could be tempted to conclude that the failures in the spot market are possibly not so grave. However, also considering the resource-providing contract reveals that large productivity increases are possible when the existing credit and input market failures are properly addressed. As discussed above, yield increases are particularly relevant to boost palm oil production while protecting tropical biodiversity and ecologically fragile ecosystems (Qaim et al., 2020).

Table 10
Robustness checks with subsamples (plot level).

	Villages closest to region borders			Villages furthest from region borders		
	Chemical fertilizer use (dummy)	Herbicide use (dummy)	Yield (t/acre)	Chemical fertilizer use (dummy)	Herbicide use (dummy)	Yield (t/acre)
Marketing contract	−0.01	0.05	−1.36	0.01	−0.05	0.43
	(0.10)	(0.15)	(1.18)	(0.05)	(0.10)	(0.27)
Resource-providing contract	0.19***	0.20*	2.63**	0.04	0.22	4.40***
	(0.07)	(0.11)	(0.27)	(0.04)	(0.15)	(1.31)
Control variables included	Yes	Yes	Yes	Yes	Yes	Yes
WTP included	Yes	Yes	Yes	Yes	Yes	Yes
Observations	383	383	383	273	273	273

Note: The villages closest to the borders include five villages with marketing contracts, five villages without contracts, and seven villages with resource-providing contracts that are closest to the joint regional borders. The villages furthest from the borders include five villages with marketing contracts, five villages without contracts, and seven villages with resource-providing contracts that are furthest from the joint regional borders. Average marginal effects are shown with cluster-corrected standard errors in parentheses. WTP, willingness-to-pay. *p < 0.1, **p < 0.05, ***p < 0.01.

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 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. Even profits or income from oil palm production would not be good indicators of household welfare, because other economic activities and income sources of the household may also be affected by contracts through the reallocation of household resources (Ruml, Ragasa, & Qaim, 2020). Analyzing the effects of contracts on farm household livelihoods more comprehensively would require other outcome variables, such as income from different farm and non-farm activities, consumption expenditures, or indicators related to family health and nutrition. These are interesting directions for follow-up research.

Declarations of interest

The authors declare no competing interests.

CRediT authorship contribution statement

Anette Ruml: Conceptualization, Methodology, Formal analysis, Investigation, Data curation, Writing - original draft, Visualization. **Matin Qaim:** Conceptualization, Writing - review & editing, Supervision, Resources, Funding acquisition.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.worlddev.2020.105110.

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