The effects of contract farming on diets and nutrition in Ghana

by Bethelhem Legesse Debela, Anette Ruml, and Matin Qaim

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Abstract

Contract farming recently gained in importance in many developing countries. While effects on smallholder farmers' incomes were analyzed in many previous studies, diet and nutrition effects are not yet well understood. Here, we examine the effects of contract farming on dietary diversity and child anthropometrics, using survey data from the palm oil sector in Ghana. Contracting clearly improves smallholder nutrition, but the effects vary by contract type. We distinguish between marketing contracts and resource-providing contracts that affect household labor use and gender roles differently. For both contract types, contracting female farmers has larger positive nutrition effects than contracting male farmers.

Keywords: Contract farming, diets, nutrition, oil palm, Ghana

JEL Codes: D3; O15; Q12; Q13

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Introduction

Contract farming recently gained in importance in many developing countries as an institution to facilitate coordination in agricultural supply chains (Mishra et al., 2018). Contracting can also serve to better integrate smallholder farmers into newly emerging value chains, which is seen as an important driver of rural development and poverty alleviation (Bellemare and Bloem, 2018; Otsuka et al., 2016). A large body of literature examined the effects of contract farming on smallholder incomes, mostly finding significant income gains (Andersson et al., 2015; Bellemare, 2012; Maertens and Swinnen, 2009; Maertens and Vande Velde, 2017; Rao and Qaim, 2011; Ruml, Ragasa and Qaim, 2020; Wang et al., 2014). In contrast, the effects of contracting on smallholder nutrition are not yet well understood. This is an important knowledge gap, as smallholder farmers make up a large proportion of the world's hungry and undernourished people. While income gains tend to improve households' economic access to purchased food, there are also several other mechanisms that may influence the nutrition effects of contract farming, such as potential changes in the households' own food production, time allocation, and gender roles. Here, we analyze the effects of contract farming on smallholder diets and nutrition, explicitly considering the different mechanisms.

A few previous studies investigated effects of contract farming on food security. Bellemare and Novak (2017) showed that contract farming contributes to a shortening of the hunger period for smallholder households in Madagascar. Mishra et al. (2018) found that households producing onions under contract in India have higher food expenditures than their counterparts without a contract. Soullier and Moustier (2018) showed that rice contracts in Senegal improve food security through mitigating price seasonality. However, all these studies used relatively simple proxies of household-level food security without further investigating effects on dietary quality and nutrition.

We are aware of only one study that analyzed dietary implications in some more detail, namely Chege et al. (2015) who showed that contracts with supermarkets improve calorie and micronutrient consumption among smallholder vegetable growers in Kenya. One drawback of the study by Chege et al. (2015) is that they used household-level dietary data, which are not suitable to analyze individual-level nutrition outcomes.

Our contribution to the existing literature is twofold. First, we analyze the nutrition effects of contract farming with more specific household-level and individual-level indicators, including women's dietary diversity score and child anthropometric measures. A focus on women and children is important, as these groups are of prime concern in a nutrition context. Second, we analyze two types of contracts, namely marketing contracts and resource-providing contracts, which may have different effects on nutrition and the underlying mechanisms. The few existing studies on the effects of contracting on household food security did not distinguish between different contract types.

Our analysis uses survey data from oil palm farmers in Ghana. The palm oil sector in West Africa is currently experiencing a rapid transition from small-scale subsistence farming towards larger-scale commercialization, with international companies and new types of contractual arrangements playing a growing role. Some of the palm oil companies use simple marketing contracts with farmers. Others use more comprehensive resource-providing contracts, through which they also assist farmers with credit, inputs, and technical advice. Our survey data include farmers under both contract types, as well as comparison farmers producing oil palm without any contract. Potential endogeneity issues are addressed through treatment-effects regression models. Our results suggest that both types of contracts have positive nutrition effects, but the effect

magnitudes differ. Comparing the effects of the two contracts helps to better understand some of the underlying impact mechanisms.

The rest of this article is structured as follows. In the next section, we briefly discuss a conceptual framework, highlighting the possible mechanisms of the effects of contract farming on smallholder nutrition. Then we explain the survey data and the econometric strategy, before presenting and discussing the regression results. The last section summarizes and concludes.

Conceptual Framework

Contract farming can influence smallholder diets and nutrition through different mechanisms. First, changes in farm and household income can occur. Studies in different countries show that contract farming typically leads to income gains in the small farm sector, often through price advantages and better access to inputs and technology (e.g., Andersson et al., 2015; Bellemare, 2012; Maertens and Swinnen, 2009; Meemken and Bellemare, 2020; Rao and Qaim, 2011). Household income gains will typically lead to improvements in food security and dietary quality, especially through additional food purchases from the market (Koppmair et al., 2017; Shively and Sununtnasuk, 2015).

Second, the production of cash crops under contract may also affect the production of food crops on the farm and therefore the availability of food for home consumption. While positive spillovers through improved inputs and technologies are possible, specialization on the contracted cash crop can also lead to less food production and lower cropping diversity. Several recent studies show that farm production diversity is positively associated with dietary diversity in smallholder farm households (Ecker, 2018; Headey et al., 2018; Hirvonen and Hoddinott, 2017; Sibhatu and

Qaim, 2018). Hence lower production diversity through contracting may potentially have negative dietary and nutrition effects.

Third, gender roles within the farm household may change through contracting. Contract farming typically involves the production of cash crops, the income of which is mostly controlled by male household members (Njuki et al., 2011; von Braun and Kennedy, 1994). A loss of female income control through contracting could have negative nutrition effects, as women are known to spend more on healthy diets than men (Chege et al., 2015; Hoddinott and Haddad, 1995). Such negative effects could possibly be prevented through contracting female household members, but so far female farmers tend to participate less in contract farming than male farmers (Meemken and Bellemare, 2020).

Fourth, and also related to gender roles, the time allocation of household members may change through contract farming. Several studies show that contract farming often increases the on-farm labor demand for crop production and post-harvest handling (Benali et al., 2018; Maertens and Swinnen, 2012; Otsuka et al., 2016; Qaim, 2017). As women in agricultural households are often particularly time-constrained, more work in the contracted cash crops may mean less time available for household chores – including home gardening, food preparation, and childcare – with possible negative implications for child nutrition and health. However, depending on the situation, contract farming may also lead to the adoption of new labor-saving practices and technologies and thus reduce farm labor demand (Ruml and Qaim, 2021). In those cases, women may have more time available for household chores, or they reallocate some time to off-farm economic activities. Female off-farm employment can contribute to women empowerment (Majlesi, 2016; Rangel, 2006), with positive expected effects on child nutrition (Malapit et al., 2015), but it can also reduce

the time available for childcare with possible negative effects (Debela et al., 2020; Popkin and Solon, 1976).

This discussion underlines that contract farming may not always lead to improved nutrition. The effects depend on the type of contract and the institutional and cultural context. Furthermore, it becomes clear that household-level data may be insufficient to fully understand the effects for different household members, especially women and children.

Study Context and Data

Study Context

Over the last few decades, rising global demand for vegetable oil led to a massive expansion of oil palm in Southeast Asia. More recently, substantial growth in palm oil production has also been observed in Ghana and other countries of West Africa. The oil palm crop is native to West Africa and was traditionally grown by smallholder farmers. Many farm households in Ghana produce small quantities of palm oil for home consumption and local markets. But the sector is transforming. During the last 10 years, several national and international palm oil companies have established large processing plants, especially in the Southern parts of Ghana.

The palm oil companies in Ghana typically have their own plantations with land concessions from the government. However, as the land concessions are limited, the companies also procure additional produce from smallholder oil palm farmers through contract schemes. Important to note is that the companies buy the entire oil palm fruit bunches directly after harvest, without any on-farm processing. This is different from traditional spot-market transactions, where

farmers either sell buckets of individual fruits or milled palm oil, both of which requiring much more labor for post-harvest handling than simply selling the entire fruit bunches.

Survey of Farmers With and Without Contracts

Data for this study were collected through a survey of oil palm farmers conducted in Ghana in 2018. At the time of the survey, there were five palm oil companies and processing plants operating in the Southern parts of the country. Farmers with and without contracts were selected through multi-stage random sampling as described in more detail by Ruml and Qaim (2020). The sample includes observations from farmers in two different contract schemes and a comparison group. The two contract schemes are the Benso Oil Palm Plantation (BOPP) belonging to Wilmar International and the Twifo Oil Palm Plantation (TOPP) belonging to Unilever.

BOPP uses simple marketing contracts with smallholder farmers, specifying minimum quantities, annually fixed prices, and regular dates for the pick-up of the fresh fruit bunches at the farm gate. TOPP uses resource-providing contracts that are very similar to the marketing contracts in terms of the output transactions, but additionally include the provision of credits for plantation establishment, inputs, and related technical support. Oil palm farmers in the comparison group have no contracts and sell their harvest in traditional local markets.

Our sample includes a total of 463 farm household observations. Of these, 193 produce oil palm under a marketing contract, 164 produce under a resource-providing contract, and the remaining 106 produce without any contract. The three groups are mutually exclusive. There are no farmers who produce oil palm under different contract types simultaneously. Nor are there farmers who switched contract types at any time in the past. Earlier research with the same data

showed that the two contract groups and the comparison group are very similar in terms of general farm, household, and contextual characteristics (Ruml and Qaim, 2020; Ruml et al., 2020). Typical farm sizes in the sample range between 5 and 15 acres, of which often more than half is typically cultivated with oil palm and the rest with other local crops such as maize and cassava.

Previous analyses of the data showed that both types of contracts lead to significant labor savings per acre of oil palm, mainly due to the omission of on-farm post-harvest handling and processing in the company supply chains (Ruml and Qaim, 2021). Both contracts also lead to significant gains in household income, even though the underlying mechanisms differ (Ruml et al., 2020). Farmers with a resource-providing contract tend to increase their faming activities, which is facilitated through the company credits and support (Ruml and Qaim, 2020). In contrast, farmers with a marketing contract are often credit-constrained, so they allocate much of the labor time saved to off-farm activities, thus increasing their non-agricultural income (Ruml et al., 2020; Ruml and Qaim, 2021).

Measurement of Diets and Nutrition

In this study, we want to evaluate the effects of both types of contracts on household-level and individual-level diets and nutrition. Household-level diets are assessed through the household dietary diversity score (HDDS), which is a count of the number of different food groups consumed by the household over a certain period of time (FAO, 2011). HDDS recently became a popular tool to evaluate access to food and dietary diversity at the household level (Fongar et al., 2019). The HDDS score ranges between 0 and a maximum of 12 food groups, with higher values indicating

better diets and nutrition.[1] In the survey, we used a 7-day food consumption recall based on which we calculate the HDDS.

To assess individual-level diets and nutrition, we focus on women and children in the farm households. In particular, as is common in the nutrition literature (Fongar et al., 2019), we focus on pre-school children aged between two and six years and their mothers or female caregivers. As many farm households in our sample did not have children in this age group, the number of individual observations is much smaller than the number of household observations. We have 115 children and 95 women in our sample. These are relatively small subsamples, which is a clear drawback. Nevertheless, many of the results are statistically significant. Women's diets are assessed with the women's dietary diversity score (WDDS), which also counts the number of food groups but has a different food group classification than the HDDS (FAO, 2016). The WDDS ranges from 0 to 9.[2] We collected individual-level dietary data from women through a 24-hour dietary recall. A WDDS below 5 is commonly used as an indication of insufficient dietary quality and micronutrient malnutrition (Fongar et al., 2019).

For children, we took anthropometric measures, which are the most precise tools to assess child nutritional status. In particular, we took height and weight measures to calculate height-for-age Z-scores (HAZ) and weight-for-age Z-scores (WAZ), using the WHO (2006) child growth standards. HAZ is a longer-term nutrition and health measure. As child linear growth is strongly associated with protein and micronutrient intakes, a low HAZ is a sign of low present or past nutritional quality. If an individual child has HAZ < -2 standard deviations of the healthy reference population, the child is classified as stunted (WHO, 2006). In contrast, WAZ is a short-term

[1] The 12 food groups for the HDDS are cereals; roots and tubers; legumes, nuts, seeds; vegetables; fruits; meat; eggs; fish; milk and milk products; oils and fat; sweets; spices, condiments, and beverages (FAO, 2011).
[2] The 9 food groups for the WDDS are grains, roots and tubers; legumes; nuts and seeds; dairy; meat, poultry and fish; eggs; dark green leafy vegetables; other vitamin A rich fruits and vegetables; other vegetables.

nutrition and health measure and is more related to food quantity and calorie intakes rather than nutritional quality. If an individual child has WAZ < -2 standard deviations of the healthy reference population, the child is classified as underweight (WHO, 2006).

It should be mentioned that diets and nutrition can vary seasonally due fluctuations in income and food supply. Seasonality is not captured in our survey. However, we do not expect seasonality to lead to any significant bias in our estimates for two reasons. First, oil palms produce fruits all year round. Fruit bunches are typically harvested every two weeks, so that seasonal fluctuations in oil palm income hardly exist. Second, even if seasonality matters more for other household income sources and local food supplies, this holds true for all sample households, with and without contracts. Data from all households were collected during the same season, so the impact estimates are unlikely to suffer from systematic bias.

Econometric Approach

Modeling the Effects of Contracting on Nutrition

We want to estimate the effects of the marketing contract and the resource-providing contract on diets and nutrition in oil palm producing farm households. For this purpose, we estimate regression models of the following type:

$$N_i = \varphi + \gamma_{MC} C_{MC,i} + \gamma_{RPC} C_{RPC,i} + \boldsymbol{X}_i' \beta + \varepsilon_i \quad (1)$$

where N_i is the diet or nutrition outcome for household *i* or the individual woman or child living in that household, $C_{MC,i}$ is a dummy variable indicating whether or not household *i* has a marketing contract for oil palm, $C_{RPC,i}$ is a dummy variable indicating whether or not household *i* has a

resource-providing contract, $\boldsymbol{X}_i'$ is a vector of control variables that may also influence diets and nutrition, and ε_i is a random error term. As mentioned in the previous section, we use HDDS as the dietary measure at the household level, and WDDS, HAZ, and WAZ as diet and nutrition indicators at the individual level.

Our main coefficients of interest in equation (1) are γ_{MC} and γ_{RPC}, which estimate the diet and nutrition effects of both contract types. Given that the contracts were shown to improve household income significantly, we generally expect positive diet and nutrition effects too. But as both contracts have different effects on time reallocation to on-farm and off-farm activities, a comparison of the coefficients γ_{MC} and γ_{RPC} may lead to interesting insights into the underlying mechanisms.

However, diets and nutrition are not only influenced by oil palm contracts, and some of the other relevant nutrition determinants may also be correlated with contract farming. Hence, properly specifying the vector of control variables $\boldsymbol{X}_i'$ in equation (1) is important. We include variables such as age, gender, and education of the household head, household structure (dependency ratio), experience with oil palm cultivation, and distance to the closest market. We also include farm size in terms of the land available for cultivation. As current farm size can be influenced especially by the longer-term resource-providing contracts (Ruml and Qaim, 2020), we use land availability in 2008, before the contracting started, to reduce issues of endogeneity. To better understand possible gendered effects, we also include the gender of the oil palm farmer (and thus the contracted person in households with a contract), which is not necessarily the same person as the household head. In the individual-level child models, we additionally include the gender and age of the child.

Identification Strategy

Even though we control for a large number of observed farm, household, and contextual characteristics, it is possible that there are unobserved factors that are jointly correlated with contract farming and nutrition. In that case, the estimates of γ_{MC} and γ_{RPC} in equation (1) would be biased. To reduce such potential endogeneity bias, we use the multinomial treatment-effects regression approach, which accounts for multiple endogenous treatments (contract types in our case) (Deb and Trivedi, 2006). In this approach, the model in equation (1) is estimated jointly with a first-stage multinomial logit using a simulated maximum likelihood estimator. The multinomial logit can be written as follows:

$$\Pr(C_{j,i}|\boldsymbol{X}_i, l_{j,i}) = g(\boldsymbol{X}_i'\tau_{MC} + \delta_{MC}l_{MC,i},\ \boldsymbol{X}_i'\tau_{RPC} + \delta_{RPC}l_{RPC,i}) \quad (2)$$

where subscript j represents the contract type with three possible values: 0=no contract; 1=marketing contract (MC); and 2=resource-providing contract (RPC). $\Pr(C_{i,j}|\boldsymbol{X}_i, l_{i,j})$ refers to the probability that household i produces under contract type C_j, given the control variables $\boldsymbol{X}_i$ and unobserved characteristics $l_{j,i}$. The function g follows a multinomial probability distribution.

According to Deb and Trivedi (2006), proper identification can be achieved by using the same set of control variables in equations (1) and (2), even without an instrument. Nevertheless, the authors recommend using an instrument in equation (1), which we do.[3] Our instrument for participation in contract type C_j is the inverse distance to the closest large palm oil mill. This instrument is significantly correlated with both types of contracts, as is shown in the different first-stage household-level and individual-level models in Tables A1-A4 in the Online Appendix. At

[3] Note that one instrument is sufficient if it is significantly correlated with treatment status, as the treatment groups are mutually exclusive.

the same time, the instrument does not influence the different nutrition outcomes through mechanisms other than contracting, as can be seen by the insignificant correlations for the control group observations in Table A5 in the Online Appendix. One could have expected that distance to a large palm oil mill is also a more general proxy for remoteness and limited market access. However, this is not the case, as the palm oil mills are not located in larger towns where other relevant markets are found. Hence, our instrument seems to be valid.

Results

Descriptive Comparisons

Table 1 summarizes the average diet and nutrition outcomes in our sample of oil palm farmers. Column (1) refers to the entire sample, including farmers in the two contract groups and the comparison group. The HDDS of around 8 food groups and the WDDS of less than 5 food groups point at relatively low dietary quality and widespread micronutrient malnutrition. The child anthropometric indicators are shown in the lower part of Table 1. Negative values for HAZ and WAZ indicate that child undernutrition is commonplace. Around 15% of the children in our sample are stunted and 10% are underweight.[4]

The other columns in Table 1 show mean diet and nutrition outcomes separately for the two contract groups and the comparison group. Farm households with a marketing contract have a slightly lower HDDS than the other two groups. The other differences in dietary diversity scores (both HDDS and WDDS) between the three groups are small and not statistically significant. For

[4] Nationally representative data from Ghana suggest that 19% of the children were stunted and 11% were underweight in 2014 (USAID, 2018). These values are similar to ours. Oil palm producing farm households in the Southern parts of Ghana do not belong to the country's poorest population segments, but they are still significantly affected by undernutrition and low dietary quality.

the child anthropometric indicators, more pronounced differences are observed. Mean HAZ and WAZ are larger for children in the two contract groups than for children in the comparison group, and some of these differences are statistically significant.

Differences in child HAZ and WAZ between the three groups are further illustrated in Figures 1 and 2. Both sets of probability density functions suggest that the best nutrition status is observed for children from households with a resource-providing contract, followed by children from households with a marketing contract. The worst nutrition status is observed for children from households without any contract. While these results could imply that contract farming improves child nutrition, the simple comparisons do not control for any potentially confounding factors. Our regression results, which do control for confounding factors, are presented and discussed in the following.

Regression Results

The estimation results for the household-level effects of contracting on HDDS are shown in Table 2. All models shown in columns (1) to (3) have HDDS as the dependent variable and differ only in terms of the control variables included. The first model estimates in column (1) suggest that – after controlling for confounding factors – both types of contracts significantly increase household-level dietary diversity. The resource-providing contract has a larger positive effect, increasing the number of food groups consumed by 0.81, whereas the marketing contract leads to an increase of 0.54 food groups on average.

Column (1) in Table 2 includes all control variables, except for the gender of the oil palm farmer. The gender of the oil palm farmer is additionally controlled for in column (2) through inclusion of a female dummy. While the female farmer dummy itself is not statistically significant,

its inclusion affects the contract coefficients in interesting ways: the size of both contract coefficients decreases, and the effect of the marketing contract even turns statistically insignificant. These results suggest that gender matters for the dietary effects of contract farming.

Gendered effects are further examined in column (3) of Table 2 through the use of interaction terms between the female farmer dummy and the contract type. While the interaction of female with the marketing contract results in a negative coefficient, the interaction of female with the resource-providing contract results in a positive coefficient. Both interaction terms are not statistically significant, which may be due to the relatively small number of female oil palm farmers in our sample.[5] Nevertheless, the opposite signs of the interaction terms suggest that the two contracts may possibly have different gender implications. This will be further analyzed below.

Table 3 shows the effects of contracting on women's dietary diversity. Both contracts significantly increase the WDDS, again with the resource-providing contract having a larger positive effect than the marketing contract. The estimate of 1.37 for the resource-providing contract in column (1) implies that mean WDDS is increased by 32%, which is a very large and welcome effect. In column (2), we additionally control for the gender of the oil palm farmer. The female farmer dummy itself has a significantly positive effect on WDDS, confirming that female decision-making and income control has positive effects on individual diets.

The contract effects are not much affected by the additional inclusion of the female farmer dummy in column (2) of Table 3. However, the interaction terms in column (3) lead to interesting additional insights. If a female farmer is contracted under a marketing contract, the positive dietary effects of contracting are somewhat smaller than if a male farmer is contracted. For the resource-

[5] About 25% of the oil palm farmers are female with no significant differences between the three groups.

providing contract, the exact opposite is true, that is, contracting a female further improves the individual-level dietary benefits.

Table 4 shows the effects of contracting on child anthropometric measures. The estimates in column (1) suggest that the resource-providing contract has a large positive effect on child HAZ, whereas the marketing contract has a negative effect. The negative child nutrition effect of the marketing contract is surprising, because both contracts lead to clear gains in household income (Ruml et al., 2020). However, the additional results in columns (2) and (3) imply that the gender mechanism is particularly important here. The estimates in column (2) show that female decision-making and income control as such have large positive effects on child HAZ, as one would expect. Column (3) further reveals that contracting female farmers leads to much more favorable effects of both types of contracts than contracting male farmers. After controlling for these gendered mechanisms, both types of contracts have positive effects on child HAZ, whereby the effect of the resource-providing contract remains significantly larger.[6]

Columns (4) o (6) of Table 4 show the effects on child WAZ. Both types of contracts significantly increase WAZ, whereby the effect of the resource-providing contract is larger than that of the marketing contract. Female decision-making and income control matter also for child WAZ, and the positive effects of both types of contracts are larger when a female farmer is contracted than when a male farmer is contacted.

[6] Interesting to observe in column (3) of Table 4 is also the significantly negative coefficient of the interaction between female farmer and comparison group. This is probably due to the fact that oil palm farming without a contract requires much more labor for post-harvest handling and processing (Ruml and Qaim, 2021). If women are heavily involved in these tasks, they have less time available for childcare, which can result in lower child nutritional status.

Analysis of Underlying Mechanisms

The regression results suggest that contract farming has positive effects on household-level and individual-level diets and nutrition, but that the effects differ by contract type. The resource-providing contract has larger positive effects on dietary quality and child nutritional status than the marketing contract, which can partly be explained by differences in the income effects. Ruml et al. (2020) showed that the resource-providing contract is associated with larger income gains than the marketing contract.

However, changes in intra-household gender roles also seem to matter for the effects of contract farming on nutrition. Contracting female farmers has larger positive effects on child nutrition than contracting male farmers. This is true for both types of contracts and can be explained by a strengthening of female decision-making power and income control. In addition, there are gendered effects on time allocation, and these differ between the two contract types. While both contracts are associated with significant female labor savings in oil palm production, women seem to reallocate the labor time saved in different ways. Females in the marketing contract group spend more time in off-farm activities (Table 5), whereas females in the resource-providing contract group have more time available for other farming activities and for childcare and other household chores (we do not have data on time allocation to household work). Off-farm employment can strengthen women's bargaining power in some situations, but less time available for childcare can also have negative child nutrition effects (Debela et al., 2020). In comparison, work on the own farm is often more compatible with childcare activities.

The reason for the different time reallocation is directly related to the contract design. As mentioned, the resource-providing contract comes with agricultural credit and technical advice, enabling farmers to expand their agricultural operations. In contrast, the marketing contract does

not involve any financial or technical support, so households are less able to further invest in their farming business and rather spend the female labor time saved in off-farm economic activities (Ruml and Qaim, 2021).

The middle and lower parts of Table 5 provide further insights into other, but still related mechanisms. In both contract groups, dietary diversity from own production is lower than in the comparison group, but the role of own production is particularly small in households with a marketing contract. The contribution of own production to household dietary diversity is directly related to the production diversity on the farm. Table 5 shows that households with a marketing contract have significantly lower production diversity on their farms and also in their home gardens than the other two groups. This is in line with our finding that women in households with a marketing contract spend more time in off-farm employment, because women are often the ones responsible for growing food crops and for tending the home garden.

Conclusions

In this article, we have analyzed the effects of contract farming on household-level and individual-level diets and nutrition, using survey data from oil palm producers in Ghana. Some of the farmers produced oil palm with a simple marketing contract, others with a resource-providing contract, and yet others without any contract. To control for confounding factors and endogeneity of the two contracting variables, we used a multinomial treatment-effects regression approach. Our estimation results suggest that contract farming improves diets and nutrition significantly, but the magnitude of the effects varies by contract type. The comparison of the effects has also helped to gain further insights into the different underlying mechanisms.

One important mechanism of the positive diet and nutrition effects are income gains through contract farming. Higher incomes contribute to better access to purchased foods. Previous research with the same data showed that the resource-providing contract leads to larger income gains than the marketing contract (Ruml et al., 2020), which is in line with our finding here that the resource-providing contract is associated with larger positive nutrition effects. Another important mechanism is related to gender roles and gendered time allocation. Both types of contracts lead to sizeable savings in female household labor in oil palm production. While in households with a resource-providing contract the saved labor time is primarily used in other farm and household activities, in households with a marketing contract females reallocate more of their time to off-farm activities. Off-farm employment reduces the time available for food crop production, home gardening, and childcare, which also explains why the positive diet and nutrition effects of the marketing contract are smaller than those of the resource-providing contract.

Another interesting finding is that the diet and nutrition effects of contract farming are larger when a female farmer is contracted than when a male farmer is contracted. Especially for the effects on the child anthropometric outcomes, this is true for both contract types and underlines the important role of female empowerment for child nutrition. Contracting female farmers improves women's bargaining power and increases the likelihood that the income from contract farming is controlled by female household members.

This is the first study that has analyzed the nutrition effects of contract farming and the underlying mechanisms with detailed individual-level data. While the specific results from oil palm contracting in Ghana cannot be generalized, a few broader implications, which also hold beyond the concrete situation, are still worth mentioning. First, contract farming in the cash crop sector can contribute to nutritional improvements in smallholder households. Second, different types of

contracts can have different nutrition effects, so that contract design matters. Third, the diet and nutrition effects of contract farming are channeled through various mechanisms, including changes in income, gender roles, time allocation, and production diversity. These mechanisms need to be well understood for designing nutrition-sensitive smallholder contract schemes. Fourth, contracting female farmers instead of male farmers can contribute to women's empowerment and improved child nutritional outcomes. Further research with larger samples from various settings will be useful to corroborate and further extend these findings.

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Table 1. Diet and nutrition outcome variables by contract status

Variables	(1) All	(2) Marketing contract	(3) Resource providing contract	(4) Comparison group
Household dietary diversity score (HDDS)	8.091	7.953*	8.152	8.245
	(1.314)	(1.367)	(1.295)	(1.233)
Observations	463	193	164	106
Women's dietary diversity score (WDDS)	4.295	4.324	4.342	4.174
	(1.360)	(1.430)	(1.341)	(1.337)
Observations	95	34	38	23
Child height-for-age Z-score (HAZ)	-0.774	-0.777	-0.537**	-1.283
	(1.425)	(1.372)	(1.542)	(1.147)
Child weight-for-age Z-score (WAZ)	-0.546	-0.385**	-0.522	-0.893
	(1.045)	(0.966)	(1.119)	(0.978)
Prevalence of stunting (%)	14.8	14.3	14.0	17.4
Prevalence of underweight (%)	9.6	4.8	14.0	8.7
Observations	115	42	50	23

Notes: Mean values are shown with standard deviations in parentheses. Statistical tests were undertaken to compare mean value differences between comparison group farmers and both contract types. * $p<0.1$; ** $p<0.05$; *** $p<0.01$.

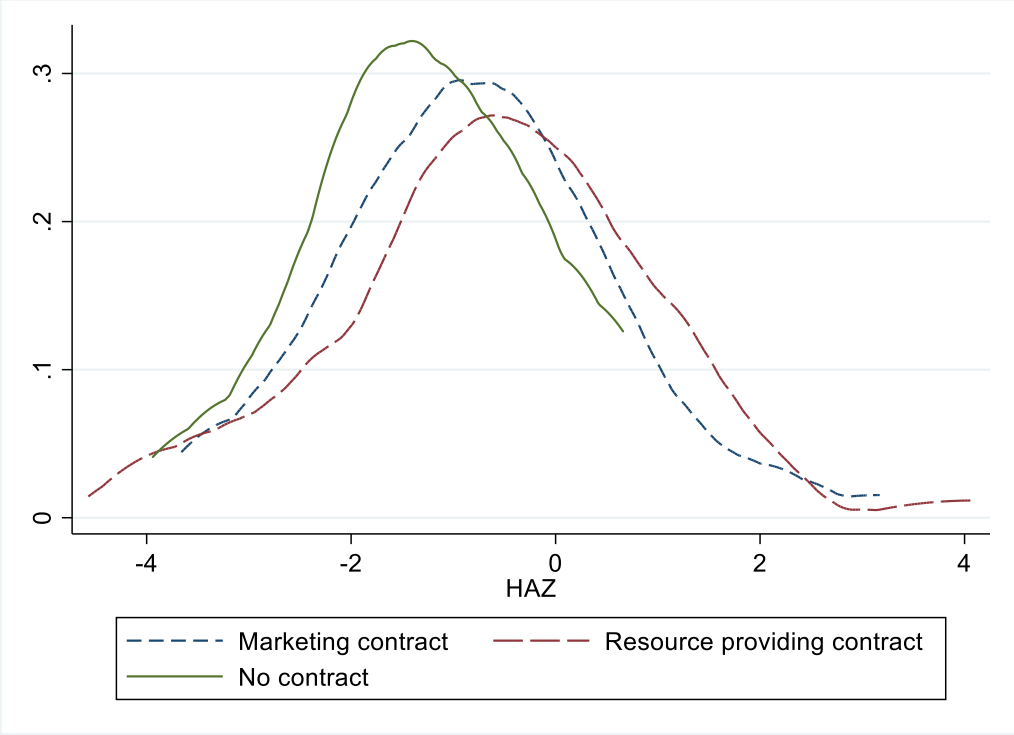

Figure 1. Height-for-age Z-score (HAZ) of children by contract status

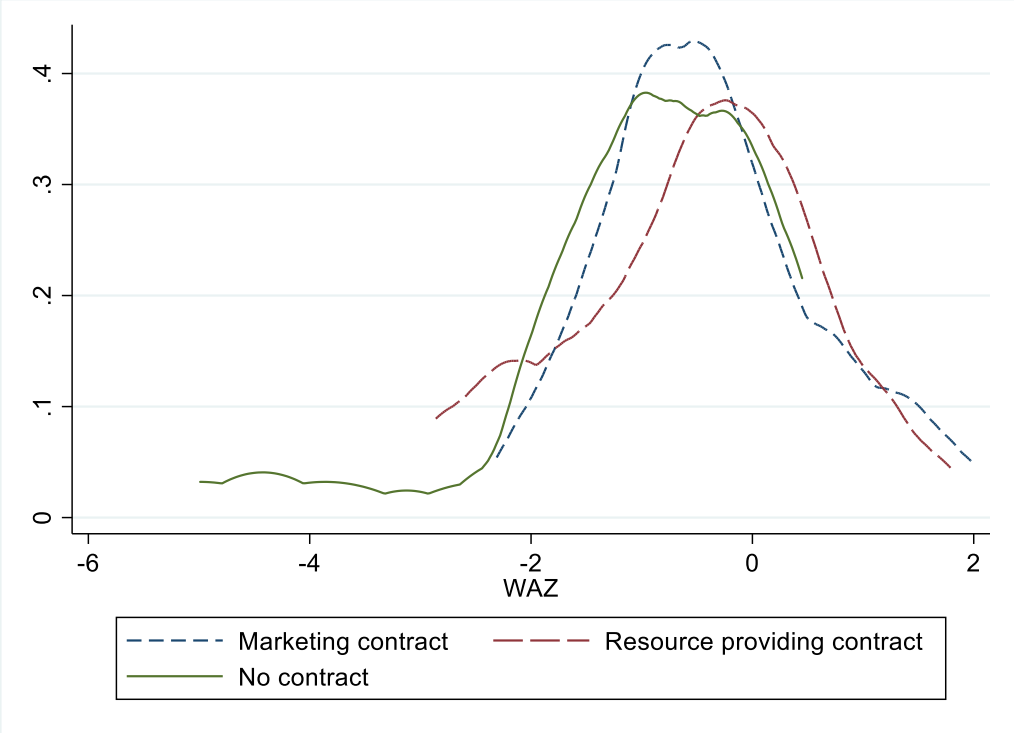

Figure 2. Weight-for-age Z-score (WAZ) of children by contract status

Table 2. Effect of contract farming on household dietary diversity score (HDDS)

	(1)	(2)	(3)
Marketing contract (1/0)	0.54***	0.25	0.17
	(0.18)	(0.47)	(0.32)
Resource-providing contract (1/0)	0.81***	0.75***	0.55***
	(0.17)	(0.19)	(0.20)
Female oil palm farmer (1/0)		-0.16	
		(0.21)	
Female farmer x Marketing contract			-0.29
			(0.25)
Female farmer x Resource-providing contract			0.21
			(0.27)
Female farmer x Comparison group			-0.49
			(0.33)
Age of household head (years)	-0.03***	-0.03***	-0.03***
	(0.01)	(0.01)	(0.01)
Female-headed household (1/0)	-0.26	-0.07	-0.10
	(0.18)	(0.23)	(0.23)
Education of head (years)	0.04***	0.05***	0.05***
	(0.01)	(0.01)	(0.01)
Experience in oil palm (years)	-0.00	0.00	0.00
	(0.01)	(0.01)	(0.01)
Distance to market (km)	-0.02*	-0.02**	-0.02**
	(0.01)	(0.01)	(0.01)
Dependency ratio [a]	0.14	0.12	0.12
	(0.09)	(0.08)	(0.08)
Land availability 2008 in acres (log)	0.16**	0.16**	0.16**
	(0.08)	(0.08)	(0.08)
Constant	8.51***	8.65***	8.74***
	(0.34)	(0.41)	(0.37)
Ln-Sigma	-0.85***	-0.20	-0.16
	(0.27)	(0.45)	(0.23)
Lambda Marketing contract	-0.94***	-0.56	-0.52
	(0.09)	(0.62)	(0.38)
Lambda Resource-providing contract	-0.72***	-0.75***	-0.73***
	(0.07)	(0.09)	(0.10)
Observations.	463	463	463
Chi 2	229.87	211.10	217.32
P-value (chi2)	0.00	0.00	0.00

Notes: Coefficient estimates of the HDDS outcome equations are shown with robust standard errors in parentheses. * $p<0.1$; ** $p<0.05$; *** $p<0.01$. Results of the multinomial logit models, which were jointly estimated with the outcome equations using simulated maximum likelihood, are shown in Table A1 in the Online Appendix. Each of the regressions was run with 400 simulations. [a] Dependency ratio is calculated by dividing the number of dependents (children under 15 and elderly above 65) by the number of adult household members.

Table 3. Effect of contract farming on women's dietary diversity score (WDDS)

	(1)	(2)	(3)
Marketing contract (1/0)	0.54***	0.63***	0.77***
	(0.01)	(0.01)	(0.00)
Resource-providing contract (1/0)	1.37***	1.32***	1.45***
	(0.01)	(0.01)	(0.00)
Female oil palm farmer (1/0)		0.21***	
		(0.01)	
Female farmer x Marketing contract			-0.04***
			(0.00)
Female farmer x Resource-providing contract			0.43***
			(0.00)
Female farmer x Comparison group			0.90***
			(0.01)
Age of individual (years)	0.01***	0.01***	0.01***
	(0.00)	(0.00)	(0.00)
Age of household head (years)	-0.04***	-0.04***	-0.04***
	(0.00)	(0.00)	(0.00)
Female-headed household (1/0)	0.10***	-0.11***	-0.18***
	(0.01)	(0.01)	(0.01)
Education of head (years)	0.04***	0.05***	0.05***
	(0.00)	(0.00)	(0.00)
Experience in oil palm (years)	0.01***	0.01***	0.02***
	(0.00)	(0.00)	(0.00)
Distance to market (km)	-0.03***	-0.03***	-0.02***
	(0.00)	(0.00)	(0.00)
Dependency ratio [a]	-0.18***	-0.20***	-0.20***
	(0.00)	(0.00)	(0.00)
Land availability 2008 in acres (log)	0.04***	0.04***	0.02***
	(0.00)	(0.00)	(0.00)
Constant	4.96***	5.05***	4.77***
	(0.01)	(0.01)	(0.01)
Ln-Sigma	-4.66***	-4.69***	-5.09***
	(0.14)	(0.24)	(0.17)
Lambda Marketing contract	-0.43***	-0.45***	-0.47***
	(0.00)	(0.00)	(0.00)
Lambda Resource-providing contract	-1.22***	-1.18***	-1.20***
	(0.00)	(0.00)	(0.00)
Observations	95	95	95
Chi 2	198,648.43	252,858.39	673,881.94
P-value (chi2)	0.00	0.00	0.00

Notes: Coefficient estimates of the WDDS outcome equations are shown with robust standard errors in parentheses. * $p<0.1$; ** $p<0.05$; *** $p<0.01$. Results of the multinomial logit models, which were jointly estimated with the outcome equations using simulated maximum likelihood, are shown in Table A2 in the Online Appendix. Each of the regressions was run with 400 simulations. [a] Dependency ratio is calculated by dividing the number of dependents (children under 15 and elderly above 65) by the number of adult household members.

Table 4. Effect of contract status on child HAZ and WAZ

	Height for-age Z-score (HAZ)			Weight-for-age Z-score (WAZ)		
	(1)	(2)	(3)	(3)	(4)	(5)
Marketing contract (1/0)	-0.30***	-0.24***	0.60***	0.85***	0.82***	0.43***
	(0.00)	(0.01)	(0.01)	(0.00)	(0.00)	(0.00)
Resource-providing contract (1/0)	1.31***	0.29***	1.69***	1.11***	1.10***	0.91***
	(0.00)	(0.01)	(0.01)	(0.00)	(0.00)	(0.00)
Female oil palm farmer (1/0)		0.88***			0.52***	
		(0.01)			(0.01)	
Female farmer x Marketing contract			1.28***			0.70***
			(0.01)			(0.00)
Female farmer x Res.-providing contract			0.84***			0.71***
			(0.00)			(0.01)
Female farmer x Comparison group			-0.28***			-0.43***
			(0.01)			(0.01)
Age of child (months)	-0.12***	-0.07***	-0.16***	-0.10***	-0.11***	-0.13***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Age of child squared	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Female child (1/0)	0.43***	0.47***	0.30***	0.07***	0.08***	0.14***
	(0.00)	(0.00)	(0.01)	(0.00)	(0.00)	(0.00)
Age of household head (years)	-0.01***	-0.01***	-0.03***	-0.01***	-0.02***	-0.02***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Female-headed household (1/0)	0.37***	-0.56***	-0.03***	0.30***	-0.17***	-0.02***
	(0.00)	(0.01)	(0.00)	(0.00)	(0.01)	(0.00)
Education of head (years)	-0.01***	0.00***	-0.03***	-0.00***	-0.00**	-0.01***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Experience in oil palm(years)	0.06***	0.04***	0.06***	0.04***	0.04***	0.03***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Distance to market (km)	-0.07***	-0.02***	-0.05***	-0.02***	-0.01***	-0.02***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Dependency ratio [a]	-0.22***	-0.02***	-0.15***	-0.18***	-0.13***	-0.13***
	(0.00)	(0.00)	(0.01)	(0.00)	(0.00)	(0.00)
Land availability 2008 in acres (log)	0.11***	0.16***	0.19***	0.14***	0.15***	0.15***
	(0.00)	(0.00)	(0.01)	(0.00)	(0.00)	(0.00)
Constant	1.96***	0.21***	2.59***	1.27***	1.53***	2.22***
	(0.01)	(0.02)	(0.03)	(0.02)	(0.02)	(0.01)
Ln-Sigma	-5.01***	-4.77***	-4.84***	-4.95***	-4.81***	-5.28***
	(0.13)	(0.15)	(0.12)	(0.17)	(0.22)	(0.19)
Lambda Marketing contract	1.21***	0.77***	-0.75***	-0.53***	-0.50***	-0.55***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Lambda Resource-providing contract	-0.35***	0.99***	-1.05***	-0.76***	-0.78***	-0.80***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Observations	115	115	115	115	115	115
Chi2 (thousand)	1,796.36	343.76	1,957.47	392.77	288.75	2,935.73
P-value (chi2)	0.00	0.00	0.00	0.00	0.00	0.00

Notes: Coefficient estimates of the child HAZ and WAZ outcome equations are shown with robust standard errors in parentheses. * $p<0.1$; ** $p<0.05$; *** $p<0.01$. Results of the multinomial logit models, which were jointly estimated with the outcome equations using simulated maximum likelihood, are shown in Tables A3 and A4 in the Online Appendix. Each of the regressions was run with 400 simulations. [a] Dependency ratio is calculated by dividing the number of dependents (children under 15 and elderly above 65) by the number of adult household members.

Table 5. Female time allocation and production diversity by contract status

Variables	Marketing contract	Resource-providing contract	Comparison group	Marketing vs. Resource-providing
Female labor days (per adult female member)				
Work in oil palm	5.392***	2.6458***	19.061	***
	(10.728)	(5.6587)	(32.306)	
Work in off-farm activities	59.467*	44.638	37.813	
	(102.708)	(91.7915)	(87.929)	
Sources of dietary diversity (HDDS)				
From own production	2.430***	3.079*	3.500	***
	(1.520)	(1.853)	(1.763)	
From market	7.420	7.189	7.245	
	(1.467)	(1.604)	(1.466)	
Production diversity				
Production diversity (farm)	2.860**	3.530	3.245	***
	(1.364)	(1.674)	(1.406)	
Production diversity (home garden)	2.062**	2.610	2.406	***
	(1.265)	(1.592)	(1.322)	
Observations	193	164	106	

Notes: Mean values are shown with standard deviations in parentheses. Statistical tests were undertaken to compare mean value differences between comparison group farmers and both contract types. The last column tests mean value differences between farmers with marketing and resource-providing contracts. * $p<0.1$; ** $p<0.05$; *** $p<0.01$.