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Anette Ruml, University of Goettingen, anette.ruml@uni-goettingen.de
Bethelhem Legesse Debela, University of Goettingen
Matin Qaim, University of Goettingen

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Bethelhem Legesse Debela [a], Anette Ruml [a, b], Matin Qaim [a]

[a] Department of Agricultural Economics and Rural Development, University of Goettingen, Goettingen, Germany

[b] German Institute for Global and Area Studies, Hamburg, Germany.

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Abstract

Contract farming is becoming increasingly important in developing countries, to coordinate transactions along agricultural supply chains. In this paper, we examine the diet and nutrition implication of engaging in contract farming among smallholder farmers in Ghana. Previous studies have analyzed the effects of contract farming on farm production and household income. However, little is known about the effects of contract farming on household and individual nutrition. We know of no study that has analyzed the effects of contract farming on household and individual dietary diversity, as well as on anthropometric measures. Our study further contributes to the existing literature by investigating differences in effects across different types of contracts, which has largely been neglected. Results show that producing oil palm under contract has implications for household and individual nutrition. However, the effect depends on the type of contract. Resource-providing contracts lead to higher dietary diversity at the household level, as well as for female household members. Our findings also reveal that children in households with resource providing contracts have a higher height-for-age z-score (HAZ) and weight-for-age z-score (WAZ), suggesting positive long-term nutritional benefits for small children aged 2-6 years. The effects of marketing contracts are less clear. The results indicate positive effects on women's dietary diversity and on the child's weight-for-age z-score. Additionally, we find positive nutrition effects if the contracted farmer is female.

1. Introduction

Contract farming has recently gained in importance in developing countries, as an instrument to facilitate coordination and integration along agricultural supply chains (Mishra et al., 2018). As such, it has the potential to integrate smallholders in higher-value markets, which is considered an important driver for rural development and poverty alleviation (Bellemare and Bloem, 2018; Otsuka et al., 2016). Thus, the increasing prevalence of contract farming in developing countries stimulates a vast body of literature examining the effects on household welfare. While the majority of studies find that households benefit through an increase in household income (Andersson et al., 2015; Bellemare, 2012; Cahyadi and Waibel, 2013; Maertens and Swinnen, 2009; Maertens and Vande Velde, 2017; Rao and Qaim, 2011; Ruml, Ragasa and Qaim, 2020; Wang et al., 2014; Warning and Key, 2002), the effects of contract farming on household and individual nutrition are less clear. (Bellemare and Novak, 2017).

A few available studies investigate the effects of contract farming on food security. Bellemare and Novak (2017) find that contract farming increases food security, through a reduction in the duration of hunger periods for households in Madagascar. These results are supported by Mishra et al., (2018) and Soullier and Moustier (2018). Mishra et al. (2018) investigate onion contracts in India and find positive effects on food security, proxied as yields and the share of food expenditure. Soullier and Moustier (2018) investigate rice contracts in Senegal and find that they lead to higher food security through price mitigation. None of the stated studies investigate household and individual diets and nutrition. However, in order to gain a comprehensive understanding of the welfare effects of contract farming, these effects require investigation (Bellemare and Novak, 2017).

In general, contract farming can lead to changes in diets and nutrition through several pathways, which potentially offset each other. Thus, the effects are not straightforward and cannot be deduced from higher household incomes. While higher household incomes indicate improvements in diets and nutrition, the strong specialization of contracted households towards the contracted crop can lead to the opposite effects through a reduction in crop diversity, particularly in settings with a high dependency on home produced foods. Moreover, contract farming generally influences agricultural labor requirements (Benali et al.,2018; Meemken and Bellemare, 2020; Ruml and Qaim, 2019), which can lead to changes in male and female on- and off-farm employment. Thus, the effects of contract farming on household and individual diets and nutrition require investigation. Currently, only one study is available that investigates such effects for horticultural production and supermarket contracts in Kenya. They find that participation in the contract scheme leads to positive effects on calorie, vitamin A, iron, and zinc consumption (Chege et al., 2015). Supermarket contacts are a particular type of contact and the results cannot be generalized. Thus, more empirical evidence is needed to understand the effects.

We address this research gap and examine the effects of contract farming on household and individual diets and nutrition. The empirical example is the Ghanaian oil palm sector, which is vastly expanding and has experienced a rapid transition from small-scale subsistence farming towards larger- scale commercialization. We further contribute to the existing literature by investigating the effects of different types of contracts, which has been largely neglected in the existing literature. A major difference exists between marketing contracts that solely provide a secure market access, and resource-providing contracts that additional supply production inputs in the form of in-kind credits. Previous analyses with the survey data showed that both types of contracts were found to have different effects on the households' cropping patterns and land use (Ruml and Qaim, 2020) , as well as on on- and off-farm income dependencies (Ruml et al., 2020), all of which are potential drivers of changes in diets and nutrition. Performing the contract comparison will thus provide important insights on the pathways through which contract farming can affect household and individual diets and nutrition.

We use 463 randomly selected oil palm producers in the South of Ghana, including farmers with marketing contracts, resource-providing contracts, and no contracts. By employing treatment -effects regression models with two treatment dummies, one for each contract type, we analyze the effects of both contracts on household and individual dietary diversity. Individual dietary diversity is examined for children between the ages 2 and 6, as well as for their female caretakers. We further investigate the effects of both contracts on height-for-age (HAZ) and weight-for-age (WAZ) z-scores.

Our empirical findings indicate that contract farming leads to changes in household and individual diets and nutrition, yet that the effects depend on the type of contract. Households producing with resource-providing contracts have higher dietary diversity than independent households, while no significant difference exists for households producing with marketing contracts. These differences in effects can be explained by differences in female labor participation. Using women's dietary diversity, results indicate improved individual dietary diversity among households with resource- providing contracts. Also, HAZ and WAZ of children belonging to households with resource providing contracts are significantly higher than children in independent households. For households with marketing contracts, we find positive and significant effects on two individual nutrition measures, women's dietary diversity and WAZ of children. Furthermore, we find that intrahousehold nutrition outcomes are generally higher, if the contracted farmer is female. These findings have relevance for policies that aim to design contract farming conditions that benefit household and intrahousehold nutrition outcomes.

2. Conceptual framework

Contract farming particpation and nutrition are linked through multiple pathways. A direct linkage is through the income benefit from the sale of crops produced under contracts. Studies undertaken in multiple contexts (e.g. Maertens and Swinnen, 2009; Rao and Qaim, 2011; Bellemare, 2012; Andersson et al., 2015) have confirmed the income effect of contract farming on smallholder households, also in this context (Ruml et al. 2020). As higher income contributes to the purchase of diverse foods at higher quality and quantity, it is expected that households with improved income status have better nutrition outcomes (Dillon et al., 2014; Shively and Sununtnasuk, 2015; Singh et al., 2020). However, indirect pathways including crop production diversity and labor reallocation can have an opposing impact on nutrition outcomes.

The production of commercial crops under contract has a direct implication on households' agricultural land use. On the one hand, households might expand their cultivation area to accommodate the commercial crop. On the other hand, households might specialize towards the contracted crop and hence reduce crop diversity. A reduction in crop production diversity can lead to negative nutrition effects, because it reduces the nutrition benefit gained from the forgone crops (Ecker, 2018). As a result, consumption diversity might be negatively affected (Shively and Sununtnasuk, 2015; Ecker, 2018). Market purchased food products can however compensate for households dietary diversity and dietary quality does not entirely depend on production diversity (Koppmair et al., 2017; Sibhatu and Qaim, 2017). Hence, market access for food purchase determines the strength of the relationship between production diversity and dietary diversity (Hirvonen and Hoddinott, 2017; Headey et al., 2018). In a study undertaken in Ghana using the same data, Ruml and Qaim (2020) find that producing oil palm under contract results in such changes in agricultural land use. In particular, the resource-providing contract leads to a strong specialization towards the contracted crop and both contracts lead to a reduction of crop production diversity. The net effect on nutrition will depend on whether the reduction in crop diversity offsets the positive income effects which allow market purchase of crops not produced.

Changes in labor requirements as a result to contract farming have direct implications on the labor allocation within the household. This potentially alters gender roles within the household (Qaim, 2017), which changes female and male household members' participation in economic activities and contribution of labor income (Maertens and Swinnen, 2012). In the context of developing countries, women are mostly responsible for the preparation of food and household nutrition in addition to their involvement in on-farm and off-farm work (Ferrant et al, 2014). Thus, if the contract requires a more labor-intensive crop production, participation can result in a negative nutrition effect, because females might be required to participate in the cash crop production or take over other agricultural work from male household members. However, contract farming can also have the opposite effect, if it implies labor-saving procedures and technologies. In this context, it was found that producing under both, the marketing contract and the resource-providing contract, leads to a substantial reduction in agricultural labor requirements and a reduction of male and female household labor participation. Moreover, it was found that the marketing contract leads to a reallocation of female household labor towards off-farm employment (Ruml and Qaim, 2019). The nutrition effect of women's participation in off-farm work depends on the income benefit from off-farm work, women's bargaining power, and time allocation (Popkin and Solon, 1976; Debela et al., 2020). A study by Malapit et al. (2015) finds that women empowerement can offset the potentially negative nutrition effects resulting from reduced crop production diversity. This study tests whether households production diversity and female members' participation in on-farm and off-farm work are the potential pathways for nutrition effects.

Given positive nutrition effects occur at the household level, nutrition benefit at the individual level depends on how food is distrubuted among household members (Dillon et al., 2014; Shively and Sununtnasuk, 2015). This paper examines the net effect of contract farming on household level dietary diversity as well as individual dietary diversity. At the individual level, we also investigate the contract farming linkages with standandardized weight and height measures of children.

3. Data and Sampling Strategy

The recently rising demand for vegetable oils has lead to a vast expansion of the oil palm sector in Southeast Asia. This trend can now also be observed in West Africa, where oil palm is native and traditionally grown by small-scale producers for home consumption. In Ghana, oil palm is the most important source of fat, and most households produce oil palm on a small scale to meet their own demand and/or to sell small amounts at the local market. By now, this sector has substantially transformed and several large national and international processing plants process palm oil in the South of Ghana. These processing plants typically cultivate company plantations and additionally procure fresh fruit bunches (FFBs) from smaller farmers through contract farming schemes.

We identified 5 large processing plants in the South of Ghana, which offer such contracts to farmers. We selected 2 schemes based on their contract characteristics and their geographical proximity to each other. The two contract farming schemes are the Benso Oil Palm Plantation (BOPP) and the Twifo Oil Palm Plantation (TOPP). BOPP offers verbal marketing contracts to the farmers that specify the timing, minimum quantities, and annually fixed prices for the regular sales and pick-ups at the farm gate. TOPP offers a written long-term contract that specifies the conditions of the regular sales, as well as the input provision in the form of in-kind credits.

For comparison, we selected a region that is currently outside of the companies' catchment areas and for which a contract scheme was developed but not implemented at the time of the survey. We purposely selected a comparison region rather than non-contracted farmers in contracted villages because of potential spillover effects and selection bias. Spillover effects can occur within contracted villages if farmers are able to sell FFBs through a contracted neighbour (for example at times of supply shortages) and through infrastructure development by the contracting companies. Selecting a separate region further reduces the risk of selection bias, as non-contracted farmers in contracted villages are few in number and decided not to participate in the contract farming scheme. This raises concerns of selection bias from the farmer side. Surrounding villages without contracted farmers were not chosen by the contracting companies, which raises concerns about selection bias from the company side. The chosen comparison villages were pre-selected by the upcoming contract farming scheme. Thus, contracts will be offered in these villages, but the farmers have not made their participation decision yet.

We sampled at two stages, at the village and at the household level. The villages were sampled based on the lists provided by the contracting companies. The comparison villages were sampled on the list of villages considered for the upcoming contract scheme. This list was provided by the local Ministry of Food and Agriculture (MoFA). We randomly sampled 9 villages under the marketing contract, 13 villages under the resource-providing contract, and 9 comparison villages registered for the upcoming contract farming scheme. Within the sampled villages we listed all households eligible for this study, and randomly sampled and interviewed 75% of the households. In total, the sample includes 463 households, of which 193 produce under the marketing contract, 164 under the resource-providing contract, and 106 without any contract. Within the sampled households, we collected individidual dietary information and anthropometric measures for all children between the ages 2 and 6, as well as for their female caretakers. The female and children sample make up 95 and 115 observations, respectively.

The survey used a multi-purpose household questinnaire and contained information such as household demographic characteristics; farm characteristics; palm oil production activities and sales; contract farming participation; income sources; labor days in agricultural and non-agriculture activities; food consumption, and anthropometric measures. To construct the main variables of interest - dietary diversity - we used household (7 day recalls) and individual (24 hour recalls) food consumption data and generated household and individual dietary diversity scores. The household dietary diversity score is generated using 12 food groups following FAO (2011). We used nine food groups to construct women's dietary diversity score (FAO and FHI, 2016). Using the height and weight measures of children between the ages of 2 and 6, we generated the height-for-age z-score (HAZ) and weight-for-age z-score (WAZ) by applying the growth standard developed by the WHO (WHO, 2006).

4. Empirical Strategy

Our empirical approach aims to estimate the nutrition effect of contract farming, capturing the effect by contract type. For this purpose, we use the multinomial treatment effects regression approach developed by Deb (2009). The estimation strategy is suitable, as it accounts for mutliple treatments (contract types) and potential endogeneity of the treatments, i.e, allowing analysis of endogenous multinomial treatment (Deb and Trivedi, 2006). The model specifications for the multinomial probability of treatment takes the following form.

$$\Pr(c_{ij}|\boldsymbol{x}_i, z_i, l_{ij}) = g(\boldsymbol{x}_i'\tau_{MC} + \alpha_{MC}z_i + \delta_{MC}l_{iMC}, \boldsymbol{x}_i'\tau_{RPC} + \alpha_{RPC}z_i + \delta_{RPC}l_{iRPC}) \quad (1)$$

where subscripts i and j in equation (1) represent household and the three treatment statuses, respectively. j can take a value of 0=no contract, 1=marketing contract (MC) and 2=resource-providing contract (RPC). $\Pr(c_{ij}|\boldsymbol{x}_i, z_i, l_{ij})$ refers to the probability that household i is in either of the contract status (c_j) given the control variables ($\boldsymbol{x}_i$), instrument (z_i), and unobserved characteristics (l_{ij}). The function g follows a multinomial probability distribution. $\boldsymbol{x}_i$ is a vector of explanatory variables (including age, gender, and education of household head; experience in oil palm cultivation; distance from market; dependency ratio; land availability[1]; and gender of the contracted person). z_i denotes the instrument variable that is excluded from the outcome equation (equation 2 below) for identification in the outcome equation, a preferred approach recommended by Deb and Trivedi, 2006. We use the inverse distance from the next large oil palm mill as our instrumental variable, which we discuss in the subsection below. l_{ij} is a latent variable that is assumed in the model and captures unobserved characteristics associated with households' selection into their contract status (treatment).

The main outcome variables in this study are nutrition outcomes (N_i) measured using the household's dietary diversity score, women's dietary diversity score, children's height-for-age Z-score and weight-for-age Z-score, which are all continuous variables. The outcome equation is presented in equation (3) below:

$$N_i = \boldsymbol{x}_i'\beta + \gamma_{MC}c_{iMC} + \gamma_{RPC}c_{iRPC} + \lambda_{MC}l_{iMC} + \lambda_{RPC}l_{iRPC} + \epsilon_i \quad (2)$$

[1] As the land availability at the time of the household survey is influences by contract participation, and thus endogenous, we use the land availability prior to contract participation in 2008. This variable was derived through recall data.

where $\boldsymbol{x}_i$ refers to the vector of explanatory variables described in equation (1). Subscript i denotes the individual when undertaking individual level analysis and we additionally include individual characteristics (e.g., age, gender) in the models. Our main parameters of interest are γ_{MC} and γ_{RPC} that estimate the effect of being in either the marketing or resource-providing contract relative to the households with no contract. The variable l_{iMC} and l_{iRPC} control for potential unobserved factors that influence selection into households' contract status and outcome variables. Therefore, λ_{MC} and λ_{RPC} are parameters that estimate whether there is a positive or negative selection. If the parameters are positive for example, it implies that there is a positive correlation between the contract status and the outcome variables due to unobserved characteristics (Deb and Trivedi, 2006). In our estimation results, we find significant coefficients for the λ_{MC} and λ_{RPC} parameters, in some cases for both the marketing (λ_{MC}) and resource providing households (λ_{RPC}) and in others for the resource providing households only. This implies that there is selection due to unobservables that is correlated with the outcome variables and the estimation method takes this into account using the instrument.

While the multinomial treatment variable-contract status (being under the marketing contract, resource providing contract or having no contract)- is estimated using multinomial logit structure, the outcome variables are estimated using a regression approach for continuous variables. The overall model is jointly estmated using a simulated maximum log likelihood approach (Deb and Trivedi, 2006).

Identification Strategy

Essentially, the treatment effects regression approach takes the endogeneity problem into account as it estimates the effect of an endogenously chosen multinomial treatment variable on the outcome variable (Deb, 2009). According to Deb and Trivedi (2006), identification can be achieved without using an exclusion restriction, i.e., by using the same set of variables in both the multinomial logit and outcome equations. Nevertheless, authors recommend using the exclusion restriction by adding an instrumental variable only in the multinomial logit regression, which is the approach we follow. Our instrumental variable, the inverse distance from the closest large oil palm mill to the village, is only included in the multinomial regressions and excluded from the outcome equations. The instrument is statistically significant in the equations of the multinomial regression (with few exceptions in the individual level regressions) and shows the instrument relevance (Table A1-A4 in the appendix).

It can be argued that the distance to the next large oil palm mill is a measure of remoteness and can directly influence the nutrition outcomes. To test this, we checked whther the correlation between the distance to the closest mill and the nutrition outcomes are statistically significant, among the subsample of households with no contract. We find that the variables are not significantly correlated, hence suggesting the distance variable is not directly linked to the nutrition outcomes but rather via the contract participation. Moreover, in the regressions, we control for market distance, which can be considered as a remoteness measure.

5. Results

5.1. Descriptive Results

Table 1 summarizes the average nutrition outcomes in the sample classified by the households' contract status. Results show that households under the marketing contract have a significantly lower household dietary diversity score compared to non-contracted households, while no on average differences exist between households with resource providing contracts and independent households. At the individual level, we do not observe significant average differences by contract status in women's dietary diversity score (see Table 1). On the other hand, the anthropometric outcomes of children reveal that children living in households with resource providing contracts have a significantly higher height-for-age Z-score (HAZ) than those living in households without contracts. Further, Table 1 shows that the weight-for-age Z-scores (WAZ) of children in households under the marketing contract are higher than those of children in non-contracted households.

In Figure 1 and 2, we illustrate the distribution of HAZ and WAZ of children categorized by the contract status of the households, respectively. Figure 1 shows that the height-for-age Z-score of children in non-contracted households is distributed to the left of the groups of children in the contracted households (both for resource-providing and marketing contracts). When comparing the two types of contracts, households with resource-provinding contracts have children with HAZ distributed to the right side of households with marketing contract. A similar pattern is observed in Figure 2 with weight-for-age Z-scores, though the pattern is less pronouced than in Figure 1. While the descriptive results seem to show significant differences in the nutrition measures, the results do not control for confounding factors. In the subsequent sub-section, we summarize findings after accounting for other confounding factors that might affect the outcome variables.

5.2. Regression Results

Estimation results for household level effects of contract status on dietary diversity are presented in Table 2. We find that households producing with the resource-providing contract have roughly 0.81 higher dietary diversity than independent households. This is significant at the 1% level. The effect of the marketing contract is positive and statistically significant, but smaller in magnitude.

Gender role in contract farming is one of the factors that affects welfare benefits from participation in agricultural value chains in developing countries (Qaim, 2017). To account for this, we include a binary variable measuring whether the contracted person in the household is female or not. Results in Table 2 show that the variable is not statitically significant. Further, the coefficient estimate for the resource-providing contract remains similar, except for a slight decline in magnitude. For the households under the marketing contract, the coefficient estimate turns insignificant once the gender of the contracted person is controlled for. This implies that female contract farmers in the sample might drive the nutrition effect.

Table 3 presents results for women dietary diversity. Women's dietary diversity in both, households with marketing and resource-providing contracts, is significantly higher than in independent households. The effect magnitude is higher for the resource-providing contract (see Table 3). Interestingly, model (2) of Table 3 shows that women's dietary diversity is significantly higher if the contracted farmer is female.

In Table 4, we take a close look at children's nutrition outcomes by using HAZ and WAZ regressions. Results reveal that the HAZ of children is significantly higher in households with resource-providing contract. In the HAZ regression, results suggest a negative effect among children in households with marketing contracts as compared to children in households with no contracts. Turning to the WAZ regressions, we find positive and siginificant effects of participating in marketing as well as in resource-providing contracts on the standardized weight measure, regardless of whether the gender of the contracted person is controlled for. Relative to the children living in households with no contracts, WAZ of children living with households under the marketing contract is 0.85 higher. For households under the resource-providing contracts the coefficient estimate is 1.11. In model (2) of the HAZ regression, an intesting insight is that the long-term nutrition outcome (HAZ) of children is positively affected with a coefficient estimate of 0.88, if the contracted person is a female. A similar pattern is observed in the WAZ regression, with a coefficent estimate of 0.52. This implies that gender sensitive contract farming that allows women's participation can have a positve influence not only on the women but also on their children.

In general, the results suggest a positive nutrition effect of the resource-providing contract, both at the household and individual level. The nutrition effect among households with the marketing contract is less clear with varying effects. A follow up question is what characterizes the households with marketing and resource-providing contracts that might contribute to the observed nutritional differences. The next sub-section examines the potential factors attributed, descriptively.

5.3. Pathway Analyses

To examine whether the relationship between types of contracts and nutrition measures is related to the essential characteristics of the contracted households, we summarize variables that can be considered as impact pathways. Table 5 presents the pair-wise test results for the variables. Prior to looking at the variables, we first examine the sources of dietary diversity by classifying it into two major parts-dietary diversity from own production and from the market. We observe that dietary diversity coming from own production is significantly lower among households with marketing contracts as compared to the independent households. A similar difference is observed when comparing households under resource-providing contracts with independent households, although with a lower significance level (10%). Further, Table 5 shows that households under the marketing contract have significantly lower dietary diversity sourced from own production than households under resource-providing countract. On the other hand, no significant differences are observed between dietary diversity sourced from the market, regardless of the contract type. This directly relates to the reduced production diversity at the farm as pathway through which contract farming can affect dietary diversity

As discussed above, female labor market participation can affect household and individual nutrition outcomes. Women are generally responsible for the preparation of foods in these contexts and a reallocation in female labor can result in a shift of diets. As mentioned, the contracts were found to reduce female labor participation in the production of oil palm. Moreover, the marketing contract leads to a reallocation of female labor towards off-farm employment. Table 5 presents these differences in female labor days spent in economic activities. While females in households with marketing and resource-providing contracts have significantly lower annual labor days in oil palm activities than independent households, the difference is more pronounced for households under the resource-providing contract. Table 5 also indicates more female labor days in off-farm wage and self employmnet among households with marketing contracts compared to those without a contract. As documented in Ruml and Qaim (2019), these differences are attributed to the differences in contracts characteristics. Oil palm cultivation under both contracts is less labor intensive than without a contract. Particularly, post-harvest handling is obsolete under contract, which was previously in the hands of women. Under the marketing contract, this leads to a reallocation of inter alia female household labor towards off-farm employment. Under the resource-providing contract, this effect cannot be observed (Ruml and Qaim, 2019).

Labor saving of female household members, especially among the resource-providing households, can explain the effect on the child nutritional outcomes. A recent study by Debela et al. (2020) shows that female off-farm employment has a negative impact on long-term child nutrition outcomes, HAZ, especially when the labor contribution is large. In line with this, the findings show that long-term child nutrition outcomes are significantly higher among households with larger female labor savings. That is among households with resource-providing contracts. The weight-for-age z-score, which measures short and long-term effects, is significantly higher in both the marketing and resource-providing households. Results imply that particularly the resource providing contract affects both short and long-term nutrition measures.

One of the limitations in this study is that the sample size for the individual level analyses is small. However, the findings imply that the linkages observed are consistent and shade light on potential effects of contract farming on multiple dimensions of the nutrition measures. This is supported by the estimation and descriptive results. Future research could use larger sample size and estimate the impact.

6. Conclusions

This paper aims to understand the effects of contract farming on household and individual nutrition, accounting for different types of contracts. We use primary data from Ghana with rural households under two types of contract farming arrangements for oil palm production, marketing contracts and resource-providing contracts. The latter provides farmers with resources necessary for the production of oil palm in addition to the marketing arrangement while the former only avails marketing opportunities for their produce. The contracted households are compared to households with no contract arrangements. Results show that participating in contract farming has effects on both household and individual nutrition. However, the results depend on the type of contract. The resource-providing contract improves household dietary diversity, which is not consistently observed among households participating in marketing contracts. Interestingly, the individual dietary diversity measure for women is significantly higher regardless of the contract type, with higher magnitude observed among households with resource-providing contracts. Turning to children's anthropometric outcomes, we find that children in households with resource-providing contracts have a higher height-for-age z-score (HAZ). Results also reveal a consistently higher weight-for-age z-score (WAZ) of children among households with both types of contracts. Individual level analyses further show that nutrition outcomes, particularly women's dietary diversity, HAZ and WAZ, are significantly higher when the contracted person is female. Descriptive analyses undertaken to understand the pathway for the observed nutrition differences indicate that crop production diversity and female labor contribution in economic activities could be the factors contributing to the findings.

Our findings have multiple implications for contract farming arrangements that can have nutritional benefits for households, women, and children. Positive nutrition benefits can be attained through simple marketing contracts. However, the effects in this context are larger and affect both household and individuals, if production resources are provided. Engaging women in contract farming can reinforce women's nutrition quality as well as the long-term nutrition outcomes of children. Policies should therefore give strong emphasis on the specific components of contract farming arrangements and the stakeholders benefiting from it.

References

Andersson, C.I., Chege, C.G., Rao, E.J. and Qaim, M., 2015. Following up on smallholder farmers and supermarkets in Kenya. *American Journal of Agricultural Economics*, 97(4), pp.1247-1266.

Bellemare, M.F., 2012. As you sow, so shall you reap: the welfare impacts of contract farming. *World Development*, 40(7), pp.1418-1434.

Bellemare, M.F. and Novak, L., 2017. Contract farming and food security. *American Journal of Agricultural Economics*, 99(2), pp.357-378.

Bellemare, M.F. and Bloem, J.R., 2018. Does contract farming improve welfare? A review. *World Development,* 112, pp.259-271.

Benali, M., Brümmer, B. and Afari-Sefa, V., 2018. Smallholder participation in vegetable exports and age-disaggregated labor allocation in Northern Tanzania. *Agricultural Economics*, 49(5), pp.549-562.

Cahyadi, E.R. and Waibel, H., 2013. Is contract farming in the Indonesian oil palm industry pro-poor?. *Journal of Southeast Asian Economies*, pp.62-76.

Chege, C.G., Andersson, C.I. and Qaim, M., 2015. Impacts of supermarkets on farm household nutrition in Kenya. *World Development*, *72*, pp.394-407.

Debela, B.L., Gehrke, E. and Qaim, M. (2020). Links between maternal employment and child nutrition in rural Tanzania. *American Journal of Agricultural Economics*, https://doi.org/10.1111/ajae.12113

Deb, P. (2009). MTREATREG: Stata module to fits models with multinomial treatments and continuous, count and binary outcomes using maximum simulated likelihood.

Deb, P., and Trivedi, P. K. (2006). Maximum simulated likelihood estimation of a negative binomial regression model with multinomial endogenous treatment. *The Stata Journal*, 6(2), 246-255.

Dillon, A., McGee, K., and Oseni, G. (2014). *Agricultural production, dietary diversity, and climate variability*. The World Bank.

Ecker, O. (2018). Agricultural transformation and food and nutrition security in Ghana: Does farm production diversity (still) matter for household dietary diversity?. *Food policy*, *79*, 271-282.

FAO (2011). *Guidelines for measuring household and individual dietary diversity*. Rome: Food and Agriculture Organization of the United Nations.

FAO and FHI 360. 2016. *Minimum Dietary Diversity for Women: A Guide for Measurement.* Rome: Food and Agriculture Organization of the United Nations.

Headey, D., Stifel, D., You, L., and Guo, Z. (2018). Remoteness, urbanization, and child nutrition in sub-Saharan Africa. *Agricultural Economics*, *49*(6), 765-775.

Hirvonen, K., and Hoddinott, J. (2017). Agricultural production and children's diets: Evidence from rural Ethiopia. *Agricultural Economics*, *48*(4), 469-480.

Koppmair, S., Kassie, M., and Qaim, M. (2017). Farm production, market access and dietary diversity in Malawi. *Public health nutrition*, *20*(2), 325-335.

Maertens, M. and Swinnen, J.F., 2009. Trade, standards, and poverty: Evidence from Senegal. *World Development*, 37(1), pp.161-178.

Maertens, M., & Swinnen, J. F. M. (2012). Swinnen (2012) Gender and Modern Supply Chains in Developing Countries. *The Journal of Development Studies*, *48*(10), 1412–1430.

Maertens, M. and Velde, K.V., 2017. Contract-farming in staple food chains: the case of rice in Benin. *World Development*, 95, pp.73-87.

Malapit, H. J. L., Kadiyala, S., Quisumbing, A. R., Cunningham, K., & Tyagi, P. (2015). Women's empowerment mitigates the negative effects of low production diversity on maternal and child nutrition in Nepal. *The journal of development studies*, *51*(8), 1097-1123.

Mishra, A.K., Kumar, A., Joshi, P.K. and D'Souza, A., 2018. Production risks, risk preference and contract farming: Impact on food security in India. *Applied Economic Perspectives and Policy*, *40*(3), pp.353-378.

Otsuka, K., Nakano, Y. and Takahashi, K., 2016. Contract farming in developed and developing countries. *Annual Review of Resource Economics*, 8, pp.353-376.

Popkin, B. M., & Solon, F. S. (1976). Income, time, the working mother and child nutriture. *Journal of Tropical Pediatrics*, *22*(4), 156–166.

Qaim, M. (2017). Globalisation of agrifood systems and sustainable nutrition. *Proceedings of the Nutrition Society*, 76(1), 12–21. https://doi.org/10.1017/s0029665116000598

Rao, E.J. and Qaim, M., 2011. Supermarkets, farm household income, and poverty: insights from Kenya. *World Development*, 39(5), pp.784-796.

Ruml, A., M. Qaim (2019). New evidence regarding the effects of contract farming on agricultural labor use. *Agricultural Economics*, in press.

Ruml, A., and Qaim, M. (2020). Effects of marketing contracts and resource-providing contracts in the African small farm sector: Insights from oil palm production in Ghana. *World Development*, 136, 105110. DOI: https://doi.org/10.1016/j.worlddev.2020.105110

Ruml, A., Ragasa, C., and Qaim, M. (2020). Heterogeneous effects of marketing contracts and resource-providing contracts on household income. GlobalFood Discussion Paper 138, University Goettingen (No. 858-2020-032).

Shively, G., and Sununtnasuk, C. (2015). Agricultural diversity and child stunting in Nepal. *The Journal of Development Studies*,51(8), 1078-1096.

Sibhatu, K. T., and Qaim, M. (2017). Rural food security, subsistence agriculture, and seasonality. *PloS one*, *12*(10), e0186406.

Singh, S., Jones, A. D., DeFries, R. S., and Jain, M. (2020). The association between crop and income diversity and farmer intra-household dietary diversity in India. *Food Security*, 1-22.

Soullier, G., and Moustier, P. (2018). Impacts of contract farming in domestic grain chains on farmer income and food insecurity. Contrasted evidence from Senegal. *Food Policy, 79,* 179-198.

Wang, H., Moustier, P., and Loc, N.T.T., 2014. Economic impact of direct marketing and contracts: the case of safe vegetable chains in northern Vietnam. *Food Policy*, 47, pp.13-23.

Warning, M. and Key, N., 2002. The social performance and distributional consequences of contract farming: An equilibrium analysis of the Arachide de Bouche program in Senegal. *World Development*, 30(2), pp.255-263.

WHO Multicentre Growth Reference Study Group. 2006. *The WHO Child Growth Standards: Length/height-for-age, weight-for-age, weight-for-length, weight-for-height and body mass index-for-age: Methods and development*. Geneva, Switzerland: World Health Organization. http://www.who.int/childgrowth/standards/en/

Table 1. Comparison of dietary diversity score at household level by contract status

Variables	All	Marketing contract	Resource providing contract	Comparison
Household level nutrition measure				
Household dietary diversity score	8.091 (1.314)	7.953 (1.367) *	8.152 (1.295)	8.245 (1.233)
#Obs.	463	193	164	106
Individual level adult nutrition measure				
Women dietary diversity score	4.295 (1.360)	4.324 (1.430)	4.342 (1.341)	4.174 (1.337)
#Obs.	95	34	38	23
Individual level child nutrition measures				
Antrhopometric outcomes of children				
HAZ	-0.774 (1.425)	-0.777 (1.372)	-0. 537 (1.542)**	-1.283 (1.147)
WAZ	-0.546 (1.045)	-0.385 (0.966)**	-0. 522 (1.119)	-0.893 (0.978)
#Obs.	115	42	50	23

Note: Standard deviations in parentheses. Statistical test is undertaken by comparing farmers in the resource providing and marketing contract with comparison farmers.

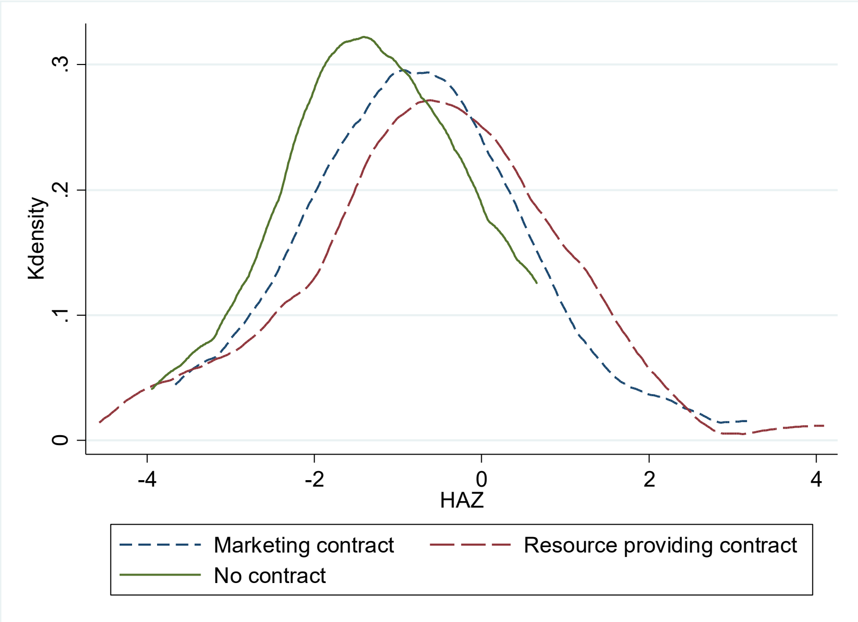

Figure 1. Height-for-age Z-score of children by contract type

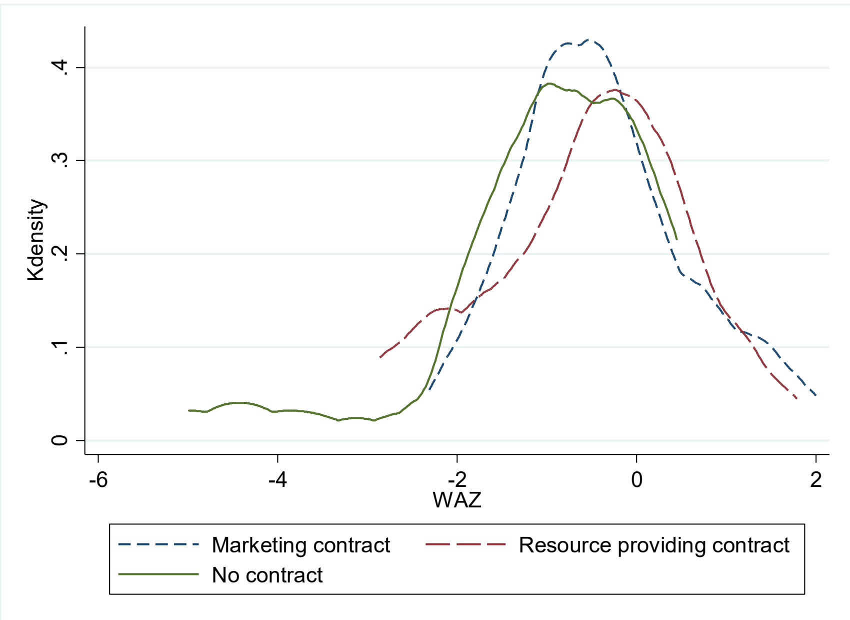

Figure 2. Weight-for-age Z-score of children by contract type

Table 2. Effect of contract status on household dietary diversity

	(1)	(2)
Marketing contract	0.54***	0.25
	(0.18)	(0.47)
Resource providing contract	0.81***	0.75***
	(0.17)	(0.19)
Age of household head	-0.03***	-0.03***
	(0.01)	(0.01)
Female-headed household (1/0)	-0.26	-0.07
	(0.18)	(0.23)
Education of head (years)	0.04***	0.05***
	(0.01)	(0.01)
Experience in oil palm(years)	-0.00	0.00
	(0.01)	(0.01)
Distance from market (km)	-0.02*	-0.02**
	(0.01)	(0.01)
Dependency ratio [a]	0.14	0.12
	(0.09)	(0.08)
Land availability 2008 in acres (log)	0.16**	0.16**
	(0.08)	(0.08)
Female contracted (1/0)		-0.16
		(0.21)
Constant	8.51***	8.65***
	(0.34)	(0.41)
lnsigma	-0.85***	-0.20
	(0.27)	(0.45)
Lambda Marketing contract	-0.94***	-0.56
	(0.09)	(0.62)
Lambda Resource providing contract	-0.72***	-0.75***
	(0.07)	(0.09)
Number of obs.	463	463
Chi 2	229.87	211.10
P-value(chi2)	0.00	0.00

Note: Robust standard errors in parentheses. * $p<0.1$; ** $p<0.05$; *** $p<0.01$. The results for the outcome variable from the mtreatreg regression output are presented. Table A1 in the appendix shows the results for the multinomial logit results that has been jointly estimated with the outcome variable using simulated maximum likelihood approach. 400 simulations are used in the regressions. [a] Dependency ratio is calculated by dividing number of dependents (children under 15 and elderly above 65) by the number of adult household members.

Table 3. Effect of contract status on women's dietary diversity

	(1)	(2)
Marketing contract	0.54***	0.63***
	(0.01)	(0.01)
Resource providing contract	1.37***	1.32***
	(0.01)	(0.01)
Age of individual	0.01***	0.01***
	(0.00)	(0.00)
Age of household head	-0.04***	-0.04***
	(0.00)	(0.00)
Female-headed household (1/0)	0.10***	-0.11***
	(0.01)	(0.01)
Education of head (years)	0.04***	0.05***
	(0.00)	(0.00)
Experience in oil palm(years)	0.01***	0.01***
	(0.00)	(0.00)
Distance from market (km)	-0.03***	-0.03***
	(0.00)	(0.00)
Dependency ratio [a]	-0.18***	-0.20***
	(0.00)	(0.00)
Land availability 2008 in acres (log)	0.04***	0.04***
	(0.00)	(0.00)
Female contracted (1/0)		0.21***
		(0.01)
Constant	4.96***	5.05***
	(0.01)	(0.01)
lnsigma	-4.66***	-4.69***
	(0.14)	(0.24)
Lambda Marketing contract	-0.43***	-0.45***
	(0.00)	(0.00)
Lambda Resource providing contract	-1.22***	-1.18***
	(0.00)	(0.00)
Number of obs.	95	95
Chi 2	198,648.43	252,858.39
P-value(chi2)	0.00	0.00

Note: Robust standard errors in parentheses. * p<0.1; ** p<0.05; *** p<0.01. The results for the outcome variable from the mtreatreg regression output are presented. Table A2 in the appendix shows the results for the multinomial logit results that has been jointly estimated with the outcome variable using simulated maximum likelihood approach. 400 simulations are used in the regressions. [a] Dependency ratio is calculated by dividing 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

	HAZ		WAZ	
	(1)	(2)	(3)	(4)
Marketing contract	-0.30***	-0.24***	0.85***	0.82***
	(0.00)	(0.01)	(0.00)	(0.00)
Resource providing contract	1.31***	0.29***	1.11***	1.10***
	(0.00)	(0.01)	(0.00)	(0.00)
Age in months	-0.12***	-0.07***	-0.10***	-0.11***
	(0.00)	(0.00)	(0.00)	(0.00)
Age in months squared	0.00***	0.00***	0.00***	0.00***
	(0.00)	(0.00)	(0.00)	(0.00)
Female (1/0)	0.43***	0.47***	0.07***	0.08***
	(0.00)	(0.00)	(0.00)	(0.00)
Age of household head	-0.01***	-0.01***	-0.01***	-0.02***
	(0.00)	(0.00)	(0.00)	(0.00)
Female-headed household (1/0)	0.37***	-0.56***	0.30***	-0.17***
	(0.00)	(0.01)	(0.00)	(0.01)
Education of head (years)	-0.01***	0.00***	-0.00***	-0.00**
	(0.00)	(0.00)	(0.00)	(0.00)
Experience in oil palm(years)	0.06***	0.04***	0.04***	0.04***
	(0.00)	(0.00)	(0.00)	(0.00)
Distance from market (km)	-0.07***	-0.02***	-0.02***	-0.01***
	(0.00)	(0.00)	(0.00)	(0.00)
Dependency ratio [a]	-0.22***	-0.02***	-0.18***	-0.13***
	(0.00)	(0.00)	(0.00)	(0.00)
Land availability 2008 in acres (log)	0.11***	0.16***	0.14***	0.15***
	(0.00)	(0.00)	(0.00)	(0.00)
Female contracted (1/0)		0.88***		0.52***
		(0.01)		(0.01)
Constant	1.96***	0.21***	1.27***	1.53***
	(0.01)	(0.02)	(0.02)	(0.02)
lnsigma	-5.01***	-4.77***	-4.95***	-4.81***
	(0.13)	(0.15)	(0.17)	(0.22)
Lambda Marketing contract	1.21***	0.77***	-0.53***	-0.50***
	(0.00)	(0.00)	(0.00)	(0.00)
Lambda Resource providing contract	-0.35***	0.99***	-0.76***	-0.78***
	(0.00)	(0.00)	(0.00)	(0.00)
Number of obs.	115	115	115	115
Chi 2	1,796,364.21	343,759.16	392,765.56	288,750.68
P-value(chi2)	0.00	0.00	0.00	0.00

Note: Robust standard errors in parentheses. * p<0.1; ** p<0.05; *** p<0.01. The results for the outcome variable from the mtreatreg regression output are presented. Table A3 and A4 in the appendix show the results for the multinomial logit results that has been jointly estimated with the outcome variable using simulated maximum likelihood approach. 400 simulations are used in the regressions. [a] Dependency ratio is calculated by dividing number of dependents (children under 15 and elderly above 65) by the number of adult household members.

Table 5. Differences in main pathway variables by contract type

Variables	Marketing contract	Resource providing contract	Comparison	Marketing vs. Resource providing
Sources of dietary diversity				
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 (all crops)	2.860**	3.530	3.245	***
	(1.364)	(1.674)	(1.406)	
Home garden production diversity (subsistence crops)	2.062**	2.610	2.406	***
	(1.265)	(1.592)	(1.322)	
Female labor days of female members				
Female labor days in oil palm activities per adult female members	5.392***	2.6458***	19.061	***
	(10.728)	(5.6587)	(32.306)	
Female labor days in off-farm self employment per adult female members	54.851*	43.098	34.557	
	(100.995)	(91.130)	(85.969)	
Female labor days in off-farm wage employment per adult female members	4.616	1.5408	3.256	
	(29.294)	(10.019)	(23.836)	
Total female labor days in off-farm (wage and self employment) per adult female members	59.467*	44.638	37.813	
	(102.708)	(91.7915)	(87.929)	
Number of obs.	193	164	106	

Note: Standard deviations in parentheses. Statistical test in the second and third columns are undertaken by comparing households in the resource providing and marketing contract with comparison households. The last column compares the marketing and resource providing contracted households.

Appendix

Table A1-First stage regressions (household dietary diversity)

	Marketing contract		Resource providing contract	
	(1)	(2)	(3)	(4)
Age of household head	0.01	0.00	0.07***	0.07***
	(0.02)	(0.02)	(0.02)	(0.02)
Female-headed household (1/0)	0.26	-0.11	0.28	0.38
	(0.42)	(0.57)	(0.44)	(0.61)
Education of head (years)	0.04	0.05	0.02	0.02
	(0.03)	(0.04)	(0.04)	(0.04)
Experience in oil palm(years)	0.05***	0.05***	-0.03	-0.03
	(0.02)	(0.02)	(0.02)	(0.02)
Distance from market (km)	0.05	0.05	0.14***	0.14***
	(0.03)	(0.03)	(0.02)	(0.02)
Dependency ratio [a]	0.11	0.13	0.55***	0.54***
	(0.22)	(0.22)	(0.20)	(0.20)
Land availability 2008 in acres (log)	-0.05	-0.03	0.07	0.08
	(0.19)	(0.19)	(0.19)	(0.19)
Female contracted (1/0)		0.48		-0.12
		(0.50)		(0.54)
Instrument				
Inverse distance from large oil palm mill (km)	12.21***	12.70***	-18.39**	-18.32**
	(3.20)	(3.29)	(7.21)	(7.37)
Constant	-2.21**	-2.30**	-3.41***	-3.41***
	(0.93)	(0.92)	(0.96)	(0.96)

Note: Robust standard errors in parentheses. * $p<0.1$; ** $p<0.05$; *** $p<0.01$. Results show the multinomial logit output that has been jointly estimated with the outcome variable in Table 2 using simulated maximum likelihood approach. 400 simulations are used in the regressions. [a] Dependency ratio is calculated by dividing number of dependents (children under 15 and elderly above 65) by the number of adult household members.

Table A2-First stage regressions (women's dietary diversity)

	Marketing contract		Resource providing contract	
	(1)	(2)	(3)	(4)
Age of individual	-0.00 (0.06)	-0.01 (0.06)	-0.10* (0.05)	-0.11** (0.05)
Age of household head	0.06 (0.07)	0.06 (0.07)	0.19*** (0.06)	0.19*** (0.07)
Female-headed household (1/0)	-0.53 (1.14)	-1.92 (1.55)	0.98 (1.12)	0.60 (1.50)
Education of head (years)	0.08 (0.08)	0.06 (0.09)	-0.01 (0.10)	0.01 (0.11)
Experience in oil palm(years)	0.03 (0.05)	0.03 (0.05)	-0.18*** (0.06)	-0.19*** (0.06)
Distance from market (km)	-0.03 (0.09)	-0.02 (0.09)	0.13** (0.06)	0.13** (0.06)
Dependency ratio [a]	0.44 (0.46)	0.59 (0.45)	1.38*** (0.43)	1.45*** (0.46)
Land availability 2008 in acres (log)	0.05 (0.38)	0.01 (0.40)	1.00** (0.44)	1.15** (0.48)
Female contracted (1/0)		1.87 (1.23)		0.61 (1.30)
Instrument				
Inverse distance from large oil palm mill (km)	11.88*** (4.04)	10.93** (4.60)	-13.41 (9.09)	-16.37* (9.81)
Constant	-5.40** (2.26)	-4.72* (2.71)	-6.08*** (2.36)	-6.45** (2.53)

Note: Robust standard errors in parentheses. * p<0.1; ** p<0.05; *** p<0.01. Results show the multinomial logit output that has been jointly estimated with the outcome variable in Table 3 using simulated maximum likelihood approach. 400 simulations are used in the regressions. [a] Dependency ratio is calculated by dividing number of dependents (children under 15 and elderly above 65) by the number of adult household members

Table A3-First stage regressions (HAZ)

	Marketing contract		Resource providing contract	
	(1)	(2)	(3)	(4)
Age in months	-0.10	-0.13	-0.14	0.14
	(0.21)	(0.23)	(0.29)	(0.28)
Age in months squared	0.00	0.00	0.00	-0.00
	(0.00)	(0.00)	(0.00)	(0.00)
Female (1/0)	0.81	1.08*	-0.04	0.09
	(0.67)	(0.64)	(0.80)	(0.80)
Age of household head	0.04	0.06	0.12***	0.12***
	(0.04)	(0.04)	(0.04)	(0.04)
Female-headed household (1/0)	-0.25	-1.65	-0.77	-0.85
	(1.01)	(1.33)	(1.37)	(1.82)
Education of head (years)	0.18**	0.19**	0.02	0.02
	(0.08)	(0.09)	(0.09)	(0.10)
Experience in oil palm(years)	0.00	0.03	-0.22***	-0.21***
	(0.05)	(0.06)	(0.06)	(0.07)
Distance from market (km)	-0.16*	-0.10	0.10*	0.11
	(0.09)	(0.10)	(0.06)	(0.08)
Dependency ratio [a]	0.49	0.63	1.55***	1.47***
	(0.39)	(0.42)	(0.41)	(0.45)
Land availability 2008 in acres (log)	-0.06	-0.19	0.98*	0.87*
	(0.49)	(0.44)	(0.50)	(0.49)
Female contracted (1/0)		1.20		-0.57
		(1.02)		(1.27)
Instrument				
Inverse distance from large oil palm mill (km)	15.77**	18.93***	-22.85	-21.53*
	(6.78)	(6.24)	(14.66)	(11.80)
Constant	-1.06	-2.10	-3.70	-9.54
	(4.67)	(5.20)	(6.67)	(6.79)

Note: Robust standard errors in parentheses. Results show the multinomial logit output that has been jointly estimated with the outcome variable in Table 4 using simulated maximum likelihood approach. 400 simulations are used in the regressions.
[a] Dependency ratio is calculated by dividing number of dependents (children under 15 and elderly above 65) by the number of adult household members

Table A4-First stage regressions (WAZ)

	Marketing contract		Resource providing contract	
	(1)	(2)	(3)	(4)
Age in months	-0.08	-0.15	0.01	0.02
	(0.22)	(0.21)	(0.26)	(0.25)
Age in months squared	0.00	0.00	0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)
Female (1/0)	0.70	0.69	-0.30	-0.11
	(0.66)	(0.63)	(0.75)	(0.84)
Age of household head	0.08*	0.06	0.12***	0.12**
	(0.04)	(0.05)	(0.04)	(0.05)
Female-headed household (1/0)	-1.38	-1.85	-0.85	-0.91
	(1.26)	(1.40)	(1.42)	(2.03)
Education of head (years)	0.18*	0.18**	0.01	0.01
	(0.09)	(0.08)	(0.10)	(0.09)
Experience in oil palm(years)	0.01	0.00	-0.22***	-0.20***
	(0.06)	(0.07)	(0.07)	(0.07)
Distance from market (km)	-0.10	-0.10	0.17***	0.16**
	(0.09)	(0.11)	(0.06)	(0.06)
Dependency ratio [a]	0.45	0.56	1.58***	1.63***
	(0.47)	(0.42)	(0.38)	(0.44)
Land availability 2008 in acres (log)	-0.35	-0.15	0.93**	0.94*
	(0.42)	(0.42)	(0.46)	(0.49)
Female contracted (1/0)		1.11		0.05
		(1.08)		(1.58)
Instrument				
Inverse distance from large oil palm mill (km)	18.50***	18.06**	-20.97**	-20.88**
	(5.85)	(7.60)	(9.32)	(9.88)
Constant	-2.46	-1.35	-7.14	-7.80
	(4.69)	(4.64)	(6.23)	(5.86)

Note: Robust standard errors in parentheses. Results show the multinomial logit output that has been jointly estimated with the outcome variable in Table 4 using simulated maximum likelihood approach. 400 simulations are used in the regressions. [a] Dependency ratio is calculated by dividing number of dependents (children under 15 and elderly above 65) by the number of adult household members