Effects of contract farming on diets and nutrition in Ghana

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Abstract
Contract farming gained importance in many developing countries. While effects of contracting on smallholder farmers' incomes were analyzed in 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 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 child nutrition effects than contracting male farmers.

KEYWORDS
contract farming, diets, Ghana, nutrition, oil palm

JEL CLASSIFICATION
O15, Q12, Q13

Contract farming gained importance in many developing countries, facilitating the coordination in modern 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 & 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 & Swinnen, 2009; Maertens & Velde, 2017; Rao & Qaim, 2011; 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 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. Soulier 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 all existing studies on contract farming and nutrition is that they used household-level dietary data, which are not suitable to analyze individual-level nutrition outcomes. As is well known, food is not always distributed equally within households (Haddad et al., 1997), meaning that household-level indicators may mask nutritional issues of particularly vulnerable groups.

Our contribution to the existing literature is twofold. First, we analyze the nutrition effects of contract farming with individual-level indicators, including women’s dietary diversity score (WDDS) and child anthropometric measures. A focus on women and children is important, as these groups are particularly prone to problems of undernutrition and low dietary quality with long-term negative health implications (Development Initiatives, 2020). Issues of unequal food and resource distribution within households can only be analyzed with individual-level data. To our knowledge, individual-level nutrition outcomes of contract farming were never analyzed before. 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 semi-subsistence farming toward 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 without any contract. Potential endogeneity issues are addressed through two-step multinomial treatment-effects regression models that consider the multinomial nature of the treatment (Deb & Trivedi, 2006; Deb, 2009). Unobservables are captured in a multinomial contract participation model using an instrumental variable. Simultaneously, the effect of the unobservables is accounted for in the outcome equation. Our results suggest that both types of contracts have positive nutrition effects under certain conditions, but the effect magnitudes differ. Moreover,
our results underline the important role of gender for the nutrition outcomes of contract farming. 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. We then 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 incomes 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 technologies (Andersson et al., 2015; Bellemare, 2012; Maertens & Swinnen, 2009; Meemken & Bellemare, 2020; Rao & Qaim, 2011). Household income gains typically lead to improvements in food security and dietary quality, especially through additional food purchases from the market (Koppmair et al., 2017; Shively & 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 crop 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 & Hoddinott, 2017; Sibhatu & 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 often controlled by male household members (Njuki et al., 2011; von Braun & 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 & 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 & 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 & Swinnen, 2012; Otsuka et al., 2016; Qaim, 2017). As women in agricultural households are often particularly time-constrained, more work in 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 & 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., 2021; Popkin & Solon, 1976).

This discussion underlines that contract farming may lead to both positive and negative partial effects on nutrition, depending on the type of contract and the particular institutional and cultural context. In the context of this study, the two types of contracts may have differential effects. Previous research in the same setting in Ghana shows that both contracts lead to significant household income gains, but through different channels (Ruml et al., 2020). Both contracts reduce the labor requirements per acre of oil palm, largely due to the fact that contract farmers can sell the entire fruit bunches, as harvested, whereas traditional spot markets require labor-intensive post-harvest handling (see below for more details). In households with a marketing contract, the family labor saved, especially female labor, is reallocated to off-farm employment (Ruml & Qaim, 2021). While this leads to off-farm income gains, maternal off-farm employment may reduce the time available for childcare, food production, and food preparation. In contrast, the resource-providing contract is associated with on-farm specialization and expansion, leading to large farm income gains and no significant female labor reallocation to off-farm activities (Ruml et al., 2020; Ruml & Qaim, 2021). Results from these previous studies in the same setting are also summarized in Table 1. Based on the conceptual discussion above and these empirical insights, we expect the resource-providing contract to have larger positive nutrition effects than the marketing contract.

### 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

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**Table 1  Previous findings on effects of contracts in Ghana’s palm oil sector**

|                      | Marketing contract | Resource-providing contract |
|----------------------|--------------------|----------------------------|
| **Land use**         |                    |                            |
| Specialization       | No effect          | Increased                  |
| Cultivated area      | No effect          | Increased                  |
| Crop yield           | No effect          | Increased                  |
| **Labor use**        |                    |                            |
| Labor use per acre   | Reduced            | Reduced                    |
| Off-farm employment  | Increased          | Increased                  |
| Female off-farm employment | Increased         | No effect                  |
| **Income**           |                    |                            |
| Income from oil palm | Increased          | Increased                  |
| Other farm income    | Decreased          | Decreased                  |
| Off-farm income      | Increased          | No change                  |
| Total income         | Increased          |                            |

*Note: Based on findings from Ruml and Qaim (2020, 2021) and Ruml et al. (2020).*
been observed in Ghana and other countries of West Africa (Byerlee et al., 2017; Qaim et al., 2020). The oil palm crop is native to West Africa and was traditionally grown by small-holder farmers. Many farm households in Ghana produce small quantities of palm oil for home consumption and local markets. But the sector is transforming (Huddleston & Tonts, 2007; Rhebergen et al., 2016). During the last 10 years, several national and international palm oil companies have established large processing plants, especially in the Southern parts of Ghana (Ministry of Food and Agriculture, 2011). These palm oil companies 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 (Ministry of Food and Agriculture, 2011). 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 (Ruml & Qaim, 2021).

Survey of farmers with and without contracts

Data for this study were collected through a survey of oil palm farmers 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. Two companies were selected based on the types of contracts offered and the geographical proximity of each other. 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. Both companies are located in neighboring regions; their catchment areas do not overlap. 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. BOPP farmers receive no production support from the contracting company.

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 in-kind credits for plantation establishment, inputs, and related technical support. TOPP farmers receive assistance and inputs for the establishment and maintenance of the oil palm plantation. The costs for the plantation establishment are deducted with 25% of each harvest, until the debt is fully repaid. The BOPP scheme was already started in the late-1990s in the Western Region, whereas the TOPP scheme was launched in 2008 in the Central Region.

Prior to the survey, we investigated the village and farmer selection process of both companies. Both companies stated that villages within their catchment area were selected such that transport and transaction costs are kept as low as possible. Within the selected villages, companies offered the contract to all farmers willing to accept the contract terms, independent of farm size or farmer characteristics such as age or gender. This was also confirmed by village officials, who we interviewed in the contract villages. Within these villages, almost all oil palm farmers participate in the contract scheme. For the survey, we randomly sampled contract farmers in these villages (see details below). The few noncontracted oil palm farmers in the same villages often produce only for home consumption, which is why they were not considered a suitable comparison group. For unbiased evaluation, comparison farmers should be market-oriented oil palm producers that do not hold a contract but that would likely accept a contract if offered one.
To sample comparison farmers without a contract, we identified similar villages without a contract scheme in place. Fortunately, at the time of the survey new contract schemes were planned in Southern Ghana, so we could select villages in another neighboring region (Ashanti Region) that had already been pre-registered for an upcoming contract scheme. The list of pre-registered villages was provided by the local Ministry of Food and Agriculture (MoFA). While a palm oil company was about to start offering contracts to farmers in these villages, at the time of the survey farmers were not yet aware of the upcoming contract scheme, as we verified with village officials and through focus group discussions.

Our sampling strategy was designed to minimize potential biases in the selection of contract and comparison villages. However, as the villages are located in three different regions, regional differences might occur with possible implications for the impact analysis. We investigated potential regional differences using primary data on soil quality, irrigation, and village infrastructure. Furthermore, we used secondary data to compare agroecological (area classification, temperature, rainfall) and socioeconomic conditions (gross income, human development index, employment, and unemployment ratios) between the three regions (Table S1). None of these comparisons indicate significant regional differences, which is reassuring for our analysis.

After randomly sampling the villages, we compiled lists of all oil palm farmers within these villages for random selection and interview. Our sample includes a total of 463 farm households. 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 simultaneously producing oil palm under different contract types. Nor are there farmers who switched contract types at any time in the past (all contract farmers adopted their contracts at least 10 years ago). As mentioned, the company contract schemes are located in different regions without an overlap of catchment areas. We also asked each respondent about their contract status and none of the farmers reported holding a contract from a company in a neighboring region.

Measurement of diets and nutrition

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 ranges between 0 and a maximum of 12 food groups, with higher values indicating better diets and nutrition. 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 2 and 6 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 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. Women’s diets are assessed with the 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. We collected individual-level dietary data from women through a
24-h 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 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 to 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 2 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 a contract. Data from all households were collected during the same season, so the impact estimates are unlikely to suffer from systematic seasonality bias.

**ECONOMETRIC APPROACH**

**Modeling 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 farm households. For this purpose, we estimate regression models of the following type:

\[ N_i = \varphi + \gamma_{MC} C_{MC,i} + \gamma_{RPC} C_{RPC,i} + X_i' \beta + \varepsilon_i, \]

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, \( X_i' \) is a vector of control variables that may also influence diets and nutrition, and \( \varepsilon_i \) 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. We consider all outcome variables as continuous and estimate linear relationships.\(^3\)

Our main coefficients of interest in Equation (1) are \( \gamma_{MC} \) and \( \gamma_{RPC} \), which estimate the diet and nutrition effects of both contract types. Given that the contracts were shown to improve household income significantly (Ruml et al., 2020), we generally expect positive diet and nutrition effects. But as both contracts have different effects on time reallocation to on-farm and off-farm activities, a comparison of the coefficients \( \gamma_{MC} \) and \( \gamma_{RPC} \) 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 $X^i_0$ 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, distance to the closest market (village or small town markets where households purchase most of their food), and dummy variables for soil quality and access to irrigation. We also include farm size in terms of the land available for cultivation. As the resource-providing contract was shown to influence farm size (Ruml & Qaim, 2020), we use household land availability in 2008, before the resource-providing contract scheme was started. 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 and a sanitation-related variable (access to toilet) that might directly affect child nutrition and health. A full list of control variables and related descriptive statistics are shown in Table S2.

**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 $\gamma_{MC}$ and $\gamma_{RPC}$ in Equation (1) would be biased. To reduce potential endogeneity bias, we use the multinomial treatment-effects regression approach, which accounts for multiple endogenous treatments (contract types in our case) (Deb & Trivedi, 2006). 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:

$$
\Pr(C_{ij} \mid X_i, l_{ij}) = g(X_i'\tau_{MC} + \delta_{MC}l_{MC,i}, X_i'\tau_{RPC} + \delta_{RPC}l_{RPC,i}),
$$

where subscript $j$ represents the contract type with three possible values: $0 =$ no contract; $1 =$ marketing contract (MC); and $2 =$ resource-providing contract (RPC). $\Pr(C_{ij} \mid X_i, l_{ij})$ refers to the probability that household $i$ produces under contract type $C_j$, given the control variables $X_i$ and unobserved characteristics $l_{ij}$. The function $g$ follows a multinomial probability distribution. When Equation (2) is jointly estimated with Equation (1), $l_{MC}$ and $l_{RPC}$ control for potential unobserved factors and estimate correlations between the contract status and outcome variables resulting from unobservables (Deb & Trivedi, 2006).

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, Deb and Trivedi (2006) recommend using an instrument in Equation (1), which we do. Our instrument for participation in contract type $C_j$ is the inverse distance to the closest large palm oil mill. This instrument captures the distance to the next contracting company and thus the likelihood of the farmer receiving (or having received) a contract offer. The instrument cannot be influenced by individual farmers and is significantly correlated with both types of contracts, as is shown in the different first-stage household-level and individual-level models in Tables S3–S6. At 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 S7. 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 the same towns that have other relevant markets for remote smallholders (we also control for market access in the regressions). Hence, our instrument seems to be valid.

One other challenge that could be raised in our context relates to identifying causal effects on child HAZ as a longer-term nutritional outcome indicator. This is because HAZ is a cumulative measure that is affected by nutritional deficiencies over a longer time period and is therefore not very sensitive to short-term interventions (O'Donnell et al., 2008; Shively, 2017). However, in our setting both contract farming schemes have existed for more than 10 years with stable farmer participation, so that identification of longer-term nutritional effects in children is generally possible.

RESULTS

Descriptive comparisons of outcome variables

Table 2 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 2. Negative values for

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

Note: 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.
HAZ and WAZ indicate that child undernutrition is commonplace. Around 15% of the children in our sample are stunted and 10% are underweight.7

The other columns in Table 2 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 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

**FIGURE 1** Height-for-age Z-score (HAZ) of children by contract status [Color figure can be viewed at wileyonlinelibrary.com]

**FIGURE 2** Weight-for-age Z-score (WAZ) of children by contract status [Color figure can be viewed at wileyonlinelibrary.com]
children from households with a marketing contract. The worst nutrition status is observed for children from households without any contract.

Descriptive comparison of underlying mechanisms

Prior to looking at the regression results, we descriptively compare some of the mechanisms underlying the nutrition effects of contract farming (see conceptual framework). Previous research showed that both types of contracts lead to significant gains in total household income (Ruml et al., 2020). Yet, differences in labor reallocation, especially among female household members, and changes in on-farm cropping patterns can lead to differential effects on nutrition, depending on the contract type.

Table 3 shows mean values for relevant variables by contract status. We observe significant differences in female time allocation between the contracts. Both contracts are associated with significant female labor savings in oil palm production, but women seem to reallocate the labor time saved in different ways. As was already shown in previous research (Ruml & Qaim, 2021), females in the marketing contract group spend more time in off-farm activities (Table 3), 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

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

Note: 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.
nutrition effects (Debela et al., 2021). In comparison, work on the own farm is often more compatible with childcare activities.

The middle and lower parts of Table 3 provide insights into other 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 3 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 the 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. Against this background, we expect the resource-providing contract to have larger positive nutrition effects than the marketing contract.

Regression results

Regression estimates of the effects of contract farming on household-level dietary diversity are shown in Table 4. The two models shown in columns (1) and (2) both have HDDS as the dependent variable. Results in column (1) suggest that—after controlling for confounding factors—the resource-providing contract increases HDDS by 0.7 food groups, whereas the marketing contract does not significantly affect dietary diversity. The model in column (1) includes all control variables, except for the gender of the oil palm farmer, which is additionally included in column (2). Comparison of these two models is interesting to better understand potential gender mechanisms. The female farmer dummy in column (2) of Table 4 is not statistically significant and does not seem to influence the contract effects. Hence, for the household-level analysis a clear gender mechanism cannot be identified.

Table 5 shows the effects of contracting on women’s dietary diversity. Results in column (1) suggest that the resource-providing contract increases WDDS, while the marketing contract has a significantly negative effect. The latter result is surprising, given that both types of contracts are income-increasing. However, as discussed, women in households with a marketing contract are more involved in off-farm activities, which seems to affect their own dietary diversity in a negative way.

In column (2) of Table 5, we additionally control for the gender of the oil palm farmer. In this model, the female farmer dummy has a significantly positive effect on WDDS, which is plausible: if the woman herself is managing the oil palm farm, she is more likely to control the farm income and less likely to spend much time in off-farm activities, both of which can influence her individual-level dietary diversity in a positive way. In addition, inclusion of the female farmer dummy also affects the coefficients of both types of contracts. The positive effect of the resource-providing contract increases in magnitude, and the negative effect of the marketing contract turns positive and significant in column (2) of Table 5. These results clearly suggest that gender mechanisms matter for women’s individual-level dietary diversity.

Table 6 shows the effects of contract farming on child nutritional status. 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. Again, the latter result is somewhat surprising, but gender mechanisms seem to play an important role. The estimates in column (2) reveal that the female farmer dummy has a large positive effect on child HAZ, as one would expect. The effect of the marketing contract remains negative, but gets smaller in absolute terms. To analyze the gender mechanisms further, we include additional interaction terms.
between the female farmer dummy and the two contract types in column (3) of Table 6. Both interaction terms have large positive coefficients, implying that the effects of contracting on child HAZ are much more positive when a female farmer is contracted than when a male farmer is contracted. For the marketing contract, the positive interaction term is larger than the negative direct effect, implying that the overall effect of the contract on child HAZ turns positive when a female farmer is contracted. These effects are in line with the expected mechanisms discussed in the conceptual framework above.

Columns (4)–(6) of Table 6 show the models with child WAZ as the outcome variable. Both types of contracts significantly increase WAZ, with the effect of the resource-providing contract being larger than the effect of the marketing contract. The female oil palm farmer dummy in column (5) has a positive coefficient, as expected. Analogously, the female interaction terms in column (6) are both positive and significant, suggesting again that contracting has a larger positive effect on child WAZ when a female instead of a male farmer is contracted.

When comparing the different models in Table 6, one interesting pattern is that the direct effect of the marketing contract on child HAZ is consistently negative, whereas the same effect on child WAZ is consistently positive. The reason is that HAZ and WAZ measure different facets of child nutrition. HAZ is a measure of child linear growth, which is influenced by longer-term conditions of dietary quality (balanced nutrient intakes), sanitation and health, as

| TABLE 4 Effect of contract farming on household dietary diversity score (HDDS) |
|-------------------------------|-----------------|-----------------|
| Marketing contract (1/0) | 0.23 (0.51) | 0.22 (0.39) |
| Resource-providing contract (1/0) | 0.70*** (0.18) | 0.70*** (0.18) |
| Female oil palm farmer (1/0) | −0.15 (0.20) | −0.03*** (0.01) |
| Age of household head (years) | −0.03*** (0.01) | −0.03*** (0.01) |
| Female-headed household (1/0) | −0.19 (0.17) | −0.07 (0.23) |
| Education of head (years) | 0.05*** (0.01) | 0.05*** (0.01) |
| Experience in oil palm (years) | 0.00 (0.01) | 0.00 (0.01) |
| Distance to market (km) | −0.02** (0.01) | −0.02** (0.01) |
| Dependency ratio | 0.12 (0.08) | 0.11 (0.08) |
| Land availability 2008 in acres (log) | 0.09 (0.09) | 0.09 (0.09) |
| Good soil quality (1/0) | 0.01 (0.01) | 0.01 (0.01) |
| Irrigation (1/0) | 0.08 (0.15) | 0.08 (0.13) |
| Constant | 8.70*** (0.40) | 8.71*** (0.38) |
| Ln-Sigma | −0.22 (0.46) | −0.20 (0.31) |
| Lambda, marketing contract | −0.56 (0.67) | −0.53 (0.49) |
| Lambda, resource-providing contract | −0.76*** (0.12) | −0.76*** (0.10) |
| Observations | 463 | 463 |
| Model p-value ($\chi^2$ test) | 0.00 | 0.00 |

Note: 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 S3. Each of the regressions was run with 400 simulations.

aDependency ratio calculated by dividing the number of dependents (children under 15 and elderly above 65) by the number of adult household members.
well as maternal nutrition and care (Headey et al., 2018; Shively, 2017). In contrast, WAZ is a measure of child weight gain, which primarily depends on individual calorie intakes. Calorie intakes tend to increase with rising incomes. Sanitation and health conditions tend to improve as well with rising incomes, but dietary quality and maternal care also depend on intra-household gender roles. As shown, the marketing contract is associated with more female off-farm labor, thus reducing maternal time available for food production, food preparation, and childcare. In a different context, Debela et al. (2021) also showed that higher levels of maternal off-farm employment can be associated with negative child nutrition effects. This interpretation is also consistent with the positive female farmer interaction term: if the female is contracted, she manages the farm and reallocates less time to off-farm employment.

One point important to mention is that the contracting companies in our context do not decide whether to contract male or female farmers. Contracts are always made with the person responsible for oil palm farming in a household. Often, oil palm farming is managed by a male household member, so most of the contracts are with male farmers. However, in about 25% of our sample households, oil palm farming is managed by women (Table S2), and it is in these households where the contracts are then also made with female farmers. Making more contracts with female farmers might contribute to female empowerment, and, as our results suggest, also to improved child nutrition.

| TABLE 5 Effect of contract farming on women's dietary diversity score (WDDS) |
|---------------------------------|------------|------------|
|                                  | (1)        | (2)        |
| Marketing contract (1/0)         | −0.33***   | 0.39***    |
| Resource-providing contract (1/0)| 0.76***    | 1.07***    |
| Female oil palm farmer (1/0)     | 0.02***    | 0.01***    |
| Age of individual (years)        | −0.04***   | −0.04***   |
| Age of household head (years)    | −0.31***   | 0.00       |
| Female-headed household (1/0)    | 0.02***    | 0.03***    |
| Education of head (years)        | 0.01***    | 0.01***    |
| Experience in oil palm (years)   | −0.02***   | 0.00***    |
| Distance to market (km)          | −0.10***   | −0.24***   |
| Land availability 2008 in acres (log) | 0.03***     | 0.05***    |
| Good soil quality (1/0)          | −0.00***   | −0.01***   |
| Irrigation (1/0)                 | 0.30***    | 0.49***    |
| Constant                         | 4.90***    | 4.85***    |
| Ln-Sigma                         | −5.05***   | −4.67***   |
| Lambda, marketing contract       | 1.25***    | −0.19***   |
| Lambda, resource-providing contract | −0.83***   | −1.27***   |
| Observations                     | 95         | 95         |
| Model p-value (χ² test)          | 0.00       | 0.00       |

Note: 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 S4. Each of the regressions was run with 400 simulations.

DEPENDENCY RATIO calculated by dividing the number of dependents (children under 15 and elderly above 65) by the number of adult household members.
|                                | Height for-age Z-score (HAZ) | Weight-for-age Z-score (WAZ) |
|--------------------------------|------------------------------|------------------------------|
|                                | (1)                          | (2)                          | (3)                          | (4)                          | (5)                          | (6)                          |
| Marketing contract, MC (1/0)   | \(-0.52^{***} (0.01)\)       | \(-0.29^{***} (0.00)\)       | \(-0.63^{***} (0.00)\)       | \(0.25^{***} (0.01)\)        | \(0.91^{***} (0.00)\)        | \(0.60^{***} (0.00)\)        |
| Resource-providing contract, RPC (1/0) | \(1.10^{***} (0.01)\)       | \(0.34^{***} (0.00)\)       | \(0.78^{***} (0.01)\)       | \(1.08^{***} (0.01)\)        | \(1.19^{***} (0.00)\)        | \(0.96^{***} (0.00)\)        |
| Female oil palm farmer (1/0)   | \(0.77^{***} (0.00)\)       | \(-0.01^{**} (0.01)\)       | \(0.49^{***} (0.00)\)       | \(-0.47^{***} (0.00)\)       |                          |                              |
| Female farmer \(\times\) MC   | \(1.10^{***} (0.01)\)       | \(0.90^{***} (0.00)\)       | \(0.47^{***} (0.00)\)       | \(0.01^{**} (0.01)\)         | \(0.49^{***} (0.00)\)        | \(0.09^{***} (0.00)\)        |
| Age of child (months)          | \(-0.13^{***} (0.00)\)      | \(-0.12^{***} (0.00)\)      | \(-0.16^{***} (0.00)\)      | \(-0.08^{**} (0.01)\)        | \(-0.10^{***} (0.00)\)       | \(-0.10^{***} (0.00)\)       |
| 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)             | \(0.40^{***} (0.00)\)       | \(0.28^{***} (0.00)\)       | \(0.49^{***} (0.00)\)       | \(-0.04^{**} (0.01)\)        | \(0.01^{***} (0.00)\)        | \(0.09^{***} (0.00)\)        |
| Age of household head (years)  | \(-0.01^{***} (0.00)\)      | \(-0.02^{***} (0.00)\)      | \(-0.02^{***} (0.00)\)      | \(-0.01^{**} (0.00)\)        | \(-0.02^{***} (0.00)\)       | \(-0.02^{***} (0.00)\)       |
| Female-headed household (1/0)  | \(0.49^{***} (0.01)\)       | \(-0.51^{***} (0.00)\)      | \(-0.12^{***} (0.00)\)      | \(0.13^{***} (0.01)\)        | \(-0.04^{***} (0.00)\)       | \(-0.13^{***} (0.00)\)       |
| Education of head (years)      | \(-0.01^{***} (0.00)\)      | \(-0.01^{***} (0.00)\)      | \(-0.02^{***} (0.00)\)      | \(0.00^{**} (0.00)\)         | \(-0.01^{***} (0.00)\)       | \(-0.02^{***} (0.00)\)       |
| Experience in oil palm(years)  | \(0.05^{***} (0.00)\)       | \(0.05^{***} (0.00)\)       | \(0.06^{***} (0.00)\)       | \(0.04^{***} (0.00)\)        | \(0.04^{***} (0.00)\)        | \(0.03^{***} (0.00)\)        |
| Distance to market (km)        | \(-0.07^{***} (0.00)\)      | \(-0.04^{***} (0.00)\)      | \(-0.05^{***} (0.00)\)      | \(-0.03^{**} (0.00)\)        | \(-0.01^{***} (0.00)\)       | \(-0.01^{***} (0.00)\)       |
| Dependency ratio \(a\)         | \(-0.22^{***} (0.00)\)      | \(-0.08^{***} (0.00)\)      | \(-0.11^{***} (0.00)\)      | \(-0.19^{***} (0.00)\)       | \(-0.16^{***} (0.00)\)       | \(-0.18^{***} (0.00)\)       |
| Land availability 2008 in acres (log) | \(0.09^{***} (0.00)\)       | \(0.17^{***} (0.00)\)       | \(0.13^{***} (0.00)\)       | \(0.15^{***} (0.00)\)        | \(0.19^{***} (0.00)\)        | \(0.21^{***} (0.00)\)        |
| Good soil quality (1/0)        | \(0.01^{***} (0.00)\)       | \(0.01^{***} (0.00)\)       | \(0.01^{***} (0.00)\)       | \(-0.00^{**} (0.00)\)        | \(-0.01^{***} (0.00)\)       | \(-0.00^{***} (0.00)\)       |
| Irrigation (1/0)               | \(0.06^{***} (0.00)\)       | \(0.08^{***} (0.00)\)       | \(0.06^{***} (0.00)\)       | \(0.21^{***} (0.00)\)        | \(0.11^{***} (0.00)\)        | \(0.10^{***} (0.00)\)        |
| Access to toilet (1/0)         | \(0.29^{***} (0.01)\)       | \(0.04^{***} (0.01)\)       | \(0.22^{***} (0.00)\)       | \(0.87^{***} (0.01)\)        | \(0.95^{***} (0.00)\)        | \(1.36^{***} (0.00)\)        |
| Constant                       | \(2.02^{***} (0.02)\)       | \(1.68^{***} (0.01)\)       | \(2.86^{***} (0.03)\)       | \(0.32^{***} (0.01)\)        | \(0.40^{***} (0.02)\)        | \(0.37^{***} (0.01)\)        |
| Ln-Sigma                       | \(-5.07^{***} (0.14)\)      | \(-5.19^{***} (0.15)\)      | \(-5.18^{***} (0.32)\)      | \(-5.39^{***} (0.16)\)       | \(-5.12^{***} (0.22)\)       | \(-5.41^{***} (0.12)\)       |
| Lambda, marketing contract     | \(1.24^{***} (0.00)\)       | \(0.76^{***} (0.00)\)       | \(1.22^{***} (0.00)\)       | \(0.48^{***} (0.00)\)        | \(-0.56^{***} (0.00)\)       | \(-0.45^{***} (0.00)\)       |
| Lambda, resource-providing contract | \(-0.17^{***} (0.00)\)   | \(0.99^{***} (0.00)\)       | \(-0.06^{***} (0.00)\)      | \(-0.78^{***} (0.00)\)       | \(-0.76^{***} (0.00)\)       | \(-0.84^{***} (0.00)\)       |
| Observations                   | 115                          | 115                          | 115                          | 115                          | 115                          | 115                          |
| Model \(p\)-value (\(\chi^2\) test) | 0.00                          | 0.00                          | 0.00                          | 0.00                          | 0.00                          | 0.00                          |

Note: 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 S5 and S6. Each of the regressions was run with 400 simulations.

*aDependency ratio calculated by dividing the number of dependents (children under 15 and elderly above 65) by the number of adult household members.
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 produce 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, but the magnitude of the effects varies by contract type. The comparison between the two contract types also helps to gain further insights into the different underlying mechanisms.

Previous research in the same setting showed that the marketing contract and the resource-providing contract both lead to sizable income gains for contracted farm households (Ruml et al., 2020). Hence, positive diet and nutrition effects could be expected. But our results here indicate that the nutrition effects are larger for the resource-providing contract, and even negative for the marketing contract in some of the specifications. These findings underline that there are mechanisms other than income that also influence nutrition outcomes. In particular, we highlight the important role of gender-related mechanisms. Both types of contracts lead to sizable female labor savings 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 (including in home gardens), food preparation, 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. For child height (linear growth), which depends more on dietary quality and maternal care than child weight, the effect of the marketing contract was even found to be negative.

The reason for the different patterns of female labor time reallocation between contracts is directly related to the contract design. The resource-providing contract comes with agricultural credit and technical advice, enabling farmers to expand their agricultural operations. Hence, the labor time saved per acre of oil palm is primarily used in other farm and household activities. 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 for off-farm economic activities (Ruml & Qaim, 2020; Ruml & Qaim, 2021).

Another interesting finding is that the child nutrition effects of contract farming are always positive and larger in magnitude when a female farmer is contracted than when a male farmer is contracted. This emphasizes the important role of female empowerment for child nutrition that is well-known from the literature (Debela et al., 2021; Malapit et al., 2015). Contracting female farmers improves women’s bargaining power, increases the likelihood that the income from contract farming is controlled by female household members, and reduces the reallocation of female labor time to off-farm activities. While the palm oil companies in Ghana always contract the person in the household who is responsible for oil palm farming anyway, our results suggest that choosing the person more purposively in a gender-sensitive way could be an effective avenue to further improve the nutrition effects of contract farming.

This is the first study that has analyzed the nutrition effects of contract farming with detailed individual-level data. Use of individual-level data is important because aggregate household-level data can mask effects for vulnerable groups and the underlying mechanisms. For instance, gender-related mechanisms became evident only in our individual-level models, not in the models with household-level dietary 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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ENDNOTES

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 nine 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.

3 HDDS and WDDS are count variables, but we found their distributions in our sample to be sufficiently near to a normal distribution, so a linear functional form for estimation is appropriate.

4 The marketing contract scheme was started earlier, but previous research shows that the marketing contract does not affect farm size (Ruml & Qaim, 2020).

5 Estimation yields $\lambda_{MC}$ and $\lambda_{RPC}$ as parameters for $l_{MC}$ and $l_{RPC}$, with the parameter signs indicating whether there is positive or negative correlation between the contract status and the outcome variables due to unobserved characteristics (Deb & Trivedi, 2006). Our results show significant estimates for these parameters in most models (Table S8), suggesting that unobservables matter and are controlled for with our estimation procedure.

6 Note that one instrument is sufficient if it is significantly correlated with both contracts, as the treatment groups are mutually exclusive.

7 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.

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**SUPPORTING INFORMATION**

Additional supporting information may be found in the online version of the article at the publisher’s website.

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