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Supermarket Contracts, Income, and Changing Diets of Farm Households: Panel Data Evidence from Kenya

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Abstract

In many developing countries, supermarkets are increasingly replacing traditional markets as preferred points of food purchases in urban areas. This has welfare implications on smallholder farmers that supply supermarkets. While previous studies have analyzed the welfare effects of smallholder participation in supermarket channels, many have focused on economic effects alone. Very little is known about the effects on farm household diets. Besides, most existing studies that have looked at economic effects used cross-sectional data that are limited in controlling for time-invariant differences between supermarket and traditional channel farmers. This study uses panel data from vegetable farmers in Kenya to examine the effects of supermarket contracting on farm household income and diets. Supplying supermarkets has increased household income by 66%, and is associated with 8% higher consumption of calories, as well as better dietary diversity, and higher levels of zinc consumption. Using these results for simple simulations suggests that wider participation of smallholders in supermarket channels could reduce the prevalence of undernourishment by 8% and the prevalence of zinc deficiency by 12%. Hence, enhancing smallholder market access could significantly contribute to reduction of undernourishment and micronutrient malnutrition and increased income of farm households.

Key words: Supermarkets, smallholder farmers, incomes, diets, Kenya

JEL codes: O12, O13, Q12, Q13, Q18

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1 Introduction

For most agro-dependent economies, smallholder agriculture contributes significantly to the aggregate agricultural output. Agricultural production is dominated by smallholder farms that employ majority of rural populations. Statistics for developing countries show that 70% of human populations reside in rural areas and rely on agriculture as main source of livelihood (FAO, 2014; World Bank, 2016). Incidences of poverty and hunger remain high in the rural areas of many developing countries. Global statistics also show that about 800 million people are hungry while another 2 billion suffer from micronutrients deficiencies – largely rural populations (Horton and Lo, 2013; IFPRI, 2016).

Alternative employment opportunities outside of agriculture are also limited for the rural populations in developing countries where manufacturing sector is less vibrant (Wiggins et al., 2010). Hence, smallholder farming takes the center stage in creating employment and rural development, and reducing poverty and hunger (World Bank 2007; Gautam et al., 2016). For sustainability of the emerging high-value chains and of accruing benefits, efforts to enhance smallholder production capacities and market access are important (Hazell et al., 2010). From poverty reduction and equity perspective, access to these markets would not only increase incomes, reduce poverty and widening inequalities, hunger and malnutrition, but also have wider spillover effects to the rural non-farm sector. This could generate off-farm employment and stimulate growth of the rural economy.

Market access is one major constraint to the viability of smallholder farming due to the relatively small-scale farm operation and the high transaction costs occasioned by market imperfections in developing countries (Hazell et al., 2010; Escobal et al., 2012). Contract farming is one of the pathways to widening smallholder farmers' access to high-value markets. This could be in the form of production or marketing contracts that are widespread in the domestic and export markets for horticultural products in many developing countries (Otsuka et al., 2016). Contract farming stabilizes prices and volumes traded while offering assured market to farmers thus could potentially increase incomes of contracted farmers.

Increased globalization has expanded trade in processed and fresh foods across countries along with dynamic transformation of agri-food systems, often with far-reaching implications on agricultural production (Jenkins, 2004; Hazell et al., 2010). These developments have led to increased integration of the food marketing systems and spread of supermarkets in what has been described by Reardon et al (2012) as "supermarket revolution". The spread first began in

Central America before spreading to Asia, and currently beginning to take shape in Sub-Saharan Africa. Supermarkets are increasingly replacing traditional retailers and wet markets as preferred shopping outlets by largely urban populations (Qaim, 2017). This is occasioned by rising incomes, urbanization and emerging urban middle classes, dynamic tastes and preferences of consumers, growing demand for variety of foods, and desire for shopping convenience among the more affluent segments of the populations (Reardon and Timmer, 2014; Tschirley et al., 2015). These demand and supply side factors have significantly contributed to nutrition transition in developing countries (Mergenthaler et al., 2009; Gómez, and Ricketts, 2013).

The rapid supermarket growth has broad implications on food retailing and access to variety of foods, and farm production of fresh foods demanded by supermarkets. Two strands of literature analyze the welfare effects of supermarkets. On the one hand, the impacts (through supermarket purchases) are analyzed in terms of household or individual level nutrition effects of food purchases from supermarkets (Asfaw, 2008; Popkin, 2014; Umberger et al., 2015; Kimenju et al., 2015). Supermarkets stock diverse nutritious foods as well as energy-dense and highly processed foods.

On the other hand, from the supply side, welfare effects of supermarket contracting on farm households are analyzed. Existing studies focus on farm profits, farm productivity, assets accumulation, on-farm and off-farm employment, and changes in gender roles among other issues (Miyata et al., 2009; Neven et al., 2009; Rao and Qaim, 2011; Michelson, 2012; Rao and Qaim, 2013; Chege et al., 2015). Hence, supermarket growth could contribute to the modernization of the small farm sector and widen market access by smallholder farmers, with far reaching welfare implications. This study contributes to the latter strand of literature with a focus on contractual arrangements between rural smallholder farmers and supermarkets. Supermarkets are modernizing their food procurement systems and increasingly sourcing FFVs directly from farmers (Chege et al., 2015). It is important to understand how the spread of supermarkets affect welfare of contracted farm households given the dynamic participation in such high value channels.

While previous studies have analyzed the welfare effects of smallholder participation in supermarket channels, many have focused on economic effects alone. Very little is known about the effects on farm household diets. Besides, most existing studies that have looked at economic effects used cross-sectional data that yield potentially biased results due to endogeneity problems. This study fills the literature and knowledge gap on the effects of supermarket contracting on household incomes and diets using panel data from a sample of vegetable farmers of Central Kenya. The study first analyzes the effects on household income before analyzing the effects on household diets - in terms of dietary diversity, as well as calories and micronutrient (iron, zinc and vitamin A) consumption. The hypotheses are that supermarket contracting increases household incomes, calories and micronutrients consumption, and dietary diversity.

Recent studies show that resource-constrained smallholder farmers are excluded from high-value markets due to the stringent consistency, timeliness, volumetric, food safety and quality requirements, and the costly on-farm investment to meet the requirements (Anderson et al., 2015; Chege et al., 2015). This has led to high drop-out rates in the supermarket channels, also partially attributed to unfavorable contractual arrangements that expose farmers to marketing risks (Ochieng et al., 2017). However, the farmers that overcome the hurdles are expected to benefit significantly from such marketing arrangements.

2 The Study Context

Kenya's economy is largely dependent on agriculture as a foreign exchange earner. The sector contributes significantly to the gross domestic product (GDP) and employs majority of the rural populations (Olwande et al., 2015). Currently, Kenya's human population stands at 46 million and is estimated to increase by 3% by year 2030 (PRB, 2017). About 70% of the population reside in rural areas and rely on smallholder agriculture as main source of livelihood, on 5% of rural farmlands (Muyanga and Jayne, 2015). Poverty and prevalence of undernourishment and micronutrient malnutrition remains widespread particularly in the rural areas of Kenya (KNBS, 2008; RoK, 2012).

Hence, smallholder agriculture could significantly contribute to poverty reduction and improved food security among rural farm households, and enhance growth of the rural economy in Kenya. As earlier mentioned, contract farming is one of the pathways to widen smallholder access to markets while reducing transaction costs when engaging with smallholder farmers. In Kenya, it is widely practiced in both the domestic (e.g. supermarkets) and export markets for horticultural products (Okello and Swinnton, 2007; Asfaw et al., 2009; Neven et al., 2009). Kenya ranks second after South Africa with respect to growth of supermarkets that currently account for 10% of national retail and 20% of grocery sales in urban areas (Planet Retail, 2017).

Supermarkets offer variety of fresh and processed foods to consumers in Kenya and are also modernizing their food procurement systems in the wake of food safety and quality concerns to procure FFVs directly from farmers. This initially involved contracting medium and large-scale farmers that could meet the stringent volumetric, timeliness, and quality requirements. However, supermarkets began contracting smallholder farmers as they expanded to other smaller towns (Chege et al., 2015). Such contracts provide opportunity for smallholder farmers to participate in such rewarding but often demanding high-value markets.

3 Materials and Methods

3.1 Study Area

This study focuses on smallholder farmers of Kiambu County of Central Kenya. Kiambu is one of the high potential regions of Kenya with favorable climatic conditions for agricultural production. Farmers in the region practice mixed farming, cultivating staples and cash crops, and rearing livestock on small pieces of lands. Household survey was conducted in Kikuyu, Limuru, and Githunguri areas of Kiambu County.

The County provides appropriate setting for this study for the following reasons. First, the region borders the capital city where demand for FFVs is increasing due to growing human populations and expansion of satellite towns (Ayieko et al., 2005). This presents marketing opportunity for vegetable farmers. Second, the region is densely populated, with the rural households mainly engaged in farming as the main source of livelihood (KNBS, 2008). Poverty rate and prevalence of undernourishment and micronutrient deficiencies is high in rural areas (KNBS, 2008). Third, Kiambu is one of the major FFVs producing regions of Kenya, and a major source of FFVs for the supermarkets in Nairobi (Neven et al., 2009; Ochieng et al., 2017). Lastly, the perishable nature of FFVs and volatile prices across seasons presents a unique marketing problem to farmers, which substantially influence farm profits. Hence, it is important to analyze the effects of supermarket contracting on farm household income and diets.

3.2 Data Collection

This study builds on a panel survey conducted over several years. Stratified random sampling procedure was employed to randomly sample 402 farmers from 31 administrative locations within Kiambu in year 2008 (Rao and Qaim, 2011). The sample comprised traditional channel (TC) and supermarket (SM) channel farmers. Face-to-face interviews were conducted using a structured questionnaire. Subsequent follow-up surveys were carried out in years 2012 and 2015. Table 1 provides a summary of the farmers surveyed over the years.

Table 1 Number of farm households interviewed

Farmers	**2008**	**2012**	**2015**
Supermarket farmers	133	85	72
Traditional channel farmers	269	299	327
Total	402	384	409

The breakdown by group of farmers in Table 1 shows how the number of contracted (supermarket) farmers declined over time. It is important to mention that 9 farm households interviewed in 2015 are excluded from the following analysis due to incomplete data. Respondents were the household heads, their spouses or household members responsible for vegetable production and marketing, and the persons responsible for food preparation in the household (for the nutrition section).

3.3 Data

Measuring household income

This study exploits unbalanced panel data from all the three rounds of survey to analyze effect of supermarket contracting on farm household income. The questionnaire included socio-demographic characteristics of the farm households, focusing on farm production and marketing activities. In particular, a detailed section on vegetable production and supermarket contracts was included. These data allowed for computation of annual household incomes. Farm income was computed from crop and livestock revenues and corresponding costs incurred by the farm enterprises. Off-farm income comprised earnings from off-farm and non-farm activities including remittances. These estimates of household income in all the survey rounds were adjusted for inflation using consumer price indices.

Measuring calorie and micronutrient consumption

Nutrition related questions were only included in the 2012 and 2015 survey rounds so that effects of supermarket contracting on household diets are analyzed using unbalanced panel data from the two survey rounds. The questionnaire detailed types and quantities of foods consumed from own production, gifts, and purchases by the households for more than 180 food items based on a 7-day recalls. This allowed for computation of quantities calories (energy) and micronutrients consumed by the households. Calorie consumption is a measure of access to adequate quantities of energy and foods for healthy living (FAO et al., 2001). Household dietary diversity was computed using a score as discussed below and is a robust indicator of household food access due to its positive and significant association with all measures of calorie consumption (Leroy et al., 2015).

The weekly quantities of foods consumed were converted into nutrient equivalents per 100 grams using food conversion tables for Kenya, while correcting for edible portions of food (Sehmi, 1993). The daily consumption estimates were determined by dividing the weekly calories and micronutrients consumed were divided by 7. These daily estimates were further divided by adult equivalents (AE) for Kenya to obtain the quantities consumed per AE, so that comparisons between households are possible. The AE accounts for age and levels of physical activity of each household member.

We accounted for micronutrient losses from food preparation that affects nutrient availability (Bognár, 2002), and issues of bioavailability that depend on diets as well as inhibitors or enhancers of zinc and iron absorption by the body. Micronutrient analysis assumed iron bioavailability of 5% , which is within suggested range of 5% to 15% (WHO and FAO, 2004) and zinc bioavailability of 15%, assuming unrefined cereal based diets as common in Kenya (IZiNCG, 2004; WHO and FAO, 2004). Calorie and micronutrient deficiencies are determined by comparing the estimated consumption levels against the prescribed standard levels of 15mg of zinc, 18.3 mg of iron, and 625 µg retinol equivalent (RE) of vitamin A per AE and day. For calories, daily intake of 3000 Kcal per AE and day is recommended for moderately active male adults in Kenya (WHO and FAO, 2004). A household is undernourished if the consumption level falls below 80% of the recommended level, meaning 2400Kcal per AE and day (FAO et al., 2001).

Measuring household dietary diversity

Household dietary diversity provides the general overview of nutritional status of the household (Leroy et al., 2015). Twelve food groups were used to calculate household dietary diversity score (HDDS). The groups comprised: vegetables; white tubers and roots; cereals; legumes; nuts and seeds; fruits; oils and fats; meat; fish and fish products; milk and dairy products; eggs; sweets and sugars; condiments, spices and beverages. Scores were assigned using a count of food groups consumed in the reference period as done in other nutrition-related studies (Jones et al., 2014; Herforth and Ballard, 2016; Koppmair et al., 2017). HDDS can also be an indicator of dietary quality when computed using 9 food groups that exclude energy dense yet micronutrient poor food groups such a fat and oils, condiments, spices and beverages, and sweets and sugars (Sibhatu et al., 2015). This provides a snapshot of micronutrient density of the diets a well a robustness check on the estimations a will be shown in the results section.

3.4 Estimation Procedure

This section discusses the model specifications used to analyze the effects of supermarket contracting on household income and diets. A binary treatment variable (supermarket participation) in all the specifications assumes a value of one if the farmer is contracted by supermarkets and zero if not. The dietary outcomes refer to the household daily consumption of calorie, zinc, iron, and vitamin A per AE, and dietary diversity. Considering the panel structure of the data, we use random effects (RE), fixed effects (FE) and ordinary least squares (OLS) estimators for analysis. Household income or dietary outcomes are regressed on supermarket participation (dummy) while controlling for other factors that may also influence income and diets as shown in the specification below:

$$Y_{it} = \gamma SM_{it} + \beta X_{it} + \delta Z_i + \alpha_i + \mathrm{u}_{it} \qquad (1)$$

where Y is either household income, calorie and micronutrients consumed per AE, or dietary diversity score. SM is the treatment variable. Subscripts index household i=1, 2,…, N and time, t=1, 2,…,T. X_i are the time variant characteristics whereas Z_i are individual time-invariant characteristics. α_i captures unobserved characteristics, independent and identically distributed – IDD (0, σ_α^2) and the error term, u_{it} is IID (0, σ_u^2) both independent of each other and among themselves (Wooldridge, 2010). The hypothesis is that supplying supermarkets improve income, calorie and micronutrients consumption, and household dietary diversity, that is $\boldsymbol{\gamma}$>0.

The other controls (X_i) are; age, gender, and education level of the household head, farm size, and household size. These factors may influence farmer participation in supermarket channels. For example, age and education level of farmers influence access to market information, managerial abilities, and farmers' willingness to contract or adopt of production technologies. Farm size is a proxy for farm household wealth status whereas household size (per adult equivalent) indicates availability of family labor, which is important for labor-intensive production and post-harvest handling activities such as of FFVs. Supermarket contracting could affect participation in off-farm activities. Including region dummies captures any heterogeneity across the regions. However, there may be other unobserved factors (or differences) between farm households that influence incomes besides the aforementioned factors e.g. farmers' entrepreneurial skills and motivation, and location specific factors (climate, elevation, and soils that favor crop production).

The unobserved heterogeneity between SM and TC farmers may yield biased estimates. Fixed effects estimator controls for this, providing unbiased estimates. For the household income model, the *P*-value for the Hausman test is significant so that the null hypothesis that the difference in the coefficients is not systematic is rejected (Hausman, 1978). Hence, FE estimator is appropriate as shown in the following discussion.

For the dietary outcome models, the *P*-values for the Hausman test are insignificant so that the null hypothesis that the differences in the coefficients are not systematic cannot be rejected. Hence, RE estimator is appropriate. Breusch-Pagan test also confirmed that OLS specification is not appropriate. Both RE and OLS estimates are shown in the following empirical results section. The RE estimator does not control for unobserved heterogeneity of the farmers. Individual regressors are assumed exogenous (not correlated with individual effects). Hence, the treatment coefficients are interpreted as associations between supermarket contracting and household diets.

Beyond the Hausman test, RE estimator is appropriate in this case for two reasons. First, only two rounds of panel data is available for dietary outcome estimations such that using FE estimator would halve the degrees of freedom. Consequently, the tails of t-distribution thicken, implying that the coefficients are estimated with greater uncertainty (Cameron and Trivedi, 2004; Townsend et al., 2013). Secondly, there is little within-group variation in the covariates, meaning the covariates would be highly correlated with the fixed effects thereby rendering FE estimator inefficient (Wooldridge, 2010; Bell and Jones, 2015).

We perform simple simulations to assess the possible significance of the magnitude of the treatment effects on dietary outcomes by adding the mean coefficients of the treatment variable to the current consumption levels and then re-estimating the levels of calorie and micronutrient deficiency. This way, we are able to assess the economic relevance of the magnitudes of the coefficients interpreted.

3.5 Results and Discussion

3.5.1 Farm and Household Characteristics

Table 2 provides a summary of farm and household characteristics from pooled sample (2008-2015). The SM and TC farmers differ in most of the characteristics. Majority of the farm households are male-headed. The household heads are about 51 years of age, with about nine years of schooling. The average farm size is about 2 acres. The average farm household comprises three persons (adult equivalent).

Table 2 Characteristics of the farmers (pooled sample)

Variable	Full sample	SM farmers	TC farmers
Total income (1000 ksh)	436.32 (763.05)	749.36*** (1294.49)	335.01 (442.85)
Male household head (dummy)	88.03 (32.48)	83.79*** (24.17)	86.16 (34.55)
Age of household head (years)	51.74 (14.09)	49.60 (12.85)	52.43 (14.40)
Education level of farmer (years)	9.48 (3.75)	10.54*** (3.18)	9.14 (3.86)
Off-farm income (dummy)	65.35 (47.61)	72.76*** (44.60)	62.95 (48.32)
Farm size (acres)	1.98 (3.10)	2.62*** (4.69)	1.78 (2.34)
Household size (AE)	2.59 (1.18)	2.93 (1.15)	2.48 (1.16)
N (number of observations)	1186	290	896

Notes: values are means with standard deviation in parentheses; SM, supermarket; TC, traditional channel; Ksh, Kenya shillings; AE, Adult equivalent; *, **,***Mean values between SM and TC farmers are statistically significant at the 1% level.

Table 3 presents a summary of the household dietary indicators by marketing channels from pooled sample (2012-2015). SM farmers consume 3% more calories than TC farmers and are less undernourished by a similar magnitude. The households have an average dietary diversity score of 8.77, a sign of access to adequate quantities of food. More than half of the sampled households are iron deficient. Overall, the differences in the estimates between SM and TC farmers are not statistically significant. Hence, the two groups are comparable.

Table 3 Nutrition indicators by marketing channels

	Full sample		SM farmers		TC farmers	
Variable	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
Calorie consumption (kcal/day/AE)	3342.96	1152.58	3416.06	1213.30	3324.65	1137.14
Prevalence of undernourishment (%)	19.13	39.36	17.20	37.86	19.62	39.74
Vitamin A consumption (µg RE/day/AE)	1420.37	930.48	1402.74	768.80	1424.78	967.23
Prevalence of vitamin A deficiency (%)	12.63	33.24	11.47	31.96	12.92	33.57
Iron consumption (mg/day/AE)	18.81	8.95	18.55	8.37	18.88	9.10
Prevalence of iron deficiency (%)	56.25	49.64	59.24	49.30	55.50	49.74
Zinc consumption (mg/day/AE)	19.54	7.91	20.38	8.75	19.33	7.68
Prevalence of zinc deficiency (%)	30.99	46.28	29.94	45.94	31.26	46.39
Dietary diversity score	8.77	1.40	9.17	1.24	8.67	1.42
N (Number of observations)	784		157		627	

Notes: Values are means; SD, standard deviation; SM, supermarket ; TC, traditional channel; Kcal, Kilo calories; AE, adult equivalent; RE, retinol equivalent; mg, milligrams; thresholds of deficiency is 2400Kcal for calories, 625 µg RE for vitamin A, 18.3mg for iron, and 15mg for zinc. The differences in the indicators between the groups are not statistically significant.

3.5.2 Empirical Results

Supermarket contracting and household income

Table 4 presents the model results from household income specification. Controlling for other factors, Supplying supermarket has increased farm household income by Ksh 222,000 – a 66% increase above the mean income of TC farmers. This is plausible, given the accruing benefits from supplying supermarkets. The channel offers stable and better prices to farmers compared to the traditional channel where prices are volatile across seasons. Hence, with assured market and stable prices, farmers are able to coordinate production and marketing activities thus possibly realize higher farm profits than TC farmers. Supermarket channel also has stringent quality and volumetric requirements that involve substantial farm investments in production technologies including farm inputs and irrigation equipment to facilitate year-round production and post-harvest handling equipment. Income growth facilitates such investments, leading to greater output and better quality produce thus minimizing product rejection by supermarkets.

Table 4 Supermarket contracting and household income

	Model (1)	Model (2)
Variables	**Total income (RE model)**	**Total income (FE model)**
SM participation (dummy)[a]	330.02*** (95.88)	222.17** (112.48)
2012 (dummy)[b]	373.60** (155.69)	268.51* (151.03)
2015 (dummy)[b]	604.55*** (230.19)	406.33* (226.46)
Age of household head (years)	-0.88 (1.91)	3.15 (3.09)
Male household head (dummy)	83.80* (48.65)	-7.65 (54.63)
Education level of farmer (years)	23.21*** (7.16)	24.82** (11.90)
Off-farm income (dummy)	128.27*** (31.97)	82.11 (49.90)
Farm size (acres)	52.02*** (17.30)	2.23 (24.00)
Household size (AE)	114.09 (96.79)	48.30 (89.53)
Kikuyu (dummy)[c]	-2.78 (58.18)	-
Githunguri (dummy)[c]	1.87 (60.29)	-
Westlands (dummy)[c]	79.77 (145.62)	-
Constant	-702.59* (414.25)	-416.44 (343.11)
Number of observations	1186	1186
R-squared		0.07
Hausman test (chi-square statistic)	20.65**	

Notes: The dependent variable is total household income, values deflated for comparisons across years; Robust standard errors in parentheses; SM, supermarket; RE, Random effects; FE, Fixed effects; AE, Adult equivalent; *, **,*** Significant at the 5%, and 1% level, respectively ; [a] Reference group is traditional channel farmers.[b] Reference year is 2008. [c] Reference region is Lari/Limuru

The income effect is comparable to those of previous studies. Rao et al (2011) estimated that supplying supermarkets increased household income by 48% whereas Chege et al (2015) estimated an increase by over 60%. Supplying supermarkets is also associated with reduced poverty rates (Rao et al., 2011). In a broader context, the magnitude of the effect is comparable to those from other studies that look at effects of smallholder participation in other high-value channels in developing countries (Maertens et al., 2012; Van den Broeck and Maertens, 2016). The results suggest that smallholder participation in high-value channels increase household income substantially.

Supermarket contracting and household diets

We examine examines the association between supermarket contracting and household dietary outcomes as well as dietary diversity. Table 5 provides a summary of the model results but detailed results are in Tables A1, A2, and A3 in the appendix.

Supplying supermarkets is associated with positive and significant changes in consumption of calorie and zinc as well as improvement in household dietary diversity. SM farmers have a

265 Kcal per AE and day higher calorie consumption - a 8% increase compared to the average consumption by TC farmers, consume 9% more zinc, and increase their dietary diversity by 2%. Dietary diversity is highly correlated with calorie consumption (Leroy et al., 2015). We do not find significant effects on vitamin A and iron consumption.

The treatment coefficient remains positive and statistically significant when only 9 groups are included. The treatment effect on dietary diversity is relatively small, possibly because the average HDDS for the farm households is already high. Using the estimated dietary effects for simple simulations suggests that wider participation of farmers in supermarket channels could help to reduce the prevalence of undernourishment by 8% and zinc deficiency by 12%. Overall, results suggest that supermarkets could potentially improve household dietary diversity, consumption of calorie, and micronutrients.

Table 5 Supermarket contracting and household diets

Analysis	Calorie(kcal/day/AE)		HDDS 1		HDDS 2		Zinc(mg/day/AE)	
	RE	OLS	RE	OLS	RE	OLS	RE	OLS
Being in SM channel	264.67**	272.51**	0.18*	0.24**	0.24***	0.28***	1.84**	2.14**
	(113.07)	(115.11)	(0.10)	(0.10)	(0.10)	(0.10)	(0.80)	(0.79)

Values are coefficients of treatment variable with robust standard errors in parentheses, clustered at household level; Kcal, kilocalories; AE, adult equivalent; HDDS, household dietary diversity score computed from 12 food groups; mg, milligram; RE, random effects; OLS, Ordinary least squares regression; SM: supermarket; *, **, *** Significant at the 5%, and 1% level, respectively; dependent variables are calorie and zinc intake, HDDS 1 and HDDS 2 computed using 12 and 9 food groups, respectively. Full model estimates are in appendix to chapter 3.

These findings show a positive and significant association between supplying supermarkets and household income. Cash income facilitates economic access to adequate, safe and quality foods particularly in situations of well-functioning food markets (Jones et al., 2014). However, we do not analyze income pathway here. It should be noted that the estimates are only measures of food availability at household level and not household food security. Some studies suggest that supermarkets increase availability and accessibility of cheap, energy-dense but less nutritious, resulting in micronutrients malnutrition and obesity (Popkin, 2014; Kimenju et al., 2015). However, considering the study area and the estimated prevalence of undernourishment and micronutrient deficiencies, there is no reason to believe that the treatment effects result in over-nutrition particularly in the short-term.

Robustness check

For HDDS estimation, it could be argued that the result is driven by how HDDS is measured. Hence, as a robustness check, additional dietary diversity score is computed (HDDS2) that only includes 9 food groups in the HDDS. The excluded food groups are; sweets and sugars, fats and oils, and condiments, spices and beverages. These food groups comprise energy dense but nutrient poor foods. HDDS 2 now captures the dietary quality component of access to food (Leroy et al, 2015). The treatment effects remain significant as shown in Table 5.

3.6 Conclusion

This study examines the effects of supermarket contracting farm household income and diets. Panel regression results suggest that supermarket contracting has positive and significant effects on income, and is associated with improved dietary diversity as wells as consumption of calories and micronutrients. Specifically, the results confirm that supplying supermarkets has increased farm household income by 66%, and is associated with increased consumption of calorie by 8% and zinc by 9%, and improvement in household dietary diversity. We do not find significant treatment effects on vitamin A and iron consumption. Using these results for simple simulations suggests that wider participation of smallholders in supermarket channels could significantly reduce the prevalence of undernourishment and the prevalence of zinc deficiency.

The findings should be interpreted with caution since supplying supermarkets and the potential spillover effects to traditional channel farmers are not analyzed. The effects could also be heterogeneous depending of context and nature of agricultural produce as seen in contract farming literature (Bellemare, 2012; Narayanan, 2014). Previous studies have highlighted high drop-out rates of smallholder farmers from supermarket channels due to stringent consistency, volumetric and quality requirements, and contract design in general. The challenges are also exacerbated by market imperfections that pervade the agricultural sector in developing countries, leading to high transaction costs even for farmers that market individually. Andersson et al (2015) find that income gains from supplying supermarkets erode when smallholder farmers drop out of the channel. This means that the improvements in diets could also diminish once the farmers exit the high-value channels. Overcoming the challenges and barriers to entry into these channels is crucial.

From a rural development perspective, policies that widen smallholder access to markets are important. Policy initiatives that improve rural road infrastructure could facilitate access to markets, reduce transportation cost and time, and improve produce quality thereby reducing product rejection rates witnessed in supermarket channel (Andersson et al., 2015). Facilitating efficient operations of farmer groups could also be beneficial in reducing the costs. This could be through public-private sector partnerships that also improve relations between farmers and supermarkets or other buyers. This facilitates greater transparency on important contract issues e.g. grading mechanisms for fairness in pricing thereby ensuring sustainability of smallholder participation in high-value chains.

Supermarket growth in sub-Saharan Africa and Kenya in particular, could have significant welfare effects on rural farm households given the rapid urbanization, rising urban middle class, rising supermarket share of domestic retailing, supermarket expansion to other smaller cities, and their contracts with smallholder farmers for supplies of fresh horticultural produce. The spillover effects such as off-farm labor employment could significantly contribute to growth of the rural economy, household incomes, and diets. Overall, the study findings suggest that supplying supermarkets could significantly benefit rural smallholder farmers through increased incomes and improved household diets. This contributes to reduction of poverty and the burden of undernourishment and micronutrients malnutrition that is widespread in developing countries and among rural households in particular.

Appendix

Table A1 Supermarket contracting and HDDS 2 -Robustness check

	HDDS 2	
Variables	**RE**	**OLS**
SM participation (dummy)[a]	0.24***	0.28***
	(0.08)	(0.08)
Year 2015 (dummy) [b]	-0.97***	-0.99***
	(0.09)	(0.10)
Male household head (dummy)	0.02	-0.02
	(0.12)	(0.12)
Education of household head (years)	0.05***	0.05***
	(0.01)	(0.01)
Off-farm income (dummy)	-0.14*	-0.12
	(0.07)	(0.07)
Farm land owned (acres)	0.03***	0.03***
	(0.01)	(0.01)
Household size (AE)	-0.12*	-0.13**
	(0.07)	(0.07)
Kikuyu region (dummy) [c]	0.09	0.10
	(0.08)	(0.07)
Githunguri region (dummy) [c]	-0.20	-0.21*
	(0.13)	(0.12)
Westlands region (dummy) [c]	0.27	0.24
	(0.19)	(0.17)
Constant	9.30***	9.39***
	(0.34)	(0.35)
Wald chi2 (10)	312.11***	-
F (10, 773)		25.95***
R-squared		0.24

Notes: Observations=784; Robust standard errors in parentheses; SM, supermarket; RE, Random effects; OLS, ordinary least squares, AE, Adult equivalent; *, **, *** Significant at the 10%, 5%, and 1% level, respectively; [a] Reference group is traditional channel farmers. [b] Reference year is 2012. [c] Reference region is Lari/Limuru

Table A2 Supermarket contracting and dietary outcomes

	Calorie (Kcal/day/AE)		HDDS 1		Zinc (mg/day/AE)		Iron (mg/day/AE)		Vitamin A (Ug/day/AE)	
Variables	**RE**	**OLS**	**RE**	**OLS**	**RE**	**OLS**	**RE**	**OLS**	**RE**	**OLS**
SM participation (dummy)[a]	264.67**	272.51**	0.18*	0.24**	1.84**	2.14***	0.50	0.55	-22.95	-12.72
	(113.07)	(115.11)	(0.10)	(0.10)	(0.80)	(0.79)	(0.85)	(0.87)	(83.26)	(80.00)
Year 2015 (dummy) [b]	-312.91**	-328.99**	-1.75***	-1.78***	-6.71***	-7.07***	1.59	0.80	-200.52**	-240.57**
	(123.43)	(127.55)	(0.10)	(0.11)	(0.79)	(0.82)	(0.97)	(0.95)	(94.08)	(96.93)
Male household head (dummy)	-138.55	-138.92	0.05	0.03	-4.49***	-4.55***	1.69*	1.74*	-225.46**	-228.85**
	(133.46)	(133.74)	(0.13)	(0.13)	(1.14)	(1.07)	(0.93)	(0.94)	(112.61)	(115.10)
Education of household head (years)	-13.37	-13.44	0.06***	0.06***	0.07	0.08	0.07	0.08	14.71*	15.57*
	(12.34)	(12.11)	(0.01)	(0.01)	(0.09)	(0.08)	(0.09)	(0.08)	(8.77)	(8.21)
Off-farm income (dummy)	-49.44	-50.03	-0.19**	-0.16*	-0.29	-0.47	-0.27	-0.19	-47.71	-58.02
	(91.06)	(91.88)	(0.08)	(0.09)	(0.57)	(0.58)	(0.75)	(0.72)	(73.91)	(73.61)
Farm land owned (acres)	50.86**	52.12***	0.05***	0.05***	0.21*	0.23*	0.25*	0.25*	33.30**	33.02**
	(20.00)	(20.15)	(0.01)	(0.01)	(0.13)	(0.13)	(0.14)	(0.13)	(13.63)	(13.60)
Household size (AE)	-459.66***	-473.38***	-0.09	-0.12	-3.39***	-3.79***	-2.34***	-3.10***	-272.48***	-308.10***
	(80.95)	(83.22)	(0.07)	(0.07)	(0.54)	(0.56)	(0.61)	(0.58)	(54.38)	(54.80)
Kikuyu region (dummy) [c]	-144.01	-141.77	0.09	0.10	-0.53	-0.46	0.30	0.38	175.31**	180.04**
	(92.03)	(88.41)	(0.09)	(0.08)	(0.63)	(0.58)	(0.75)	(0.67)	(79.20)	(75.16)
Githunguri region (dummy) [c]	-94.01	-96.47	-0.11	-0.12	-1.02	-0.98	0.87	0.79	0.64	8.01
	(161.05)	(147.17)	(0.16)	(0.15)	(1.06)	(0.96)	(1.27)	(1.25)	(116.66)	(108.31)
Westlands region (dummy) [c]	-691.04***	-693.76***	0.36	0.31	-4.24***	-4.32***	-3.88***	-3.81**	19.71	12.07
	(211.11)	(203.58)	(0.24)	(0.21)	(1.37)	(1.22)	(1.40)	(1.62)	(139.04)	(143.16)
Constant	5225.74***	5289.41***	9.22***	12.83***	32.50***	47.59***	19.80***	19.83***	2389.01***	2554.32***
	(451.19)	(477.48)	(0.22)	(0.40)	(1.77)	(3.11)	(1.74)	(3.34)	(340.50)	(353.86)
Wald chi2 (10)	68.29***		709.84***	-	122.41***		100.37***		48.02***	
F (10, 773)		6.32***		57.39***		12.58***		10.21***		5.49***
R-squared		0.08		0.41		0.16		0.10		0.05

Notes: Observations=784; Robust standard errors in parentheses; SM, supermarket; RE, Random effects; OLS, ordinary least squares, AE, Adult equivalent.
*, **, *** Significant at the 10%, 5%, and 1% level, respectively; [a] Reference group is traditional channel farmers.[b] Reference year is 2012. [c] Reference region is Lari/Limuru.

Table A3 Fixed effects models for dietary outcomes

VARIABLES	Calorie(kcal/day/AE)	HDDS 1	HDDS 2	Zinc(mg/day/AE)	Iron (mg/day/AE)	Vitamin A (Ug/day/AE)
SM participation (dummy)[a]	72.30	-0.14	0.04	0.17	-0.48	-153.00
	(185.30)	(0.17)	(0.13)	(1.31)	(1.24)	(182.97)
Year 2015 (dummy) [b]	-160.57	-1.63***	-0.88***	-5.22***	4.11***	27.33
	(174.33)	(0.14)	(0.12)	(1.10)	(1.45)	(128.56)
Male household head (dummy)	-103.19	0.42	0.49**	-2.42	2.85	123.96
	(358.84)	(0.27)	(0.21)	(2.50)	(2.45)	(166.99)
Education level of farmer (years)	-	-	-	-	-	-
Off-farm income (dummy)	-53.28	-0.29**	-0.22**	0.01	-0.45	-29.67
	(128.81)	(0.12)	(0.10)	(0.76)	(1.01)	(101.45)
Farm size (acres)	-2.53	0.01	0.01	-0.13	0.001	-1.97
	(76.05)	(0.05)	(0.04)	(0.40)	(0.45)	(51.19)
Household size (AE)	-318.79**	0.01	-0.07	-1.82**	0.10	-69.77
	(128.8)	(0.11)	(0.09)	(0.79)	(1.04)	(88.79)
Kikuyu region (dummy) [c]	-	-	-	-	-	-
Githunguri region (dummy) [c]	-	-	-	-	-	-
Westlands region (dummy) [c]	-	-	-	-	-	-
Constant	4462.86***	12.69***	9.20***	38.38***	6.25	1430.76***
	(759.30)	(0.64)	(0.52)	(5.02)	(6.17)	(529.10)
Number of observations	784	784	784	784	784	784
R-squared	0.04	0.63	0.39	0.13	0.13	0.01
Hausman (chi-square statistic)	4.40	9.47	6.45	4.37	2.33	4.75

Notes: Robust standard errors in parentheses; SM, supermarket; AE, Adult equivalent; mg, milligram; * , **,*** significance at the 10%, 5%, and 1% level, respectively; .
[a] Reference group is traditional channel farmers.[b] Reference year is 2012. [c] Reference region is Lari/Limuru.

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