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THE ROLE OF CONTRACT FARMING ON HOUSEHOLD FOOD SECURITY IN KENYA AND MADAGASCAR

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ABSTRACT

Context and background

Contract farming has been promoted as a more 'inclusive business model' in which local smallholder farmers can participate in and benefit from the wider benefits of investments in rural areas such as infrastructure development (power supply, roads, water supply), spillovers from increased incomes and, in some cases, mandatory development of education and health facilities. Contract farming models could have a positive impact on agricultural development and innovation in developing countries. Contract farming creates a system that links smallholder farmers with domestic and international buyers. Contract farming could secure existing local land rights of smallholder farmers by continuing farming on their land, promoting investments by investors and fostering the commercialization of smallholder farmers. Contract farming could enhance local food security. However, contract farming models do not always have a positive impact. Sometimes contractors make a profit without supporting or, sometimes, exploiting contracted smallholders.

Goal and Objectives:

The primary focus of this paper is to analyze the impact of contract farming on household food security. The paper will address the following research questions: What are the determinant factors that affect participation in contract farming? and What is the impact of contract farming on household food security in Kenya and Madagascar?

Methodology:

This study used three internationally recognized food security indicators to measure the food security status of the household: household dietary diversity score (HDDS), food consumption score (FCS) and the months of adequate household food provisioning (MAHFP). This study used an endogenous switching regression (ESR) model to estimate the impact of contract farming on household food security.

The research is purely empirical research is based on observation and measurement of phenomena, as directly experienced by the researcher

Results:

AI can be effectively applied by Informal Cross-Border Traders (ICBT) to enhance their businesses and enhance competitiveness. There are several AI applications accessible to ICBT within their operational context. Although the adoption and utilization of AI in Africa are still in their infancy, there is considerable promise for the future. Africans must address the challenges hindering the adoption and utilization of AI, as technology is advancing rapidly, and opportunities await those who embrace it.

Keywords

Contract farming; large-scale agricultural investments; endogenous switching regression model; food security.

1. INTRODUCTION

Two models for the engagement of small-scale farming households with large-scale agricultural investments (LSAIs) in the developing world have been widely discussed in the literature: plantation/estate farm and contract farming (or out-grower schemes) (Burnod et al., 2015; Hall et al., 2017; Scoones et al., 2014). Many papers have pointed to the negative impact of large-scale land acquisitions on the surrounding communities (Bottazzi, et al., 2018; Cotula et al., 2009; Hall, 2011; Matenga and Hichaambwa, 2017; Vermeulen and Cotula, 2010).

Contract farming models could have a positive impact on agricultural development and innovation in developing countries (Abebe et al., 2013; Barrett et al., 2012; Bellemare, 2012; Bellemare and Novak, 2016; Eaton and Shepherd, 2001; Reardon et al., 2009; Singh, 2002). Contract farming creates a system that links smallholder farmers with domestic and international buyers (Barrett et al., 2012). Eaton and Shepherd (2001) define contract farming as an agreement between farmers, processing, and/or marketing firms to produce and supply agricultural products under forward contracting agreements at predetermined prices. Contract farming has been promoted as a more 'inclusive business model' in which local smallholder farmers can participate in and benefit from the wider benefits of investments in rural areas such as infrastructure development (power supply, roads, water supply), spillovers from increased incomes and, in some cases, mandatory development of education and health facilities (Cotula et al., 2009; Deininger et al., 2011; Hall et al., 2017; Lindholm, 2014; Oya, 2012). Contract farming could secure existing local land rights of smallholder farmers by continuing farming on their land, promoting investments by investors and fostering the commercialisation of smallholder farmers (Väth et al., 2019; Von Braun and Meinzen-Dick, 2009).

Indeed, studies have shown that contract farming can help achieve multiple Sustainable Development Goals (SDGs) related to food security, poverty alleviation and biodiversity conservation (Bolwing et al., 2010; Deans et al., 2012; Vabi Vamuloh et al., 2019). Contract farming could enhance local food security (Mishra et al., 2018; Soullier and Moustier, 2018). However, contract farming models do not always have a positive impact (Andriamparany et al., 2021; Meemken and Bellemare, 2020; Olounlade et al., 2020). Sometimes contractors make a profit without supporting or, sometimes, exploiting contracted smallholders (Borras and Franco, 2012; Ruml and Qaim, 2020; Vicol, 2017).

Some of these studies have used non-parametric analysis to estimate the impact of contract farming (Bellemare, 2012; Minot and Sawyer, 2016). Others used econometrics models, such as instrumental variable techniques (Probit-2SLS) to control the endogeneity problem (Mwambi et al., 2016); propensity score matching to adjust for local average treatment effects (Olounlade et al., 2020) and regression analysis (Khan et al., 2019; Väth et al., 2019). In a meta-analysis of 22 case studies, Ton et al. (2017) reviewed the effectiveness of contract farming in low and middle-income countries, finding that most studies analysed the impact of contract farming on household income. Only one study analysed the effects of contract farming on household food security (Bellemare and Novak, 2017).

This paper examined the impact of contract farming in Kenya and Madagascar. These two countries were chosen because they were among the top destinations of LSAIs in Africa, where contract farming has been used to engage smallholder farmers with LSAIs in Africa (Hall et al., 2017). Available studies of contract farming in Kenya and Madagascar have focused on analysing income (Bellemare, 2010; Bellemare, 2012; Burnod et al., 2015; Mwambi et al., 2016; Wainaina et al., 2012); determinants affecting participation in contract farming (Dindi, 2013; Kagwiria and Gichuki, 2017; Kokeyo, 2013) and other socio-economic impacts (Tamura, 2021; Väth et al., 2019; Wainaina et al., 2014) rather than food security. This paper contributes empirical evidence for some of the disputed outcomes of the impact of large-scale agricultural investments through contract farming on household food security. The paper will address the following research questions:

1. What are the determinant factors that affect participation in contract farming?
2. What is the impact of contract farming on household food security in Kenya and Madagascar?

2. DATA AND ANALYTICAL FRAMEWORK

The study used secondary data from Kenya and Madagascar collected by the African Food, Agriculture, Land and Natural Resource Dynamics in the Context of Global Agro-food-energy System Changes (AFGROLAND) project. The data were collected using a semi-structured questionnaire in Kenya and Madagascar conducted in 2017.

2.1. The description of study areas

Kenya has a well-integrated economy with a comparatively mature commercial agriculture sector compared to Madagascar (Oberlack et al., 2021). The agriculture sector in Kenya and Madagascar is dominated by smallholder production. The agriculture sector contributes 51 percent of Kenya's GDP, accounts for 60 percent of employment and 65 percent of exports. In Madagascar, agriculture accounts for 80 percent of employment and 70 percent of the total agricultural production comes from smallholder farmers (World Bank, 2016). Madagascar has a very high poverty rate, with 70 percent of the population living in absolute poverty compared to Kenya. By the end of 2022, 4.3 million hectares had been negotiated for LSAI deals in Kenya and 4.2 million ha in Madagascar (Land Matrix, 2022). As with many other African countries, most rural land in Kenya and Madagascar are under customary law (Alden, 2018; HRW, 2020; USAID, 2020). Only about 30% of Kenya's and 7% of Madagascar's land are titled (Alden, 2018; Teyssier et al., 2010; HRW, 2020).

2.2. Data source and sample size

Kenya and Madagascar were purposively selected by the project team based on the availability of LSAIs. The project used a three-stage stratified sampling technique. In the first stage, one district was selected from each country (Nanyuki from Kenya and Ambatofinandrahana from Madagascar) based on the availability of the contract farming business model. In the second stage, one company was selected from each district based on the development level (10 to 20 years), area of cultivated, the number of households potentially engaged in contract agreements, and the willingness of the company to work with the researchers In the third stage, 797 representative households were randomly selected for interviews from the two areas 500 from Kenya (58 households were engaged with a contract and 442 were non-engaged) and 297 from Madagascar (110 engaged with contract and 187 non-engaged households) (Table 1).

Table 1: Sample size

Country	Number of households interviewed	Households engaged in contract	Non-engaged households
Kenya	500	58	442
Madagascar	297	110	187
Total sample	797	168	629

Contract households were engaged in a contract agreement with the LSAI company, and non-engaged households were not engaged in a contract agreement. Therefore, the dependent variable was a binary variable taking a value of one for engaged in a contract agreement with an LSAI and zero for non-engaged. The company in the Nanyuki area of Kenya produces and exports fresh vegetables. The company has contracted 1700 smallholder farmers to produce flowers (roses) and vegetables (including peas and potatoes). The company provides seeds and fertilisers to contracted farmers at a reduced price and the farmers sell their products to the company at a price set by the company during the signing of the contract. The Malagasy barley out-grower scheme has operated in Ambatofinandrahana for more than 20 years and contracted about 8000 farmers, covering over 2000 ha.

2.3. Characteristics of the sampled households

The characteristics of the sampled households are presented in Table 2. More male-headed households were engaged in contract agreements than non-engaged households. In general, the number of female-headed households in the Kenya sample was higher than in the Madagascar sample. More sampled household heads in Madagascar were married compared to heads in Kenya. Most of the sampled household heads in both countries had attended primary school. On average, contract farming households in Kenya were younger and owned more livestock than other households. In general, contract farming households in Madagascar were larger than in Kenya (Table 2).

On average, more contract farming households in Kenya migrated from the nearby districts into the area. Most non-engaged households in Kenya were less than one-hour walking distance from markets and roads. Almost all contract farming households in Kenya had access to irrigation. In general, Kenyan households had greater access to income such as pensions, remittances and social transfers than the sampled households in Madagascar. Only a few households in both countries had a chance to access new technologies such as improved seeds, storage facilities, marketing facilities, pesticides and different types of machinery. In Kenya, most contract farming households held title deeds, with only ten percent of households reporting holding informal titles. While more than 70 percent of the sampled households in Madagascar held informal land rights (Table 2).

Table 2: Descriptive statistics

Variable		**Kenya**			**Madagascar**		
	Category	Engaged in contract	Non-engaged	Difference	Engaged in contract	Non-engaged	Difference
Sex of the household head (Dummy)	Male	75.44	58.18	0.17**	89.09	81.28	0.09
	Female	24.56	41.82		10.91	18.72	
Marital status of the household head (Dummy)	Married	73.68	64.77	0.09	81.82	80.21	0.02
	Single	26.31	35.23		18.18	19.79	
Education status of the household head (Years)	No school	21.05	21.30	0.05	8.18	9.63	0.07
	Primary	52.63	50.00		69.09	70.05	
	Secondary	26.32	27.32		22.73	19.79	
	College	0.00	1.39		0.00	0.53	
Migration status (Dummy)	Migrant	86.06	16.59	0.03	31.82	36.90	0.05
	Non-migrant	14.04	83.41		68.18	63.10	
Distance from market (minute/hour)	<=30 minute	8.77	15.49	0.61***	0.91	17.65	0.22
	30 min. to 1hr	3.51	51.71		41.82	30.48	
	>= 1 hour	87.72	32.80		57.27	51.87	
Distance from road (minute/hour)	<=30 minute	22.81	48.97	0.76***	26.36	25.53	0.16
	30 min. to 1hr	12.28	36.45		32.73	19.79	
	>= 1 hour	64.91	14.58		40.91	54.55	
Access to irrigation (Dummy)	Yes	100.00	32.65	0.68***	31.82	25.13	0.07
	No	0.00	67.35		68.18	74.87	
Other source of revenue (Dummy)	Yes	87.72	60.87	0.05	0.00	0.53	
	No	12.28	39.13		100.00	99.47	
Access to new technology Dummy)	Yes	14.29	20.69	0.27***	19.09	5.35	0.14
	No	85.71	79.31		80.91	94.65	
Land tenure system (Dummy)	Informal	7.02	8.40	0.20*	70.91	77.54	0.26
	Customary	26.32	17.04		20.91	18.05	
	Titled	66.67	74.55		8.18	3.21	
Continuous variables		**Mean**	**Mean**	**Difference**	**Mean**	**Mean**	**Difference**

Age of the household head (Years)	37.59	44.82	7.22***	44.89	42.79	2.10
Family size (Individuals)	4.49	4.07	0.42	5.75	5.61	0.14
Livestock ownership (TLU)	4.76	2.54	2.21***	1.42	1.04	0.07
Land size (Hectares)	1.03	1.29	0.26	1.07	0.98	0.08
Observations	58	442		110	187	

Note: *p<0.10, ** p<0.05, ***p<0.01

2.4. Characteristics of the sampled households

Food security is multidimensional and there is no single indicator that measures all dimensions (Hendriks et al., 2016). Therefore, this study used three internationally recognised food security indicators: household dietary diversity score (HDDS), food consumption score (FCS) and the months of adequate household food provisioning (MAHFP).

The household dietary diversity score (HDDS) measured the diet quality and quantity, capturing the number of food groups consumed in the last 24 hours (Cheteni et al., 2020; FANTA, 2006, Hendriks et al., 2016; Hirvonen et al., 2016; IFPRI, 2006; Mekonnen, 2017). The HDDS was typically significantly correlated with caloric adequacy measures. The FCS considered dietary diversity, food frequency and the relative nutritional importance of food groups (Hendriks et al., 2016; Marivoet et al., 2019; Leroy, 2015; WFP, 2008). The FCS measured the sum of the frequency of consumption of food groups during the previous seven days and then weighted by a coefficient. The MAHFP measured household food access and availability above the minimal level of the year. The indicator was the sum of the months of adequate provision (Africare, 2007; Bilinsky and Swindale, 2010; Lopera et al., 2019).

2.5. Methods of data analysis

The household dietary diversity score (HDDS) measured the diet quality and quantity, capturing the number of food groups consumed in the last 24 hours (Cheteni et al., 2020; FANTA, 2006, Hendriks et al., 2016; Hirvonen et al., 2016; IFPRI, 2006; Mekonnen, 2017). The HDDS was typically significantly correlated with caloric adequacy measures. The FCS considered dietary diversity, food frequency and the relative nutritional importance of food groups (Hendriks et al., 2016; Marivoet et al., 2019; Leroy, 2015; WFP, 2008). The FCS measured the sum of the frequency of consumption of food groups during the previous seven days and then weighted by a coefficient. The MAHFP measured household food access and availability above the minimal level of the year. The indicator was the sum of the months of adequate provision (Africare, 2007; Bilinsky and Swindale, 2010; Lopera et al., 2019).

This study used an endogenous switching regression (ESR) model to estimate the impact of contract farming on household food security. Lee (1982) developed the ESR model to generalise 'Heckman's selection correction approach (Lokshin and Sajaia, 2004). ESR accounts to address both unobserved factors and self-selection problems (Dutoit, 2007; Heckman, 1979).

An ESR consists of two stages (Kabunga *et al*., 2012; Kassie, 2014; Lokshin, 1977; Malikov and Sun, 2018). In the first stage, a probit model was used to identify the socio-economic factors that determined household participation in contract farming. We estimated the selection equation as follows (Di Falco *et al*., 2011):

$$Z_i^* = a + \gamma Q_i + \varepsilon_i \tag{1}$$

Where Z_i* was a binary variable that takes the value one if the household was engaged in contract agreement with LSAI and zero otherwise; *a* was an intercept; Q*i* was a vector of exogenous variables influencing the participation decision; γ was a vector of coefficient and ε_i was the disturbance term with zero mean and a constant variance.

The binary outcomes (the food security status of the households) conditional on being contracted in LSAIs were represented as switching regimes as follows:

Regime 1: $Y_{1i} = X_{1i}\beta_1 + \sigma_{1\varepsilon}\lambda_{1i} + u_{1i}$ If $A_i = 1$ for contract farming households (2)

Regime 2: $Y_{2i} = X_{2i}\beta_2 + \sigma_{2\varepsilon}\lambda_{2i} + u_{2i}$ If $A_i = 0$ for non-engaged households (3)

Where Y_i represented the outcomes variables (food security indicators) of household i for each regime (1 = for contract and 0 = non-engaged); X_i was a vector of determinant variables that affect household food security status. The variables in vectors X in equations (2) and (3) may overlap with Q in equation (1), but it required that at least one variable in Q that does not appear in X. β and σ were parameters to be estimated, and u_{1i} and u_{2i} were an independently and identically distributed error term of the food security estimation equation.

The three error terms ε_i, u_{1i} and u_{2i} are assumed to follow a trivariate normal distribution with zero mean vector and covariance matrix defined as (Lokshin and Sajaia, 2004):

$$\Omega = \begin{bmatrix} \sigma_1^2 & \sigma_1\sigma_2 & \rho_{1e}\sigma_1 \\ \sigma_1\sigma_2 & \sigma_2^2 & \rho_{2e}\sigma_1 \\ \rho_{1e}\sigma_1 & \rho_{2e}\sigma_2 & \sigma_\varepsilon^2 \end{bmatrix} \tag{4}$$

The covariance between the error terms of the selection equation and outcome equation was denoted by (cov (ε, u) = ρ). Where ρ_{1e} and ρ_{2e} were the correlation coefficients between u_{1i} and ε_i and between u_{2i} and ε_i respectively.

The average treatment effect was represented by Y_i (HDD, FCS and MAHFP) as shown in equations (5) – (8). The equations for the expected conditional and average treatment effects of contract farming and non-engaged groups were given as:

The equation for contract farming (engaged) in an LSAI:

$$E[Y_{1i}/X, \ A_i = 1] = \alpha_1 + X_{1i}\beta_1 + \rho_{1i}\sigma_{1\varepsilon}\lambda_{1i} \quad \text{..........} \quad (5)$$

The equation for contract farming, they decided not to engage in a contract in an LSAI:

$$E[Y_{2i}/X, \ A_i = 1] = \alpha_2 + X_{2i}\beta_2 + \rho_{2i}\sigma_{2\varepsilon}\lambda_{2i} \quad \text{..........} \quad (6)$$

The equation for non-engaged, they decided to engage with contract agreement in an LSAI:

$$E[Y_{1i}/X, \ A_i = 0] = \alpha_1 + X_{1i}\beta_1 + \rho_{1i}\sigma_{1\varepsilon}\lambda_{1i} \quad \text{..........} \quad (7)$$

The equation for non-engaged, which did not engage in contract agreement with LSAI:

$$E[Y_{2i}/X, \ A_i = 0] = \alpha_2 + X_{2i}\beta_2 + \rho_{2i}\sigma_{2\varepsilon}\lambda_{2i} \quad \text{..........} \quad (8)$$

The expected change in the level of food security for contracted households (the average treatment effect of treated households or ATT) was given as:

ATT = (a) – (b)

$$= E[Y_{1i}/X, A_i = 1] - E[Y_{2i}/X, A_i = 1] \quad \text{..........} \quad (9)$$

$$= X_{1i}(\beta_1 - \beta_2) + \lambda_{1i}(\sigma_{1\varepsilon} - \sigma_{2\varepsilon}) \quad \text{..........} \quad (10)$$

Similarly, we estimated the expected change on non-engaged households as, the average treatment effect on the untreated households (ATU) given as:

ATU = (c) – (d)

$$= E[Y_{1i}/X, A_i = 0] - E[Y_{2i}/X, A_i = 0] \quad \text{..........} \quad (11)$$

$$= X_{2i}(\beta_1 - \beta_2) + \lambda_{2i}(\sigma_{1\varepsilon} - \sigma_{2\varepsilon}) \quad \text{..........} \quad (12)$$

3. RESULTS AND DISCUSSION

This section presents and discusses the findings of the study in two sections. The determinant factors of contract farming in the first section and the ESR results in the second section shows the impact of being contracted in an LSAI on household food security.

3.1. Determinants of participation in contract farming

The results of the selection model (first stage ESR) of the two countries presented in the second column of Table 3 and 4, which estimated the household determinant factors to engage in a LSAI contract farming agreement. Out of 14 explanatory variables, the sex of the household head, distance from a road and distance from a market were the common determinant factors of participation in contract farming in the two countries. Besides this, there were four additional determinant factors of contract farming with the LSAI in Kenya (age and marital status of the household head, livestock ownership and access to new technology). In Madagascar, three additional determinant factors include land size, access to new technology and the land tenure system (Table 3).

Table 3: Kenya endogenous switching regression estimation of outcomes variables

Variables	Selection	HDDS		FCS		MAHFP	
		Contract	Non-engaged	Contract	Non-engaged	Contract	Non-engaged
Sex of the household head	0.326* (0.193)	-0.498 (0.465)	0.091 (0.143)	-7.251 (5.229)	-2.219 (1.611)	-0.284 (0.842)	-0.412** (0.217)
Age of the household head	-0.019*** (0.006)	-0.038** (0.015)	-0.004 (0.004)	-0.584*** (0.172)	-0.071 (0.043)	-0.049 (0.031)	-0.003 (0.006)
Household size	0.040 (0.058)	-0.175 (0.155)	0.091*** (0.034)	-3.091 (1.812)	0.201 (0.417)	-0.261 (0.260)	-0.082 (0.056)
Education status of the head	-0.008 (0.135)	0.317 (0.269)	0.317*** (0.089)	0.164 (3.272)	2.751** (1.089)	0.223 (0.503)	0.321** (0.146)
Marital status of the head	-0.489** (0.232)	-1.033** (0.478)	-0.125 (0.145)	-1.934** (5.411)	-5.206*** (1.782)	-2.269 (1.055)	-0.615** (0.269)
Livestock owned (TLU)	0.065** (0.031)	-0.029 (0.035)	0.094*** (0.027)	-0.241 (0.399)	1.489*** (0.352)	-0.004 (0.061)	0.175*** (0.045)
Land size	-0.1555 (0.105)	0.577* (0.305)	0.045 (0.042)	0.057** (3.439)	1.238** (0.517)	0.766 (0.537)	0.077 (0.069)
Distance to market	0.652*** (0.152)	1.039** (0.439)	-0.102 (0.096)	6.372 (4.937)	-3.478*** (1.176)	-0.693 (0.618)	-0.199 (0.149)
Distance to road	0.526*** (0.115)	-0.231 (0.279)	-0.062 (0.092)	-2.268 (3.128)	3.521*** (1.121)	-0.123 (0.201)	-0.261 (0.026)
Other source of revenue	0.217 (0.252)	0.116 (0.526)	0.031 (0.162)	6.847 (5.925)	-0.839 (1.973)	0.477 (1.038)	0.031 (0.264)
Migration status	-0.178 (0.244)	0.954** (0.415)	0.084 (0.164)	0.729 (4.673)	4.154** (1.548)	-0.513 (1.050)	0.105 (0.269)
Location dummy	0.069 (0.187)	-0.161 (0.454)	0.064 (0.126)	1.798 (5.297)	0.455 (1.542)	-0.476 (0.749)	0.127 (0.207)
Access to new technology	0.800*** (0.185)						
Land tenure system	-0.096* (0.047)						
σ_i		0.393* (0.220)	0.267*** (0.054)	2.805*** (0.214)	2.766*** (0.043)	2.439*** (0.354)	2.062*** (0.073)
ρ_i		0.680 (0.470)	-0.567* (0.329)	0.659 (0.469)	-0.324 (0.262)	0.309 (0.407)	-0.076 (0.468)
Log likelihood		-897.09		-2027.64		-1237.23	
Wald $\chi 2$		43.08***		52.93***		38.40***	
LR test of independent equations $\chi 2$		3.75		2.95		0.41	
Observations	500	58	442	58	442	58	442

Note: σ_i- sigma; ρ_i - correlation coefficients (rho); *p<0.10, ** p<0.05, ***p<0.01

The positive coefficient of the sex of the household head indicated that the probability of engaged in a contract with an LSAI was higher for male-headed households than female-headed households.

The negative coefficient for the age of the household head, marital status of the household head and land size showed that older, married household heads with larger land sizes were less likely to engage in contract agreement with an LSAI. Whereas holding livestock was a positive coefficient, the more livestock the household had, the higher the probability to engage in a contract agreement with an LSAI. Distance from a market and a road were other determinants factors.

The positive coefficient for distance from a market and road showed that the probability of engaging in a contract in an LSAI was higher for further away households from a market and road (Table 3). The estimated results of the second stage ESR model results of Kenya and Madagascar are presented in Tables 3 and 4. A selection bias was detected and represented by the significant correlation coefficients of the selection equations in Tables 3 and 4. The statistically significant coefficients for access to new technology and land tenure system in the selection equation indicated that the selected instruments were relevant and affected household participation decisions.

The significant results of the likelihood ratio test (χ^2), the sigma (σ_i) and correlation coefficients (ρi) implied the presence of self-selection problems and the model specification controlled for this inferred endogeneity. The finding implied that contract farming might not have had the same impact if non-engaged households decided to engage in a contract agreement with an LSAI. The negative and statistically significant correlation coefficient of contract farming households (ρie) of FCS and MAHFP in Madagascar indicated the existence of positive selection bias (Table 4). This showed that more food secure households were, more likely they would engage in a LSAI contract. While in Kenya, the correlation coefficient (ρie) of all three food security indicators were not statistically significant (Table 3).

Table 4: Madagascar endogenous switching regression estimation of outcomes variables

Variables		**HDDS**		**FCS**		**MAHFP**	
	Selection	*Contract*	*Non-engaged*	*Contract*	*Non-engaged*	*Contract*	*Non-engaged*
Sex of the household head	0.613* (0.327)	-1.997*** (0.705)	0.598 (0.432)	0.936 (4.637)	-1.336 (2.704)	-0.929 (0.744)	-0.215 (0.557)
Age of the household head	0.002 (0.006)	0.002 (0.013)	0.008 (0.009)	0.188** (0.087)	0.041 (0.054)	-0.008 (0.014)	0.013 (0.011)
Household size	0.009 (0.035)	0.058 (0.066)	-0.061 (0.053)	0.132 (0.447)	-0.713** (0.334)	0.076 (0.069)	-0.102 (0.069)
Education status of the head	0.041 (0.090)	0.064 (0.172)	-0.009 (0.129)	1.677 (1.186)	0.958 (0.812)	-0.447 (0.195)	0.246 (0.169)
Marital status of the head	0.152 (0.194)	-0.798** (0.360)	-0.214 (0.292)	0.624 (2.402)	-0.055 (1.834)	0.325 (0.410)	-0.352 (0.375)
Livestock owned (TLU)	0.042 (0.037)	0.065 (0.084)	0.048 (0.053)	0.618 (0.568)	1.404*** (0.334)	0.142 (0.094)	0.157 (0.067)
Land size	-0.034** (0.059)	0.424*** (0.149)	0.291*** (0.089)	2.184** (0.973)	1.973*** (0.515)	0.412 (0.156)	0.069 (0.106)

Distance to market	0.436*** (0.132)	0.161 (0.352)	-0.472*** (0.149)	-1.576 (2.482)	-2.201** (0.951)	-0.209 (0.400)	-0.222 (0.197)
Distance to road	-0.199* (0.114)	-0.033 (0.248)	0.297* (0.155)	0.071 (1.743)	-0.044 (0.990)	-0.694 (0.287)	0.271 (0.205)
Other source of revenue	-0.901 (0.263)	-0.303 (0.418)	0.659** (0.309)	2.248 (2.887)	4.144** (1.971)	0.262 (0.488)	1.401 (0.409)
Migration status	-0.059 (0.154)	0.268 (0.309)	0.423* (0.225)	3.471 (2.117)	1.680 (1.364)	0.586 (0.364)	0.452 (0.283)
Location dummy	0.170 (0.168)	-0.345 (0.334)	0.063 (0.242)	-2.031 (2.323)	0.589 (1.501)	0.053 (0.378)	-0.016 (0.310)
Access to new technology	0.588*** (0.189)						
Land tenure system	0.143* (0.076)						
σ_i		0.805*** (0.125)	0.727*** (0.075)	2.427*** (0.099)	2.249*** (0.054)	1.043*** (0.131)	0.699*** (0.074)
ρ_i		-1.301 (0.286)	1.418*** (0.231)	-0.473* (0.253)	-0.078 (0.404)	-1.666*** (0.402)	-0.304 (0.334)
Log likelihood		-738.84		-1288.29		-799.57	
Wald $\chi 2$		47.56***		60.30***		32.27***	
LR test of independent equations $\chi 2$		19.32***		2.75		9.62***	
Observations	297	110	187	110	187	110	187

Note: σ_i- sigma; ρ_i - correlation coefficients (rho); * p<0.10, ** p<0.05, ***p<0.01

3.2. Impact of contract farming on food security

The expected values of the observed and unobserved scenarios of the three food security indicators are presented in Table 5. The ESR results of the three food security indicators (HDDS, FCS and MHAFP) in Kenya were statistically different from zero. On average, the HDDS of contract farming households increased from 6.23 to 8.16 in Kenya and decreased from 8.72 to 5.96 in Madagascar. If the household contracted in an LSAI decided not to be contracted, the HDDS decreased by 1.93 points in Kenya and increased by 2.76 points in Madagascar. In the non-engaged scenario, the HDDS were 7.29 in Kenya and 5.87 in Madagascar. If non-engaged households decided to be engaged in a contract farming agreement with an LSAI, the HDDS of the household would decrease from 7.29 to 6.72 in Kenya and increase from 5.87 to 9.06 in Madagascar (Table 5).

The FCS result showed that a LSAI contract agreement increased FCS from 69.86 to 82.28 in Kenya. However, a LSAI contract agreement was not statistically significantly different in Madagascar's FCS of households. If non-engaged households decided to engage in an LSAI contract farming, the FCS decreased by 4.52 points in Kenya and increased by 7.34 points in Madagascar (Table 5).

On average, households had access to food for almost ten months of the year in Kenya and more than six months in Madagascar. This indicated that, on average, Kenyan households had better food access than in Madagascar. Contract farming households enjoyed adequate food for 10.33 months in Kenya and 8.18 months in Madagascar. If contract farming households decided not to be engaged in an LSAI contract, the household's access to food decreased by 0.49 points in Kenya 1.21 points in Madagascar. If non-engaged households decided to be engaged in an LSAI contract, household food access decreased from 9.93 to 9.24 in Kenya and increased from 7.85 to 12.29 in Madagascar (Table 5).

The signs of base heterogeneity and transitional heterogeneity for all food security indicators (HDDS, FCS and MAHFP) in Kenya were positive, indicating that households engaged in LSAI contract farming were more food secure than non-engaged households. Whereas in Madagascar, the base heterogeneity and transitional heterogeneity for all food security indicators were negative, implying that the impact of contract farming on household food security would be higher for non-engaged households if they decided to be engaged in LSAI contract farming (Table 5).

Table 5: Endogenous switching regression treatment effects

Outcome variables	Household type and contract farming effects	Kenya			Madagascar		
		Decision stage			Decision stage		
		To engage	Not to engage	ATE	To engage	Not to engage	ATE
HDDS	Contract farming (ATT)	8.16	6.23	1.93***	5.96	8.72	-2.76***
	Non-engaged (ATU)	6.72	7.29	-0.56***	9.06	5.87	3.19***
	Heterogeneous effects	1.44	-1.06	2.49	-3.10	2.85	-5.95
FCS	Contract farming (ATT)	82.28	69.86	12.41***	38.91	38.01	0.89
	Non-engaged (ATU)	70.82	75.34	-4.52***	46.12	38.78	7.34***
	Heterogeneous effects	11.46	-5.48	16.93	-7.21	-0.77	-6.45
MAHFP	Contract farming (ATT)	10.33	9.84	0.49**	8.18	6.97	1.21***
	Non-engaged (ATU)	9.24	9.93	-0.69***	12.29	7.85	4.44***
	Heterogeneous effects	1.09	-0.09	1.18	-4.11	-0.88	-3.23

Note: ATE- average treatment effect; ATT- average treatment effect for treated; ATU-average treatment effect for untreated; ** p<0.05, ***p<0.01

The average treatment effects on treated (ATT), which indicated the impact of contract farming on contracted households are presented in Table 6. The positive sign of the ATT for the three food security indicators (HDDS, FCS and MAHFP) in Kenya indicated that households engaged in an LSAI contract had better food security than non-engaged households. This finding concurred with other studies that showed that contract farming improved household food security (Bellemare and Novak, 2017; Ton et al., 2017). While only the MAHFP had positive and statistically significant ATT in Madagascar, the ATT for FCS was positive but not statistically significant, showing that contract farming did not impact on the food security of contract households in Madagascar. The negative sign of the ATT for HDDS in Madagascar implied that households engaged in a contract agreement with an LSAI consumed less diversified food than non-engaged households (Table 6). This finding agreed with Andriamparany et al.

(2021), which found that contract farming did not improve the food security status of vanilla farmers in Madagascar.

This difference between the findings for the two countries might be because contract farming households in Kenya produced vegetables for an LSAI that helped diversify their diets. However, in Madagascar, contract farming households produced barley. Madagascar's staple food is rice. Contract farming that produces non-food crops for export markets, increases productivity and income may not improve local food security (Williams et al., 2021).

Table 6: Comparing results of Average treatment effects for treated (ATT)

Outcome variables	Country ATT	
	Kenya	Madagascar
Household dietary diversity score (HDDS)	1.93***	-2.76***
Food consumption score (FCS)	12.41***	0.89
Month of adequate household food provision (MAHFP)	0.49**	1.21***

Note: ATT- average treatment effect for treated; ** $p<0.05$, *** $p<0.01$

4. CONCLUSIONS

This study examined the impact of contract farming on household food security in Kenya and Madagascar. Overall, the three food security indicator results (FCS, HDDS and MAHFP) in Kenya and the MAHFP in Madagascar confirmed that households engaged in LSAI contract farming were more food secure than non-engaged households. However, contract farming households in Madagascar were less food secure than non-engaged households for two food security indicators (FCS and HDDS). The findings of the study confirmed that contract farming models do not always have a positive impact on household food security due to the differences between Kenya and Madagascar; the effect may be location and context specific. Kenyan households were more food secure even without engaging in contract agreements and had better access to production resources such as access to irrigation. The type of crop and its commercial value could also play a role in determining household food security.

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