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The Dynamics and Role of Gender in High-Value Avocado Farming in Kenya

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Abstract

We used two-waves panel data obtained from avocado growers in Murang'a County in Kenya to examine, through the perspective of gender, the dynamics of farmers' participation in avocado production and marketing organizations (PMOs), and test whether understanding group dynamics is important for analyzing contract farming. Using a multinomial logit model, we identify the characteristics of men and women participation in PMOs categorized as early adopters, dis-adopters, late adopters, and non-adopters. We focus on dis-adopters and late adopters because these categories are most often ignored in the literature. Moreover, without considering the dynamics, we verify the influencing factors of PMOs by estimating a random-effects logit model that controls for unobserved heterogeneity across households. Furthermore, we estimate a sequential-choice model to test whether the process of selection into group membership affects the process of selection into contracting. Our results reveal heterogeneity with regard to household, farm, and resource characteristics across categories of farmers and between gender groups. Moreover, the results reveal that group and contracting dynamics are related, and ignoring the former leads to biased estimates of the determinants of contracting dynamics. Policy efforts should focus on supporting women farmers to enhance their participation in PMOs, which ultimately has an effect on contracting. Improving access to high-yielding avocado varieties and building capacity in orchard management would enhance women's decision-making including group participation, contracting, and marketing. Low-cost agricultural credit may also improve women's ownership of improved avocado trees and hence their participation in high-value markets. These efforts are equally important for men who farm avocados.

Keywords: Contract farming, group membership, avocado, dynamics, gender, Kenya

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I. Introduction

Progressively lower productivity, unpredictable climate variations, and the lack of markets, especially in rural settings, have led to increasing concern about the food security of smallholder farmers in sub-Saharan Africa (Boko et al., 2007). Because of the remarkable growth in recent years, high-value horticultural farming, has been identified as one of the fastest-growing agricultural sub-sectors and, as a result, is a possible driver of economic growth, development, and poverty reduction, especially among low-income smallholder households (Henson & Jaffee, 2008; Barrett et al., 2012). Innovative farming strategies have been devised to increase gains from the high-value markets, link smallholder farmers to markets, make markets work for the poor (Njuki et al., 2011; Gramzow et al., 2018).

Such strategies have included organizing farmers into groups, associations, or cooperatives; contract farming and out-grower schemes; training on good agricultural practices; and providing market information, among others. Although studies have clearly documented the benefits of such approaches (Barrett et al., 2012), the participation of smallholders in the global market has recently declined (Muriithi & Matz, 2014). The factors that drive smallholders out of high-value markets are not entirely clear. The conventional belief is that constraints to participation include limited access to market information, lack of credit, stringent market requirements, aversion to risk, and lack of an organized marketing and transportation infrastructure.

One of the challenges to understanding the drivers of farmers' participation in high-value markets has been the lack of household-level longitudinal data, which is often the result of limited resources for data collection. With the help of panel data obtained from a sample of avocado-growing households in Murang'a County in Kenya, we contribute to the limited literature on the dynamics of smallholder participation in high-value markets. We used baseline information from sample households to describe them at the time they were surveyed, thus controlling for the endogeneity that arises from household self-selection, which might include shifting from one market-participation decision to another. Subsequently, we incorporated the time span between adoption and abandonment. Our analysis also incorporated the question of gender, with the understanding that men and women participate differently in production and markets (Symes, 1991), an aspect that is often ignored in agricultural studies.

We focused on two aspects of participation: 1) production and marketing organizations (hereafter, PMOs) and 2) farmer group membership and contract farming. Originally produced mainly for home consumption, the avocado crop is referred to as "green gold" in Kenya, and has overtaken traditional cash crops such as coffee and tea, whose profitability has declined over time. The fruit ranks fourth among the economically important fruits in the country, after banana, mangoes, and pineapples (Horticultural Crops Directorate, 2017). Among fruit exports, avocados rank highest, contributing about 5.4 billion Kenyan shillings in 2017 and accounting for 74% of fruit exports by value (Horticultural Crops Directorate, 2017).

Contract farming (sometimes referred to as out-grower schemes) is a longstanding farming practice in developing countries. In Kenya, contract farming schemes date to the colonial period (Minot & Ngigi, 2004). The practice can be defined simply as agricultural production carried out according to a prior agreement between a farmer and a buyer (Minot, 2011). For farmers to participate in such contractual arrangements, they must be organized in special interest groups (Ashraf, Giné & Karlan, 2009). Such associations have been particularly important in increasing market share among smallholder horticultural farmers, especially in export markets (Barrett et al., 2012). Collective action enables pooling volumes of product to attain economies of scale and to joint investment in facilities needed to meet the good agricultural practices and safety standards that most exporters require. The schemes may provide inputs and production services, open new markets, provide new technology, reduce transactional costs, and, as a result of these, raise income (Bolwig, Gibbon & Jones, 2009; Little & Watts, 1994; Maertens, Minten & Jo, 2009; Warning & Key, 2002).

Conversely, contract farming may exclude disadvantaged groups, mainly the poor, women, youth, and those with very little or no land at all. High rates of failure for contract farming are evident in Kenya as schemes collapse and new ones are launched (Ashraf, Giné & Karlan, 2009; Minot & Ngigi, 2004). The main challenges to success include lack of enforcement of contract agreements, which contributes to side-selling and strategic default on credit advanced to farmers; price default by buyers; high transaction costs of dealing with a large number of small, dispersed farmers; and a limited number of commodities and markets (Kirsten & Sartorius, 2002; Minot, 2011; Sartorius & Kirsten, 2004; Sartorius & Kirsten, 2005). The design of sustainable PMOs and contract-farming schemes requires an understanding of the dynamics of farmers' participation through the use of longitudinal data, which are limited in the literature. We address this knowledge gap. In addition, understanding gender dynamics, which we explore in this study, is important in sustaining social networks such as PMOs (Njuki et al., 2011; Fischer & Qaim, 2012).

The contribution of this paper to the existing literature is threefold: first, we estimate the determinants of group membership dynamics (early adopter, late adopter, discarder dis-adopter (joins and leaves), or non-adopter (decides not to join). Second, while most past studies estimated contract farming as an independent variable, based on the premise that smallholder farmers can only be contracted as a group, we viewed contract farming as conditional on group membership by designing a sequential-choice model based on a bivariate probit framework in which a farmer first chooses whether to join a group or not, then decides whether or not to enter into a contract. The unobserved factors that affect group non-adoption may be correlated with unobserved factors affecting contract non-adoption. Consequently, if the decisions were somehow correlated, ignoring group membership when analyzing contracting would lead to inconsistent estimates. Third, we tested whether gender matters in smallholder participation in high-value avocado chains. Success in agricultural development is greatly influenced by differences in roles between men and women, and greater gender equality can improve productivity and enhance sustainable development. Further, men's appropriation of women's spheres of influence and activity may negatively impact the adoption of agricultural innovations (Dolan, 2001).

Our results showed heterogeneity with respect to farm and farmer characteristics across categories of PMOs. For instance, the gender-specific analysis showed that, among women-headed households (WHHs), early adopters were more educated, but had fewer Hass avocado trees (the Hass is a cultivar of avocado) and were more credit-constrained compared to dis-adopters. The results of the sequential-decision model revealed that group and contracting dynamics were related and suggested that ignoring the former would lead to biased estimates. Gender of the head of household has an impact on the group-membership-participation decisions as shown by the random-effects model estimation; gender is, thus, indirectly important for contracting. These findings have important implications for the participation of smallholders and especially women in high-value avocado chains and thus for inclusive development.

The remainder of the paper is organized into six sections. Section 2 highlights the literature on gender and smallholder participation in high-value markets. Section 3 describes the data and presents descriptive statistics. The estimation strategy is provided in Section 4, and empirical results and discussion appear in Section 5. Section 6 concludes.

II. Literature Review

2.1 Gender and Participation in High-Value Horticultural Farming

Early literature on contract farming suggested that women were contracted by firms to supply vegetables. Commercial farming was thus integrated into existing farming activities without disrupting women's participation in other food-production activities (Little & Watts, 1994). Thereafter, however, firms' preferences shifted to contracts with men in commercial farming or with large export growers, excluding women (see, e.g., von Bülow & Sorensen, 1993). The result was a widening gap between resources controlled by men vs. those controlled by women.

The International Finance Corporation (2013, p. 102) has concurred that women are marginalized in many aspects of farming because men are formal landowners, making it difficult for women to have access to financing and other resources as well as to participate in certification schemes. As the result of such constraints, women are either excluded or participate solely at the lower end of export value chains (Baden, 1998; Chan, 2010; Dolan & Sorby, 2003; Dolan & Sutherland, 2002; Mwambi et al., 2016; Oduol, Mithöfer & Place, 2014; Will, 2015; Porter & Phillips-Howard, 1997; and Temu & Temu, 2005). The absence of women in contract farming in Africa and Asia is evident, for example, fruit and vegetable export value chains in Kenya (Dolan, 2001), large contract schemes in China (Eaton & Shepherd, 2001), export vegetables production in Senegal

(Maertens & Swinnen, 2009; Maertens & Swinnen, 2012). Moreover, even where women participate as much as men in contract schemes, they have much less control over the benefits than do men in the same position (Bolwig, 2012; Dolan, 2001). Most of the above studies, observe registration in a farmer's group as a prerequisite for contract agreement, which unfortunately constrains women as they have less access to productive resources than men.

Some studies carried out in the last two decades, however, have documented increased participation in aspects of contract farming in some countries, including a steady increase in the number of women registered in out-grower schemes. Strohm and Hoeffler (2006) found that 80% of those contracted by French bean trading companies in Kenya were women. Studies in Zimbabwe also showed that a higher number of women were involved in contract farming (Schneider & Gugerty, 2010), including providing labor services such as sorting the harvest. The wages for work done by women are, however, often lower than those that men receive (Dancer & Sulle, 2015; Lavers, 2012), which is mainly the result of gender stereotypes.

Some constraints, including lack of capital, credit, and information, or lack of access to land, have kept women from cash-crop farming and in essence, contract farming (Dube & Mugwagwa, 2017; Kirui & Njiraini, 2013; and Maertens & Swinnen, 2012). Lower access to extension services, lower outcomes in terms of food security and food production are important determinants in accessing contracts (Navarra, 2017). Maertens & Swinnen (2012) argued that, if women were included in production or labor contracts in the modern value chain, they were highly disadvantaged as a result of their lower levels of education and general lack of skills. They asserted that men in contract farming might rely heavily on women's labor to produce high-value crops, thus increasing women's work intensity, especially in areas in which labor was divided by gender.

2.2 Factors Influencing Sustainable Smallholder High-Value Horticultural Farming

Smallholder participation in high-value horticultural farming has widely been researched (Barrett, 2008; Barrett et al., 2012; Muriithi & Matz, 2014). This literature has focused on low-input market participation systems adopted by small, resource-constrained producers who farm marginal lands. Most of the work thus far has addressed the pattern of adoption (or failure to adopt) by smallholders in high-value horticultural farming, including contract farming and group membership. Others have focused on the adoption and abandonment of agriculture technologies for food and cash crops. The findings vary depending on the type of technologies under consideration, methodological approaches, and region of focus.

Studies suggest that factors influencing the adoption of technologies, farmer group associations, and contract farming may differ from those influencing abandonment of the same. Several studies have documented a positive effect of the level of literacy, education, and experience on participation in PMOs and contract farming of horticultural produce in Kenya (Ashraf, Giné & Karlan, 2009; Barrett et al., 2012; Muriithi & Matz, 2014), and between age and level of market participation (Heltberg & Tarp, 2002; Key et al., 2000; Muriithi & Matz, 2014). More widely considered have been the farm and household resources that influence smallholder participation in high-value markets. For instance, farmers with bigger farm sizes and other assets are more likely to participate in market (Barrett, 2008; Mather, Boughton, & Jayne, 2013; Muriithi & Matz, 2014; Olwande et al., 2015; Amare et al., 2019). Risk of export markets, lack of trust, resource, and infrastructure constraints have also been found to be key factors hindering small farmers from adopting and marketing export crops (Ashraf, Giné & Karlan, 2009). Market risks and other exogenous shocks, as well as the violation of contracts also adversely impact participation in PMOs and contract farming (Ashraf, Giné & Karlan, 2009; Barrett et al., 2012).

Studies from other countries in Africa support findings from Kenya. In their analysis of adoption and abandonment of hand-hoe and oxen-drawn minimum tillage in Zambia, Grabowski et al. (2016) found that increased labor and investment costs limited adoption of technology. In addition, they found that agro-ecological conditions, availability of extension/farmer training, and livelihood strategies influenced adoption and abandonment decisions. Lambrecht et al. (2014) found interesting dynamics of adoption and abandonment between young and inexperienced farmers and older and more experienced farmers in Congo, with the former more likely to try out new technologies but to drop them soon after in comparison to the latter. Simtowe, Asfaw, and Abate (2016), in a study of Malawi, found that access to financial markets and credit to purchase improved seeds, as well as access to extension services, were important factors for the adoption of modern agricultural technologies, particularly for women. Other constraints to contract farming include financial constraints, poor infrastructure, lack of up-to-date market information, and difficulty in accessing technical advisory services and agricultural inputs (Minot & Sawyer, 2016; Minot & Ronchi, 2014).

Similar findings have also been documented beyond Africa. Bravo-Ureta, Cocchi, and Solís (2006), in a study of farmers who abandoned conservation technologies in El Salvador, found that off-farm income, education, the frequency of extension visits, access to markets, infrastructure, farmer experience, and participation in social organizations affected the abandonment of conservation technologies. In the same way, Läpple (2010), in a study in Ireland, showed that farmer experience, social learning, and environmental and risk attitudes influenced the adoption of organic farming, while economic and structural factors, such as off-farm activities, influenced abandonment. Romero, Dey, and Fisher (2014) found that past farming experience and family ties influenced participation of smallholders in high-value export chains, while negative external (market) shocks were a major threat to the sustainable participation of smallholder farmers in Ecuador.

Walton et al. (2008), in a study of the southeastern United States, found that age of the farmer, land ownership, and use of computers favored the adoption of "precision soil sampling," and the amount of land cultivated and livestock ownership motivated abandonment. These findings were supported by An (2013), who found that age, education, experience, and farm characteristics in the U.S. favored the abandonment of dairy technologies, while large herd size was negatively correlated with the intensity of adoption of dairy technologies. These findings supported earlier findings on the adoption and abandonment of dairy technologies in the U.S. (Foltz & Chang, 2002).

Neill and Lee (2001), in a study of Northern Honduras, found that the initial adoption of cover-crop technologies was determined by agronomic characteristics, economic factors, knowledge and experience, land tenure, and farm size, while the abandonment of the technologies was associated with infrastructure, off-farm activities, and increased demand for labor input for weeding. Diederen et al. (2003), in a study of the decisions of Dutch farmers to be innovators, early adopters, or laggards (same as late adopters), found that farm size, market position, solvency, and age of the farmer explained adoption and non-adoption of agricultural innovations. Early adopters were found to have structural characteristics that were similar to those of innovators but differed in such behavioral characteristics as the use of external sources of information.

The literature reviewed in this section suggests that factors that influence the adoption of technologies, including participation in modern farming networks, differ from those that influence abandonment. Although the literature suggests that early adopters are wealthier, have larger social networks, and enjoy better access to information through media outlets, all individuals may be equally likely to adopt an innovation early. Subsequent transmission, however, may depend upon characteristics of initial adopters (Henrich, 2001).

Our work, conversely, focuses on the adoption and abandonment of high-value avocado chains and participation in groups. In addition, while most studies have analyzed participation in contract farming as an independent decision, they have agreed that most smallholders are contracted as a group and not as individuals. We go further than previous studies by estimating the factors that influence contract farming, factoring in membership in an avocado-farming association.

III. Data and Descriptive Statistics

3.1 Study Area and Data Collection

The data used for this study were collected by the Partnership for Economic Policy (PEP), in collaboration with the VU-University of Amsterdam and Amsterdam Institute for International Development (AIID); the University of Nairobi; the Fresh Produce and Exporters Association of Kenya (FPEAK); and PRIME-ITC (coordinated by LEI Wageningen UR). The baseline survey was carried out in November-December 2015, followed by an end-line household survey in July 2017. The baseline covered 790 farming households, but only 714 were interviewed in the end line.

Data were collected from Kandara Sub-County, one of the eight sub-counties within Murang'a County in Central Kenya. Murang'a County is Kenya's leading avocado producer, and Kandara, as its highest-producing sub-county, has become a hub of avocado production and trade. Avocado production (both volume and exports) has expanded substantially since 2005 (Horticultural Crops Directorate, 2017) and therefore provides an opportunity to analyze the implications of government policies for rural development (Amare et al., 2019).

At the baseline survey, three main household groups were identified from across the seven administrative locations in Kandara Sub-County, based on their participation in avocado-marketing contracts. The first group (contract farmers) was composed of farm households involved in modern avocado marketing through contract arrangements with an established exporter. The lists were provided by the chairpersons of fourteen such groups and by Kandara Sub-County agricultural officers. Members of all the households in the lists provided by farmer groups were interviewed.

The second group of farmers included those who had recently signed contracts to sell avocados to exporters (transition farmers). Farmers in four groups, each of which consisted of 50-60 farmers on average, had already signed contracts with exporters (regarding price, quality, grade, and delivery of avocados). Thirty to forty farmers from each group were randomly sampled.

The third group included farmers involved in traditional avocado marketing who sold their avocados to middlemen or brokers (non-contract farmers). We selected twenty villages whose farmers were not linked to exporters and whose production approaches and geographical locations were similar. These villages were also similar in size, socio-economic and agro-climatic conditions, and road and market access. From each of the villages, farmers who were not organized in any farmers' groups were randomly selected. Members of a total of 790 households were interviewed (see Figure 1 for sample distribution), though only 714 of these households were available for follow-up during the end line survey. After cleaning the sample for missing data and enumerator errors, we analyzed a balanced sample of 674 households.

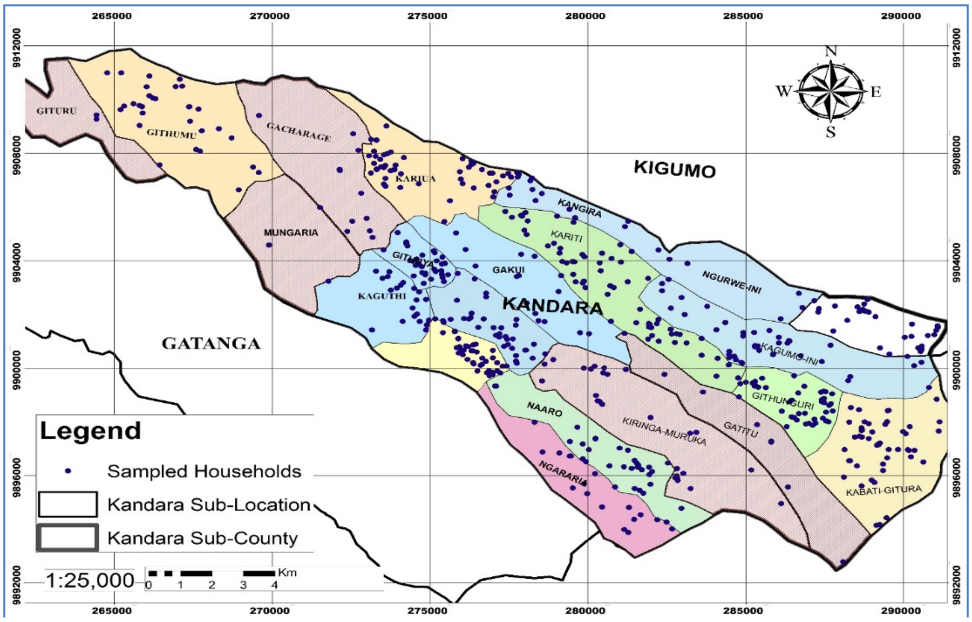

Fig. 1: Distribution of Sampled Households - Kandara Sub-County

Household survey data were complemented by qualitative data collected through focus-group discussions and informant interviews. These interviews targeted men, women, and youth who participated in avocado farming, group leaders in the area of study, brokers, and avocado exporters. The objective of the qualitative survey was to explore the participation of men, women, and youth in avocado contract farming as well as to establish the challenges farmers faced to participation in contract farming, especially in the case of women. The findings were used to validate and complement the results of the quantitative household survey.

3.2 Descriptive Statistics

3.2.1 Dynamics of Avocado Farmers Participation in High-Value Horticultural Farming

We considered two different ways of participating in the high-value horticultural farming: (1) whether any member of the household was a member of an avocado-producing and/or marketing group; and (2) whether a farmer had a contract with an avocado trader (contract farming). The nature of our data (in two-rounds of the survey) enabled us to define the dynamics of participation in the different pathways of high-value avocado farming. For ease of analysis, we use the terms "adopter" (meaning a farmer who participated) and "non-adopter" (who did not).

Adopters were further categorized into (a) "late adopters," referring to farmers who were not group or contract participants during the first round of the survey, but were participants by the time of the follow-up survey, (b) "dis-adopters," who were discovered during the follow-up survey to have ended their participation, and (c) "early adopters," who participated in both rounds of the survey.

Although empirical analysis did not provide the dynamics of contract participation, Table 1 describes avocado farmers' participation in both group membership and contract farming as described in the paragraph above, according to the gender of the household head. The majority of the households headed by women (59%) did not participate in contract farming (non-adopters), while about 10% (fifteen households) were no longer participating at the time of the follow-up survey (dis-adopters). This suggests a potential resource constraint among women farmers that may have hindered their participation in the high-value market. Similarly, most of the women-headed households (WHHs) (58%) did not participate in avocado PMOs (non-adopters). Participation by men-headed households (MHHs) followed that of women, and a larger proportion of surveyed households did not participate in contract and group membership (47% and 37%, respectively).

Table 1: Dynamics of Avocado Farmers' Participation in High-Value Horticulture Farming

	Group membership			Contract farming		
Dynamics	Women-headed households (WHHs)	Men-headed households/(MHHs)	Total	Women-headed households (WHHs)	Men-headed households (MHHs)	Total
Non-adopters	84	194	278	85	247	332
Late adopters	5	56	61	22	114	136
Dis-adopters	17	95	112	15	59	74
Early adopters	39	184	223	23	109	132
Total	145	529	674	145	529	674

3.2.2 Farm and Farmer Characteristics

Table 2 provides a description and summary statistics of selected household, farm, and social capital characteristics that are likely to influence the participation of smallholder avocado farmers in the high-value market based on the literature (Section 2) and the study context. On average, households headed by women were larger than households headed by men. Men who were heads of households were younger and had more years of schooling than did women who led households. While bigger families may hinder participation in high-value crop production because subsistence needs are prioritized over commercial activities (von Braun, Haen & Blanken, 1991; von Braun & Kennedy, 1994), they may provide labor required in the management of the commercial crops. Better-educated farmers are expected to possess skills and ability to use better market information, which may reduce market and other transaction costs and thus make participation in high-value markets more profitable (Geoffrey et al., 2013). A significantly larger proportion of women heads of household reported farming as their main occupation. While relying on agriculture alone may motivate farmers to invest in commercial production for high-value products, it may also suggest limited opportunities to receive the capital required to finance production.

Table 2: Selected Household, Farm, Market, and Social-Capital Characteristics

	Full sample n=1348		Women-headed households (WHHs) (n=299)		Men-headed households (MHHs) (n=1049)		Difference
Household and farm characteristics	Mean	SD	Mean	SD	Mean	SD	
Household size (adult equivalent)	1.97	0.67	1.69	0.64	2.05	0.65	-0.361***
Age of household head (years)	63.83	12.44	65.63	11.97	63.32	12.53	2.311***
Education of household hear (years of schooling)	7.97	3.86	5.94	3.86	8.55	3.66	-2.618***
Farming main head occupation (1=Yes 0=No)	0.66	0.48	0.74	0.44	0.63	0.48	0.106***
Resource constraints							
Number of Hass avocado trees	7.50	15.04	4.07	5.84	8.48	16.63	-4.413***
Number of Fuerte avocado trees	4.48	7.93	4.53	5.26	4.46	8.55	0.068
Owned cultivated land (hectares)	0.66	0.64	0.64	0.57	0.67	0.65	-0.028
Major farm assets and furniture (in 1000s of Kenyan shillings)	63.43	169.10	50.19	105.85	67.20	183.04	-17.012
Access to off-farm income (1=Yes 0=No)	0.72	0.45	0.73	0.45	0.72	0.45	0.013
Credit-constrained household (1=Yes, 0=No)	0.13	0.34	0.06	0.24	0.15	0.36	-0.090***
Livestock owned in TLU	1.47	1.75	1.32	2.28	1.51	1.56	-0.184
Hired labor (1=Yes, 0=No)	0.51	0.50	0.54	0.50	0.50	0.50	0.050
Market access							
Distance to local market (kilometers)	17.57	66.30	10.79	49.54	19.50	70.25	-8.707*
Distance to main market (walking minutes)	39.26	27.56	39.60	27.55	39.16	27.57	0.446
Social capital networks							
Trust neighbors (1=Yes, 0=No)	0.35	0.48	0.34	0.48	0.35	0.48	-0.004
Cooperate with other avocado farmers (1=Yes, 0=No)	0.05	0.22	0.05	0.23	0.05	0.22	0.002
Avocado production perceptions							
Stability for avocado farming (1=Stable, 0=otherwise)	0.83	0.37	0.81	0.40	0.84	0.37	-0.033
Avocado working conditions (1=Strenuous 0=Otherwise)	0.78	0.42	0.78	0.41	0.77	0.42	0.009
Keep avocado related records (1=Yes, 0=No)	0.10	0.30	0.08	0.28	0.10	0.30	-0.019
Risk preference (1=Yes, 0=No)	0.73	0.44	0.63	0.48	0.76	0.43	-0.138***
Location dummies							
Gaichanjiru	154		23		131		0.048**
Ithiru	179		46		133		0.027
Kagunduini	184		41		143		0.001
Others	157		35		122		0.0008

Note: Statistical significance at *p<0.1, **p<0.05, ***p<0.01. [a]1348 observations (two rounds of survey) from 674 households.

As a measure of household wealth, we included the total number of productive Hass and Fuerte varieties of avocado, farm size, the value of major farm assets, and livestock ownership (in tropical livestock units or TLU). We also included dummy variables equal to 1 if the household had access to off-farm income including remittances, businesses, or employment from other sources, and a second dummy equal to 1 if a household was credit-constrained as an indicator of working capital. We also included a dummy variable equal to 1 if farmers hired labor for agricultural activities.

The number of improved productive avocado trees is a prerequisite for participating in high-value avocado markets. On average, households headed by men had significantly more Hass trees than those headed by women, while the two groups of households had more or less the same number of Fuerte trees. Farm size is often used as collateral for obtaining credit and, consequently, may positively influence farmers' decisions to participate in commercial production. Farm size may determine the size of the avocado orchard and, subsequently, decisions to participate in the market. Following Feder et al. (1990), we defined credit-constrained farmers as those who needed credit but were unable to get it. On average, a significantly larger proportion of men-headed households were credit-constrained that were their women-headed counterparts.

Market-access variables are directly associated with the transaction costs related to both input and output marketing activities and can negatively influence smallholders' participation in production for high-value markets (Key, Sadoulet & de Janvry, 2000; Feder, Just & Zilberman, 1985; Sadoulet & de Janvry, 1995). We measured market access as distance to the local market and to the main market, both in walking minutes. The average distance to the local market was seventeen minutes, with households headed by women reporting significantly shorter distances than did households headed by men.

Following Barrett (2005) and Shiferaw, Hellin, and Muricho (2011), we also controlled for social capital and networks that could influence high-value-market participation decisions among avocado growers. We considered two measures of social capital: household relationships with neighbors, defined as whether the household trusted neighbors; and household relationships with other avocado producers, defined as whether the household cooperated with other avocado farmers in the village. Different forms of social capital and networks may affect farmer's participation in high-value markets through information sharing, stable market contracts, bargaining for better prices, labor sharing, soothing credit constraints, mitigation of risks, and other ways (Shiferaw, Hellin & Muricho, 2011; Fischer & Qaim, 2012; Wossen et al., 2017). The two variables, however, are not significantly different between the households headed by women and households headed by men.

We also considered some perceptions regarding avocado production that were likely to influence smallholder participation in high-value markets, including stability of avocado farming and working conditions (input application, harvesting, record-keeping by farmers, and risk preferences e.g., all measured as dummy variables). Risk-preferring households were likely to try new markets or technological innovations such as producing crops for high-value markets through contracts. On the other hand, risk-averse farmers tended to join a group to mitigate the risks associated with non-payments from traders.

Appendix Table A1 presents sample characteristics of different categories of contract adoption groups. The data show significant differences in most household and farm characteristics across the groups. As is well documented in the literature, relative to women, men dominate all categories of contract adoption groups. Women are more likely to be dis-adopters and non-adopters than men. Though there were significant differences in household size and education of the head, the main distinguishing factor across groups is that farming was the main occupation of the head of household. Late adopters were more educated than all other groups, suggesting the availability of alternative livelihoods that diverted efforts from farming. These statistics support findings in the literature (see, for instance, Ashraf, Giné & Karlan, 2009; Barrett et al., 2011; Muriithi & Matz, 2014).

With regard to resource constraints, the number of avocado trees, whether the farmers owned cultivated land, and whether they used hired labor were key factors that distinguished groups. Early adopters had more Hass trees, while dis-adopters had more Fuerte trees. Early adopters, on average, owned more cultivated land, while dis-adopters used more hired labor, which concurs with existing literature (e.g. Barrett et al., 2011; Muriithi & Matz, 2014). The finding on hired labor supports Grabowski et al. (2016) who found that increased labor demand is a disincentive to the adoption of agricultural technologies. On social capital networks, the data shows that early adopters cooperate more with other avocado farmers compared to all other groups, while non-adopters hardly cooperate, which corroborate with findings on the effect of participation in organizations and social learning (Bravo-Ureta, Cocchi & Solís, 2006; Läpple, 2010). Early adopters had better avocado-production perceptions, including risk preferences, than all other groups, which is in line with Bolwig, Gibbon, and Jones (2009) who found that expected higher profitability enhanced farmers' participation.

Appendix Table A2 presents characteristics of different categories of avocado PMO membership among sample participants. The results show patterns close to those shown in Appendix Table A1. Men once again dominated all categories, but a striking observation is the high proportion of late adopters (93.4%), meaning that, although men were likely to be members of groups, they entered groups relatively late compared to women. Another highlight is that non-adopters had more access to off-farm income than did other groups. This finding supports studies that have found that off-farm income and livelihood diversification influenced adoption and abandonment decisions (Grabowski et al., 2016; Läpple, 2010; Bravo-Ureta, Cocchi & Solís, 2006; Neill & Lee, 2001). Differential effects of social-capital variables were also observed among late adopters, who were more likely to cooperate with other avocado groups.

IV. Conceptual Framework and Estimation Strategy

4.1 Conceptual Framework

Methodologies for evaluating the dynamics of agricultural-technology vary across studies, largely depending on the objective of the study. Most studies, however, have evaluated static adoption vs. non-adoption decision (Kassie, Shiferaw & Muricho, 2011; Shiferaw et al., 2014; Sunding & Zilberman, 2001), but often limited by the available data, mainly cross-sectional datasets. Analyzing the dynamics of technology adoption requires the use of longitudinal data. Only a few studies have examined what happens when technologies are abandoned (e.g., Neill & Lee, 2001, in their study of the cultivation of cover crops in

Northern Honduras; and Moser & Barrett, 2003, who studied a system of rice intensification in Madagascar). Such studies are, however, limited in Africa.

Neill and Lee (2001) used a bivariate probit to analyze the adoption and abandonment of cover crops. The model took into account dichotomous decisions (adopt yes/no; abandon yes/no) and the potential correction between them. In estimating the adoption and abandonment of precision soil sampling in cotton production, Walton et al. (2008) used a probit model, while Rigby, Young, and Burton (2001) used a logit model to explore reasons for the abandonment of organic farming in the UK. Läpple (2010) used duration analysis to explore the adoption and abandonment of organic farming in the Irish dry-stock sector, while Moser and Barrett (2003), used a probit model and an asymmetrically trimmed least-squares estimation of a dynamic Tobit model to analyze decisions to adopt, expand, and abandon SRI technology in Madagascar. It is evident from these and related studies that the adoption of agricultural technologies is dynamic. Technologies are widely and spontaneously accepted by farmers at the initial stages but later abandoned.

Similar to the adoption of agricultural technology, the participation of smallholders in high-value-market farming is a dynamic process, but most studies on this topic are based on static models that have used cross-sectional data (e.g. Ashraf, Giné & Karlan, 2009; Heltberg & Tarp, 2002). Smallholders follow different pathways, for instance through contracts offered by exporters or selling through brokers. While some maintain one production-marketing pathway, others abandon one channel to follow a different one from season to season or eventually retreat to an earlier path or follow a new one altogether. Capturing the dynamics of market-participation decisions may provide more information on behaviors and differences among households who continue to participate, those who abandon the market, those who participate later, and those who never participate. Using static models, biased results arise from ignoring the dynamic effect of learning and the inability to control for unobserved heterogeneity (Moser & Barrett, 2003). Treating early adopters and late or recent adopters the same, as is often done in static models, may result in misleading and biased coefficients estimates because early adopters may have more experience and, subsequently, may be more likely to continue with technology in comparison to late adopters (Cameron, 1999).

Lack of panel data is cited as the major setback for persistent use of cross-sectional technology-adoption analysis. In the absence of panel data, recall data can be used as proposed in the literature (see, for instance, Besley & Case, 1993). Those authors used a probit model with time dummies and interaction terms to capture the dynamic influence of independent variables over time. This method is, however, limited by farmers' ability to remember and also by the assumption that explanatory variables did not change over the adoption process or were not influenced by adoption decisions.

Even when panel data is available, controlling for the endogeneity that arises from household self-selection is still a challenge in adoption models. To address this challenge, Barham et al. (2004) used a multinomial logit model, incorporating household characteristics from the baseline to describe the current period. Self-selection could arise when households change from one market choice to another (for instance late adopters and dis-adopters). Similarly, Diederen et al. (2003) applied nested logit models, an extension of a multinomial logit model, to analyze farmers' adoption behavior in choosing to be laggards, early adopters, or innovators of a dairy farming technology.

We adopted a multinomial logit model following Barham et al. (2004) to establish the factors that influenced farmers' participation in either of the four group categories. A second estimation used the panel nature of our data to control for unobserved variables in a random-effects logit model. The random-effects logit model provides a means of testing the reliability of the multinomial logit model (Barham et al., 2004).

Based on the evidence that smallholder farmers in Kenya can only be contracted by exporters as a group (Ashraf, Giné & Karlan, 2009), and especially by those exporting avocados (Gyau, Mbugua & Oduol, 2016), we did not estimate contract farming as an independent decision. Rather, we estimated the factors that affected contract farming conditional on group membership by designing a sequential-choice model based on the bivariate probit framework developed by Chang & Boisvert (2005 and Khanna (2001).

4.2 Group Dynamics Estimation

4.2.1 Multinomial logit

We estimated a multinomial logit model (MNL) using panel data to capture the determinants of participation in high-value avocado markets of each household category (early adopters, late adopters, dis-adopters, and non-adopters). Unlike cross-sectional data analysis, this estimation allowed us to compare determinants associated with households that moved in and out of high-value market participation with those who continued to produce for these markets, an aspect that is mostly ignored in studies that have analyzed market participation. This study follows a related analytical framework developed by Moser and Barrett (2003), who employed separate dynamic probit models to establish who adopted and who abandoned SRI technology. The dynamic model allowed us to explore the role of selected explanatory factors in adoption decisions.

Participation in the high-value market in any of our categories was not ordered. Given the unordered nature of the dependent variables, we motivated the selection of categories through a random utility model following Greene (2012). The utility model assumes that each household makes its market- or group-participation choice for each period or season according to a latent utility function y_{it}^{*}, such that

$$y_{ikt}^{*} = \beta' x_{it} + \varepsilon_{ikt} \qquad (1)$$

where y_{it}^{*} is the utility household i derives from the high-value market-participation choice *k(0,1,2,3)* at time *t,* $x_{it}$are the observed explanatory variables that may influence participation decisions, β' is a vector of parameters to be estimated, and $\varepsilon_{ikt}$is the error term. Consider the multiple high-value market participation categories (i.e. *k=0,1,2,3)* and time, *t=0,1 (*two survey rounds, *t=0* if 2015 and *t=1* if 2017), such that the categories can be expressed as follows:

$k = 0 \quad if \ y_{ikt}^{*} \leq 0 \quad for \ t = 0 \ , and \quad y_{ikt}^{*} \leq 0 \ for \ t = 1$
High-value market participation non-adopters

$k = 1 \quad if \ y_{ikt}^{*} > 0 \quad for \ t = 0 \ and \ t = 1$
Early high-value market participants (early adopters)

$k = 2 \quad if \ y_{ikt}^{*} \leq 0 \quad for \ t = 0 \ , but \quad y_{ikt}^{*} > 0 \ for \ t = 1$
Late high-value market participants (late adopters)

$k = 3 \quad if \ y^*_{ikt} > 0 \quad for \ t = 0 \ , but \quad y^*_{ikt} \leq 0 \ for \ t = 1$
High-value market participation dis-adopters (2)

The participation of smallholders in PMOs is dynamic as presented in the above formulation. If characteristics that determine the category into which a farming household falls can be sufficiently defined in the baseline period, then the analysis can be reduced to a single-period estimation. Our interest was to describe the probability of adoption of either of the four high-value-market participation choices given a set of specific household explanatory variables (x_{it}):

$$Pr(y_{it} = 0|x_i) = P_{ik} = \frac{exp(\beta' x_{it})}{1+\sum_{k=0}^{K} exp(\beta' x_{it})} \qquad (3)$$

where *Pr(.)* is the probability of the ith household to make the K^{th}market choice conditional on observed explanatory variables ***x.*** With *K (0,1,2,3)* categories*, K* log-odds are computed. Because the probabilities of the outcomes must add up to the unit value, 1, a benchmark outcome (*k=0)* can be assigned to identify the coefficients in the estimation of different market-participation choices relative to the benchmark outcome, such that:

$$Pr(y_{it} = 0|x_i) = P_{ik} = \frac{1}{1+\sum_{k=0}^{K} exp(\beta' x_{it})} \qquad (4)$$

The above specification is a multinomial logistic regression model. The regression estimates how marginal changes in observable farm and farmer characteristics affect the probability of being in one category relative to another. The above estimation was repeated three times to estimate the factors that affected group participation among the interviewed households and gender-specific factors based on the head of the sampled household (i.e., the respondent).

Barham et al. (2004) noted that, by using explanatory variables from the baseline to describe the adoption process from baseline to the current period, as done above, the MNL partially addresses endogeneity. The authors, however, cautioned that, while baseline explanatory variables were conceivably exogenous for all categories of farmers who made participation decisions later, the model did not remove potential endogeneity for early participants (early adopters*).* To ameliorate this concern, the authors suggested following the panel nature of the data by estimating a random effect regression model described below.

4.2.2 Random Effects Logit Model

For the random effects logit specification, we specify farmers' participation in PMOs as follows.

$$y_{it}^{*} = \boldsymbol{\beta} \boldsymbol{x}_{it} + a_i + \mu_{it} \tag{5}$$

where a_i controls for unobserved heterogeneity across households because it is distributed normally with mean zero and variance σ_a^2, and the error term μ_{it} has a logistic distribution with mean zero and variance σ_ε^2. The fact that the model controls for unobserved heterogeneity across households, and that it focuses on changes within households over time rather than on average effects across households, plausibly addresses the problem of self-selection into group membership. $\boldsymbol{x}_{it}$ and $\boldsymbol{\beta}$ are as described above in the MNL model. The random-effect logit panel data model also accounts for omitted variables and the possible endogeneity of some independent variables.

a. Sequential Farmers' Participation in High-Value-Market Decisions Based on a Bivariate Probit Framework

In a given period, say a year, a farmer's choice of whether or not to participate in high-value horticulture production not is determined by the expected utility or benefit associated with either option. Let U_G and U_0 represent, respectively, farmers' expected utility from joining an avocado PMO or not. Subsequently, a farmer decides to join a group if $U_G^* = U_G - U_0 > 0$. As highlighted earlier, we assumed, based on previous literature, that the decision to participate in contract farming would be conditional on PMO membership. A farmer first joins a group, and then decides whether to participate in contract farming. The contract-participation decision is determined by comparing the expected benefits from selling through brokers and selling through a contract (U_C), and the farmer participates if $U_C^* = U_C - U_G > 0$. The net benefits U_G^* and U_C^* for an avocado-growing household are latent variables, assumed to be random functions of the vectors of observed explanatory variables $\boldsymbol{X_G}$ and $\boldsymbol{X_C}$, respectively.

$$U_G^* = \boldsymbol{Z_G \beta_G} + \varepsilon_G \tag{6}$$

$$U_C^* = \boldsymbol{Z_C \beta_C} + \varepsilon_C \tag{7}$$

where ε_G and ε_C are random errors distributed normally with mean zero and variance one and $\boldsymbol{\beta_G}$ and $\boldsymbol{\beta_C}$ are vectors of coefficients of the explanatory variables to be estimated. The observable choices of the farmer are presented as follows:

$$I_G = 1 \; if \; U_G^* > 0; \; or \; I_G = 0, otherwise \tag{8}$$

$$I_C = 1 \; if \; U_C^* > 0; \; and \; I_G = 1, or \; I_C \; \; otherwise \tag{9}$$

where I_G is the observable decision to join a group given as 1 if the expected benefits (U_G^*) of group membership are higher than zero, while I_C is the subsequent decision to join contract farming, given as 1 if the expected benefits (U_C^*) from being under contract are higher than zero. The covariance of the error terms is $Cov(\varepsilon_G, \varepsilon_C) = \rho$ when random factors affecting group and contract participation decisions are not independent because of unobservable factors that could affect either participation decision. Subsequently, joint distribution $(\varepsilon_G, \varepsilon_C)$ has a bivariate normal distribution with mean vector zero and covariance matrix $\begin{bmatrix} 1 & \rho \\ \rho & 1 \end{bmatrix}$, where the correlation coefficient (ρ) captures the joint nature of these two decisions, which can be estimated using a bivariate probit procedure (Hausman & Wise, 1978). However, because the nature of group membership and contact decisions is sequential rather than joint, the above needs to be modified to account for the sequential participation process. Because the contract decision (Equation 8) can be defined only over the sub-sample where group membership I_G=1 (we assumed that only farmers in a group were contracted), we get three-way regimes of observations with a non-zero ρ that leads to a bivariate sequential model (Khanna, 2001). The probabilities of the three outcomes are:

$$P_{GC} = \Pr(I_{G=}1; \; I_C = 1) \tag{10}$$

$$= \Phi_1(\boldsymbol{Z_G \beta_G}, \boldsymbol{Z_C \beta_C}, \rho)$$

$$P_{G0} = \Pr(I_{G=}1; \; I_C = 0) \tag{11}$$

$$= \Phi(\boldsymbol{Z_G \beta_G},) - \rho_{GC}$$

$$P_{00} = \Pr(I_{G=}0;\ I_C = 0) \quad (12)$$
$$= 1 - \Phi(\boldsymbol{Z_G \beta_G},)$$

where Φ and Φ_1 are the cumulative distribution functions of the standard normal distribution and the standard bivariate normal distribution with correlation coefficient $\boldsymbol{\rho}$**,** respectively (Alpu & Fidan, 2004; Khanna, 2001). The above models can be estimated by the Full Information Maximum Likelihood (FIML) using the likelihood function:

$$L = \prod_{I_G=1, I_C=1} \Phi_1(\boldsymbol{Z_G\beta_G}, \boldsymbol{Z_C\beta_C}, \rho). \prod_{I_G=1, I_C=0} \Phi(\boldsymbol{Z_G\beta_G},) - \rho_{GC}). \prod_{I_G I_C} 1 - \Phi(\boldsymbol{Z_G\beta_G},)$$
[13]

V. Empirical Results and Discussions

5.1 Results and Discussion

As outlined in the previous section, we applied multinomial regression and random-effects models to estimate the determinants of dynamic participation in PMO membership among avocado farmers in Murang'a County, and a sequential bivariate model approach to assess determinants of contract farming conditional on group membership. The results are presented below, starting with a PMO-membership-dynamics analysis. To determine whether certain factors affected farmers differently by gender, we conducted separate MNL and random-effects estimations for households headed by women and those headed by men. Sequential bivariate models were, however, estimated for the pooled sample, with a focus on gender as our variable of interest. The random-effects model used the panel nature of our data; therefore, it did not incorporate farmer dynamics in group membership. Before running the models, we conducted a multicollinearity test for the variables included in the analysis. The results showed no strong correlation because the values of the Variance Inflation Factor (VIF) were far less than 10.

5.1.1. Factors Affecting Dynamics of Smallholder Farmers' Participation in Avocado Production and Marketing Groups

Multinomial logit regression results

Table 3 reports estimates derived using a multinomial regression model for the determinants of avocado farmer's behavior in PMOs participation. Tables 4 and 5 report gender-specific estimations. Because the set of late group participants was small among the Households headed by women (see Table 1), we merged this group with the non-adopters while analyzing the WHH models. Analyzing the two groups together is supported by Diederen et al. (2003) who compared laggards (late and non-adopters) and frontrunners (innovators and early adopters). Similarly, Rogers (1995) depicts the characteristics of late adopters and of non-adopters as very similar. The author makes a general comparison of late adopters (comprising late majority and laggards) to earlier adopters (innovators, early adopters, and early majority).

With respect to full sample regression (Table 3), household and farm characteristics matter for the choice of different participation decisions. Early group participants have smaller families than non-adopters and dis-adopters. The gender variable is also significant, with late adopters and early adopters likely to be households headed by men in comparison with non-adopters. This suggests the existence of a resource gap among WHHs relative to households headed by men, thus affecting group participation. As observed by Rogers (1995), early adopters have more years of formal education, and more likely to depend upon farming as their main occupation in comparison to non-adopters.

As expected, the number of Hass avocado trees had a positive impact on group participation decisions across different categories compared to non-participants. Surprisingly, the size of the farm has a negative influence on late adopters and dis-adopters in relation to the non-adopters, while early group participation relative to late participation decisions are likely to be positively influenced by access to hired labor. While market access characteristics don't seem to matter in group-participation decisions, social-capital networks (developed through trust of neighbors) are likely to positively influence group-exiting decisions in comparison to late or non-participation. In accordance with our expectations, satisfaction with avocado farming and record-keeping correlated positively with the probability of being an early adopter compared to non-adopters. Relative to non-participation, group-exit decisions (dis-adopters) were also positively related to record-keeping.

Table 3: Factors that Affect Participation in Avocado Production and Marketing Groups

	Late adopters vs. non-adopters	Dis-adopters vs. non-adopters	Early adopters vs. non-adopters	Dis-adopters vs. late adopters	Early adopters vs. late adopters	Early adopters vs. dis-adopters
Household and farm characteristics						
Household size (adult	-0.265	0.152	-0.336	0.416	-0.071	-0.487
equivalent)	(0.231)	(0.185)	(0.167)**	(0.243)*	(0.238)	(0.179)***
Gender of household head	1.169	0.557	0.542	-0.611	-0.626	-0.015
(1=male, 0=Female)	(0.552)**	(0.348)	(0.305)*	(0.612)	(0.573)	(0.368)
Age of household head (years)	0.015	0.031	0.004	0.016	-0.011	-0.027
	-0.014	(0.012)***	(0.010)	(0.016)	(0.015)	(0.012)**
Education of household head	0.108	0.047	0.066	-0.061	-0.042	0.019
(years of schooling)	(0.055)**	-0.041	(0.037)*	(0.058)	(0.053)	(0.038)
Farming main head	0.4	-0.111	0.635	-0.510	0.235	0.745
occupation (1=Yes 0=No)	(0.359)	(0.286)	(0.259)**	(0.386)	(0.368)	(0.283)***
Resource constraints						
Number of Hass avocado trees	0.104	0.124	0.124	0.020	0.020	0.00
	(0.031)***	(0.027)***	(0.026)***	(0.019)	(0.018)	(0.007)
Number of Fuerte avocado	0.013	0.006	-0.012	-0.008	-0.026	-0.018
trees	(0.016)	(0.012)	(0.016)	(0.015)	(0.016)	(0.014)
Owned cultivated land	-0.657	-0.666	-0.269	-0.009	0.388	0.397
(hectares)	(0.310)**	(0.261)**	(0.173)	(0.373)	(0.311)	(0.264)
Major farm assets and furniture (in 1000s of Kenyan	0.000	0.000	0.001	0.000	0.000	0.001
shillings)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Access to off-farm income	0.225	-0.078	0.038	-0.303	-0.187	0.115
(1=Yes 0=No)	(0.427)	(0.342)	(0.300)	(0.450)	(0.390)	(0.321)
Credit-constrained household	-0.343	-0.383	-0.525	-0.039	-0.181	-0.142
(1=Yes, 0=No)	(0.448)	(0.351)	(0.293)*	(0.472)	(0.434)	(0.350)
Livestock owned in TLU	0.105	-0.079	0.053	-0.183	-0.052	0.131
	(0.089)	(0.110)	(0.084)	(0.114)	(0.052)	(0.111)
Hired labor (1=Yes, 0=No)	-0.328	-0.035	0.321	0.293	0.649	0.356
	(0.332)	(0.287)	(0.247)	(0.357)	(0.321)**	(0.273)
Market access						
Distance to local market	-0.019	0.019	0.012	0.037	0.031	-0.007
(kilometers)	(0.043)	(0.017)	(0.022)	(0.038)	(0.037)	(0.020)
Distance to main market	0.001	0.001	0.001	0.000	0.000	0.000
(walking minutes)	(0.006)	(0.005)	(0.005)	(0.006)	(0.006)	(0.004)
Social capital networks						
Trust neighbors (1=Yes,	-0.116	0.537	0.311	0.653	0.427	-0.226
0=No)	(0.357)	(0.266)**	(0.231)	(0.378)*	(0.346)	(0.257)
Cooperate with other avocado	1.05	-0.337	0.146	-1.387	-0.903	0.484
farmers (1=Yes, 0=No)	(0.677)	(0.848)	(0.610)	(0.706)**	(0.546)*	(0.615)
Avocado farming perceptions and practice						
Satisfaction with avocado farming (1=satisfied	-0.274	0.022	0.61	0.296	0.885	0.589
0=Otherwise)	(0.388)	(0.337)	(0.319)*	(0.432)	(0.382)**	(0.342)*
Avocado working conditions	0.442	0.571	0.224	0.129	-0.217	-0.347
(1=Strenuous 0=Otherwise)	(0.380)	(0.316)*	(0.246)	(0.420)	(0.363)	(0.315)

Keep avocado related records	0.158	0.944	0.827	0.786	0.669	-0.117
(1=Yes, 0=No)	(0.594)	(0.415)**	(0.372)**	(0.599)	(0.560)	(0.359)
Risk preference (1=Yes,	0.418	0.584	0.267	0.166	-0.151	-0.317
0=No)	(0.426)	(0.316)*	(0.267)	(0.458)	(0.418)	(0.302)
Location dummies	Yes	Yes	Yes	Yes	Yes	Yes
Constant	-6.527	-4.861	-2.66	1.666	3.867	2.201
	(1.642)***	(1.223)***	(1.026)***	(1.817)	(1.687)**	(1.247)*
Number of observations		674				
Wald chi^2(72)		270.17***				
Pseudo R^2		0.231				
Log pseudolikelihood		-646.29				

Note: Statistical significance at *p<0.1, **p<0.05, ***p<0.01. Presented above are the odds ratio coefficients (standard error).

Table 4 shows MNL estimations for households headed by women. As noted earlier, the analysis of households headed by women is composed of three categories of group participation: early adopters, dis-adopters, and laggards (late and non-adopters). Among such households, the education of the household head matters for early group-participation decisions in comparison to dis-adopters. Similarly, the number of Hass avocado trees has a positive impact on early adoption and abandonment decisions in comparison to late and non-adopters. This finding is consistent with most of the gender literature which show that access to resources among women increases their capacity to participate in rural institutions and subsequently adopt new technologies (Croppenstedt, Goldstein & Rosas, 2013; Doss, 2001; Peterman, Behrman & Quisumbing, 2014; Quisumbing & Pandolfelli, 2010). Credit-constrained households headed by women are more likely to be late adopters or non-adopters in comparison to dis-adopters. This is plausible as participation in PMOs requires contributions for group membership and other group maintenance expenses, hence cash outlay. However, credit-constrained households headed by women are more likely to be early adopters in comparison with dis-adopters. This implies that credit-constrained female farmers may choose to remain in groups where they receive credit and other financial services that may be required for the production and marketing of their produce (Quisumbing & Pandolfelli, 2010).

Consistent with agriculture commercialization literature (e.g. Muriithi & Matz, 2014), farmers located far away from the market have limited market opportunities for their produce and hence may choose to join rural institutions to facilitate their marketing activities. Surprisingly, none of the social capital networks influenced group participation among households headed by women but dis-adopters had a high probability of keeping records in comparison with late and non-adopters.

Table 4: Factors Affecting Participation in Avocado-Production and Marketing Groups by Women-Headed Households

	Dis-adopters vs. laggards	*Early adopters vs. laggards*	*Early adopters vs. dis-adopters*
Household and farm characteristics			
Household size (adult equivalent)	-0.393	-0.368	0.025
	(0.503)	(0.323)	(0.513)
Age of household head (years)	-0.064	-0.000	0.064
	(0.042)	(0.030)	(0.045)
Education of household head (years of schooling)	-0.187	0.118	0.305
	(0.133)	(0.087)	(0.142)**
Farming main head occupation (1=Yes 0=No)	0.125	1.367	1.242
	(1.840)	(1.083)	(1.841)
Resource constraints			
Number of Hass avocado trees	0.224	0.116	-0.107
	(0.065)***	(0.048)**	(0.049)**
Number of Fuerte avocado trees	0.007	-0.050	-0.057
	(0.065)	(0.052)	(0.064)
Owned cultivated land (hectares)	0.228	0.527	0.299
	(0.683)	(0.618)	(0.597)
Major farm assets and furniture (in 1000s of Kenyan shillings)	-0.000	-0.000	-0.000
	(0.006)	(0.003)	(0.006)
Access to off-farm income (1=Yes 0=No)	0.314	0.593	0.279
	(1.005)	(0.623)	(1.059)
Credit-constrained household (1=Yes, 0=No)	-15.829	0.199	16.027
	(2.041)***	(1.021)	(1.977)***
Livestock owned in TLU	-0.024	0.080	0.104
	(0.387)	(0.244)	(0.368)
Hired labor (1=Yes, 0=No)	-1.939	-0.260	1.679
	(1.014)*	(0.586)	(0.979)*
Market access			
Distance to local market (kilometers)	1.528	1.536	0.008
	(0.870)*	(0.869)*	(0.021)
Distance to main market (walking minutes)	-0.097	-0.096	0.001
	(0.059)	(0.060)	(0.012)
Social capital networks			
Trust neighbors (1=Yes, 0=No)	0.466	0.263	-0.203
	(0.854)	(0.694)	(0.813)
Cooperate with other avocado farmers (1=Yes, 0=No)	-0.800	-0.530	0.269
	(1.443)	(1.021)	(1.572)
Avocado farming perceptions and practice			
Satisfaction with avocado farming (1=satisfied 0=Otherwise)	0.325	0.524	0.199
	(1.000)	(0.672)	(1.032)
Avocado working conditions (1=Strenuous 0=Otherwise)	1.077	0.070	-1.007
	(0.811)	(0.571)	(0.852)
Keep avocado related records (1=Yes, 0=No)	2.460	1.409	-1.051
	(1.203)**	(0.863)	(1.167)
Risk preference (1=Yes, 0=No)	1.584	0.550	-1.034
	(0.934)*	(0.651)	(1.042)
Location dummies	*Yes*	*Yes*	*Yes*
Constant	2.236	-3.500	-5.736
	(4.223)	(3.092)	(4.662)
Number of observations	145		
Wald chi^2(46)	1291.1***		
Pseudo R^2	0.3277		
Log pseudolikelihood	-88.13		

Note: Statistical significance at *p<0.1, **p<0.05, ***p<0.01. Laggards include late adopters and non-adopters.

Presented above are the odds ratio coefficients (standard error).

Table 5 presents the regression results for households headed by men. Early adopters have smaller families, while dis-adopters have older household heads, both in comparison to non-adopters. Dis-adopters, however, have larger families in comparison with early adopters. Similarly, the size of a Hass avocado orchard positively affects PMO participation, suggesting the need to encourage the production of improved avocado tree crops and, consequently, in rural institutions through which farmers can benefit from access to information, finance, and inputs. Interestingly, we found a negative relationship to all group-adoption categories in comparison with non-adopters with regard to the size of land cultivated. The finding contrasts with Rogers' (1995) argument on the adoption of agricultural technologies. Farmers with less land probably use rural groups for marketing in order to maximize earnings from their small plots. In the same way as households headed by women, credit-constrained households headed by men are likely to be early adopters in comparison with non-adopters. Households headed by men that exit from groups are more likely to trust their neighbors in comparison with late and non-adopters, while early adopters are more likely to be satisfied with avocado farming compared with the same groups, while both those who exit and those who stay keep records of their production activities.

Table 5: Factors Affecting Participation in Avocado Production and Marketing Groups among Households Headed By Men

	Late adopters vs. non-adopters	Dis-adopters vs. non-adopters	Early adopters vs. non-adopters	Dis-adopters vs. late adopters	Early adopters vs. late adopters	Early adopters vs. dis-adopters
Household and farm characteristics						
Household size (adult equivalent)	-0.355 (0.247)	0.236 (0.218)	-0.376 (0.198)*	0.591 (0.254)**	-0.021 (0.249)	-0.613 (0.205)***
Age of household head (years)	0.017 (0.016)	0.044 (0.013)***	0.006 (0.012)	0.027 (0.017)	-0.011 (0.016)	-0.038 (0.013)***
Education of household head (years of schooling)	0.108 (0.058)*	0.062 (0.046)	0.058 (0.042)	-0.046 (0.061)	-0.05 (0.055)	-0.004 (0.042)
Farming main head occupation (1=Yes 0=No)	0.362 (0.383)	-0.268 (0.301)	0.545 (0.284)*	-0.63 (0.405)	0.182 (0.388)	0.812 (0.303)***
Resource constraints						
Number of Hass avocado trees	0.109 (0.035)***	0.127 (0.032)***	0.128 (0.032)***	0.018 (0.018)	0.02 (0.018)	0.001 (0.007)
Number of Fuerte avocado trees	0.01 (0.019)	0.005 (0.012)	-0.009 (0.018)	-0.005 (0.018)	-0.019 (0.018)	-0.014 (0.015)
Owned cultivated land (hectares)	-0.829 (0.372)**	-1.032 (0.318)***	-0.45 (0.240)*	-0.203 (0.433)	0.379 (0.362)	0.582 (0.306)*
Major farm assets and furniture (in 1000s of Kenyan shillings))	0.00 (0.001)	0.00 (0.001)	0.00 (0.001)	0.00 (0.001)	0.00 (0.001)	0.00 (0.001)
Access to off-farm income (1=Yes 0=No)	0.095 (0.467)	-0.233 (0.377)	-0.121 (0.344)	-0.327 (0.488)	-0.216 (0.417)	0.111 (0.357)
Credit-constrained household (1=Yes, 0=No)	-0.479 (0.465)	-0.231 (0.365)	-0.631 (0.312)**	0.248 (0.487)	-0.153 (0.453)	-0.401 (0.369)
Livestock owned in TLU	0.128 (0.110)	-0.097 (0.134)	0.074 (0.107)	-0.226 (0.138)	-0.054 (0.053)	0.171 (0.137)
Hired labor (1=Yes, 0=No)	-0.458 (0.372)	0.115 (0.320)	0.32 (0.286)	0.574 (0.394)	0.778 (0.353)**	0.205 (0.305)
Market access						
Distance to local market (kilometers)	-0.076 (0.103)	0.056 (0.063)	-0.231 (0.148)	0.132 (0.074)*	-0.155 (0.141)	-0.287 (0.135)**
Distance to main market (walking minutes)	0.004 (0.010)	-0.001 (0.008)	0.017 (0.011)	-0.005 (0.007)	0.012 (0.010)	0.018 (0.009)*
Social capital networks						
Trust neighbors (1=Yes, 0=No)	-0.327 (0.391)	0.496 (0.294)*	0.276 (0.261)	0.824 (0.413)**	0.603 (0.374)	-0.221 (0.290)
Cooperate with other avocado farmers (1=Yes, 0=No)	1.094 (0.750)	-0.407 (0.951)	0.328 (0.679)	-1.501 (0.808)*	-0.766 (0.584)	0.735 (0.707)
Avocado farming perceptions and practice						
Satisfaction with avocado farming (1=satisfied 0=Otherwise)	-0.389 (0.412)	-0.018 (0.364)	0.653 (0.355)*	0.371 (0.459)	1.043 (0.411)**	0.671 (0.378)*
Avocado working conditions (1=Strenuous 0=Otherwise)	0.277 (0.410)	0.403 (0.347)	0.209 (0.290)	0.125 (0.449)	-0.069 (0.388)	-0.194 (0.352)
Keep avocado related records (1=Yes, 0=No)	0.208 (0.620)	0.775 (0.467)*	0.752 (0.418)*	0.567 (0.634)	0.545 (0.592)	-0.022 (0.409)
Risk preference (1=Yes, 0=No)	0.259 (0.458)	0.302 (0.358)	0.148 (0.316)	0.044 (0.480)	-0.111 (0.438)	-0.154 (0.327)
Location dummies	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Constant	-5.221 (1.951)***	-4.96 (1.363)***	-1.843 (1.195)	0.26 (2.113)	3.378 (1.986)*	3.117 (1.347)**
Number of observations	529					

Wald chi²(69)	214.1***
Pseudo R^2	0.2379
Log pseudolikelihood	-516.53

Note: Statistical significance at *p<0.1, **p<0.05, ***p<0.01. Presented above are the odds ratio coefficients (standard error).

Random Effects Model Estimations

Table 6 presents the results of the random-effects model for farmers' participation in group membership (Equation 5). The first rows present estimations for the full sample; subsequent rows show results by gender. Similar to the MNL results, the gender of the household head had a significant positive impact on the probability of participating in PMOs, implying that households headed by men are more likely to join groups than households headed by women, again suggesting the existence of a resource gap among the latter group.

Table 6: Random-Effects Model for Participation in Avocado- Production and -Marketing Groups

	Full sample		Households headed by women		Households headed by men	
Household and farm characteristics						
Household size (adult equivalent)	-0.008	(0.019)	0.023	(0.039)	-0.011	(0.022)
Gender of the household head	0.073	(0.035)**				
Age of household head (years)	0.001	(0.001)	0.000	(0.002)	0.002	(0.001)
Education of household hear (years of schooling)	0.008	(0.004)**	0.010	(0.007)	0.005	(0.004)
Farming main head occupation (1=Yes 0=No)	0.035	(0.025)	0.031	(0.051)	0.035	(0.029)
Resource constraints						
Number of Hass avocado trees	0.010	(0.002)***	0.010	(0.009)	0.01	(0.002)***
Number of Fuerte avocado trees	0.004	(0.003)	0.014	(0.011)	0.005	(0.003)
Number of Hass avocado trees squared	0.000	(0.000)***	0.000	(0.000)	0.000	(0.000)**
Number of Fuerte avocado trees squared	0.000	(0.000)**	-0.001	(0.000)*	0.000	(0.000)**
Owned cultivated land (hectares)	-0.004	(0.019)	0.089	(0.041)**	-0.018	(0.019)
Major farm assets and furniture (in 1000s of Kenyan shillings))	0.000	0.000	0.000	(0.000)	0.000	(0.000)
Access to off-farm income (1=Yes 0=No)	-0.049	(0.027)*	0.011	(0.058)	-0.06	(0.032)*
Credit-constrained household (1=Yes, 0=No)	0.002	(0.035)	-0.065	(0.085)	0.004	(0.038)
Livestock owned in TLU	-0.013	(0.006)**	0.000	(0.010)	-0.016	(0.008)**
Hire labor (1=Yes, 0=No)	0.067	(0.029)**	0.064	(0.062)	0.061	(0.033)*
Market access						
Distance to local market (kilometers)	0.000	(0.003)	0.002	(0.002)	-0.017	(0.006)***
Distance to main market (walking minutes)	0.000	(0.001)	0.001	(0.001)	0.002	(0.001)**
Social capital networks						
Trust neighbors (1=Yes, 0=No)	0.041	(0.024)*	0.024	(0.046)	0.056	(0.028)**
Cooperate with other avocado farmers (1=Yes, 0=No)	0.032	(0.056)	-0.037	(0.135)	0.042	(0.057)

Avocado farming perceptions and practice						
Satisfaction with avocado farming (1=satisfied 0=Otherwise)	0.080	(0.030)***	0.083	(0.046)*	0.079	(0.037)**
Avocado working conditions (1=Strenuous 0=Otherwise)	0.006	(0.027)	-0.012	(0.041)	0.014	(0.033)
Keep avocado related records (1=Yes, 0=No)	0.081	(0.042)*	0.017	(0.101)	0.094	(0.046)**
Risk preference (1=Yes, 0=No)	0.031	(0.031)	0.053	(0.067)	0.015	(0.036)
Location fixed effects	*Yes*		*Yes*		*Yes*	
Constant	0.005	(0.115)	-0.070	(0.222)	0.089	(0.135)
Number of observations	1348		299		1,049	
Wald Chi squared (29)	638.58***		289.27		432.22	
R-squared	0.2811		0.3543		0.2659	

Note: Statistical significance at *p<0.1, **p<0.05, ***p<0.01; Robust standard errors in parenthesis

Consistent with the MNL pooled data results for early adopters, education of the household head, the number of improved avocado trees (Hass*),* satisfaction with avocado farming, and record-keeping are significant and positively related to participation in groups. Better educated farmers are more aware of the benefits of innovations and greater ability to interpret available information to address their production constraints such as joining PMOs to reduce marketing transaction costs (Korir et al., 2015; Pender & Alemu, 2007). Farmers with more improved avocado trees are expected to join farmer associations to reap benefits associated with ownership of improved avocado varieties.

For gender-disaggregated analysis, ownership of a larger amount of land had a positive impact on the probability that households headed by women would join an avocado production and marketing group. Farm size has been shown to be important in determining participation in productivity and income-enhancing activities such as farmer associations and contract farming (Khonje et al., 2015). Although only significant at 10%, similarly to the pooled sample, the number of Hass avocado trees owned (squared) had a significant positive impact on the probability that households headed by women would join a group, while ownership of Fuerte avocado trees (squared) had a significant negative impact. For households headed by men, most significant determinants were similar to those in the pooled sample, with the exception of market-access variables. As expected, longer distance to the local market had a significant negative impact on the probability of households headed by men joining a group, which could be attributed to high transaction costs of delivering the farm produce to the sellers (Feleke & Zegeye, 2006).

5.1.2 Factors Affecting Contract Farming Conditional on Group Membership

Table 7 shows the estimates of sequential participation in the high-value-market value chain using a bivariate probit (Equations 8 and 9), together with the marginal effects of the explanatory variables. A bivariate-probit-model estimation requires an identification condition for Equations 8 and 9, suggesting establishing variables that correlate with group membership but not directly with contract farming. We achieved this by including the "group membership fees" in Equation 8. The model estimation shows that the null hypothesis (i.e., that ρ is zero) was rejected at the 1% level, suggesting the validity of estimating the two selection equations jointly. The ρ is positive, implying that the unobserved factors that affect participation in groups also increased the probability of participation in contract farming.

Table 7: Determinants of the Probability of Participation in the High-Value Avocado Market

	Bivariate model		Marginal effects[1]	
	Group membership	Contract farming	Both Group and contract	Group only
Household and farm characteristics				
Household size (adult equivalent)	-0.233 (0.108)**	0.064 (0.116)	0.003 (0.019)	-0.095 (0.038)**
Gender of household head (0=Women 1=Men)	0.25 (0.157)	0.183 (0.187)	0.035 (0.029)	0.064 (0.057)
Age of household head (years)	-0.002 (0.006)	0.006 (0.007)	0.001 (0.001)	-0.002 (0.002)
Education of household hear (years of schooling)	0.017 (0.018)	-0.004 (0.020)	-0.0001 (0.003)	0.007 (0.006)
Farming main head occupation (1=Yes 0=No)	0.146 (0.128)	0.353 (0.150)**	0.057 (0.024)**	0.001 (0.046)
Resource constraints				
Number of Hass avocado trees	0.036 (0.009)***	0.027 (0.011)**	0.005 (0.002)***	0.009 (0.003)***
Number of Fuerte avocado trees	0.014 (0.020)	-0.005 (0.022)	-0.0003 (0.003)	0.006 (0.007)
Number of Hass avocado trees (squared)	-0.0002 (0.000)***	-0.0003 (0.000)*	-0.00005 (0.00002)**	-0.0001 (0.00003)
Number of Fuerte avocado trees (squared)	-0.001 (0.001)	-0.0001 (0.001)	-0.00004 (0.0001)	-0.0002 (0.0002)
Owned cultivated land (hectares)	0.191 (0.120)	0.103 (0.143)	0.0210 (0.023)	0.054 (0.043)
Major farm assets and furniture (in 1000s of Kenyan shillings))	-0.0001 (0.0003)	0.0005 (0.0004)	0.0001 (0.0001)	-0.0001 (0.0001)
Access to off-farm income (1=Yes 0=No)	-0.319 (0.131)**	-0.143 (0.141)	-0.0308 (0.023)	-0.096 (0.047)**
Credit-constrained household (1=Yes, 0=No)	0.021 (0.195)	-0.045 (0.218)	-0.0061 (0.035)	0.014 (0.070)

	-0.022	-0.067	-0.0107	0.002
Livestock owned in TLU	(0.040)	(0.055)	(0.008)	(0.015)
Market access				
Distance to local market (kilometers)	-0.008	0.019	0.0026	-0.006
	(0.009)	(0.018)	(0.003)	(0.004)
Distance to main market (walking	0.002	-0.001	-0.0001	0.001
minutes)	(0.002)	(0.003)	(0.000)	(0.001)
Social capital networks				
	-0.126	0.03	0.0008	-0.051
Trust neighbours (1=Yes, 0=No)	(0.131)	(0.144)	(0.023)	(0.047)
Cooperate with other avocado farmers	0.522	-0.257	-0.0229	0.230
(1=Yes, 0=No)	(0.277)*	(0.300)	(0.047)	(0.103)**
Satisfaction with avocado farming	0.534	0.321	0.0637	0.148
(1=satisfied 0=Otherwise)	(0.165)***	(0.210)	(0.033)*	(0.060)**
Avocado working conditions	0.084	-0.046	-0.0043	0.038
(1=Strenuous 0=Otherwise)	(0.156)	(0.172)	(0.027)	(0.055)
	-0.017	0.549	0.0815	-0.088
Risk preference (1=Yes, 0=No)	(0.141)	(0.178)***	(0.028)***	(0.052)**
Group membership fees (in 1000s of	0.015		0.0004	0.006
Kenyan shillings))	(0.004)***		(0.000)***	(0.002)***
Location fixed effects			Yes	Yes
Constant	-0.84	-2.764		
	(0.552)	(0.669)***		
RHO (ρ)	0.612 (0.068)***			
Number of observations	658			
Log- likelihood	- 529.55			
LR test	207.53***			

Note: Standard errors in parenthesis. Statistical significance at *p<0.1, **p<0.05, ***p<0.01. [1]Contract participation is only observed if a farmer participates in a group ($\boldsymbol{I_C \neq 1 \; if \; I_G = 0}$).

Our variable of interest, the gender of the household head, was positive but not significant, implying that households headed by men are not significantly more likely to join a group or enter into a contracting. The result contradicts those from random-effects estimation, perhaps because the bivariate probit estimation did not account for omitted variables because of the potential endogeneity of some independent variables, which are both addressed in the former regression model. However, as in the previous estimation, ownership of a higher number of Hass avocado trees has a significant positive impact on the probability of joining a farmer group and of contract farming, supporting the hypothesis that participation in income-enhancing agricultural activities is not scale neutral. Smallholders are rational and are therefore expected to adopt or participate in productivity and income-enhancing innovations or practices such as contract farming. Risk preference, one of the social capital measures of this study, has a significant positive effect on contract farming as hypothesized. Farmers with greater risk preferences are likely to adopt income-enhancing farm practices including new technologies and collective produce marketing strategies, such as contract farming.

5.2 Smallholders' Motivations for Participating in High-Value Avocado Farming

The analytical results above and findings from qualitative data show that participation of smallholders in high-value avocado farming is clearly driven by economics—mainly better market prices and assured markets for perishable produce. Results from the qualitative survey further show that, like many market-value chains in Kenya, middlemen compete with export firms to bridge the gap between farms and the market. Farmers view them as exploitative, however, both for the prices they offer and for their defaults on market transactions, which are often informal agreements. Although faced with some challenges, farmers noted that contract farming is a better market-participation pathway than using middlemen. Contract adopters recounted that they could plan for expected income as opposed to receiving small payouts by brokers on no specific schedule. They also received training in crop management, including spraying, fertilizing, pruning, harvesting, and grading, which was perceived to enhance the production and quality of their avocado crop. Similar sentiments were echoed by those who stayed in avocado PMOs. Respondents to the qualitative survey perceived production and marketing in groups as an entryway to the lucrative export market and subsequently to higher earnings as compared to alternative market outlets. Being in a group also facilitated collective produce collection thereby reducing market-transportation transaction costs.

Although the benefits of smallholder farmers' participation in high-value markets are clear from the literature, information regarding the success of participation pathways—group membership and contract farming—is limited. In the study area, side-selling was observed as a common obstacle to the success of contract farming (in this scenario, farmers fail to honor the contract and sell produce to a third party). Farmers engage in side-selling for various reasons, some of which are purely economic: opportunistic sale to another buyer who offers a higher price, for example. The need for liquidity also inspired farmers to sell their fruit through brokers in spot markets.

Women observed that they sometimes felt cheated by the returns they received from the produce they delivered and were thus tempted to sell to brokers when they offered better prices than the contracting company. The lack of trust between farmers and contracting firms was evident, including failure to communicate and abide by the terms and conditions of contracts. In general, farmers observed that the contracting companies did not provide records of fruit sold, including prices offered for various produce grades and quantity sold and rejected. Lack of timely collection of the produce by firms also persuaded farmers to look for alternative buyers in order to avoid post-harvest losses that are most often not covered by firms.

Most agreements, however, were loose contracts with weak or no regulatory and institutional framework and were thus only legally binding in theory. As a result, either party might be prompted to engage in opportunistic behavior to the detriment of the other. Although the government, through the Ministry of Agriculture, is involved during the drafting of contracts between firms and farmers, it offers little support to farmers in resolving conflicts. Furthermore, unlike many horticultural crops that have shorter harvesting seasons, avocado is an annual crop, which compels farmers to leave contract or group membership to avoid paying the subscription fees during off or low seasons. Group abandonment was also attributed to poor group leadership and other management-related disputes. The majority of those who exited contract and group membership were men, perhaps because they had more information and greater access to alternative markets in comparison to women.

VI. Conclusions and Policy Recommendations

We used panel data consisting of two waves of household-level data obtained from one of the avocado-producing counties in Kenya, Murang'a County, to examine the factors associated with smallholder participation in high-value export markets. The study contributes to the limited literature on the dynamics of smallholder horticultural farmers' participation in high-value markets. We diverged from previous studies that considered adoption using binary models and instead used panel data to construct the dynamics of market participation. Using a multinomial logit model and baseline household information to describe the current period, we controlled for the endogeneity that arose from households' self-selection of one participation choice or another. This allowed us to incorporate the time span between adoption and abandonment. In addition, our analysis focused on the gender of the household head, based on existing evidence that men and women participate in markets differently, an aspect that is quite often ignored in many studies of the adoption of agricultural technology. We considered two forms of high-value market participation: group membership and contract farming, both of which have been widely used as avenues to link smallholders to markets. Based on existing evidence that the majority of smallholder farmers in Kenya can only be contracted by exporters as a group, we estimated the factors that affected contract farming conditional on group membership.

Given the nature of our data, we divided group participation dynamics into four categories: late adopters, early adopters, dis-adopters, and non-adopters. Late adopters were farmers who were not in groups during the first round of the survey but were participants during the follow-up; dis-adopters had dropped out of participation by the time of the follow-up survey, early adopters were participating during both rounds of the survey, and non-adopters were respondents who were not participating during both rounds of the survey. Our descriptive results show that a significant proportion of respondents exited (dis-adopters) from contract farming (11%) and from groups (17%), hence demonstrating the need to model smallholder market participation beyond binary analysis.

We estimated the model using the full sample, and then separated estimations for households headed by men or by women for group-participation and pooled model for contract farming. Our results showed that the categories of farmers differed with regard to household and farm characteristics, resource constraints, market access, and avocado-farming perceptions and practices. We found that early adopters had smaller families, their household heads were younger, were more likely to rely on farming as their main occupation, and perceived greater satisfaction with avocado farming than did dis-adopters. As a result of data limitations, and based on existing literature on technology-adoption dynamics, we combined late adopters and non-adopters and referred to them as laggards in the analysis of households headed by women. We found that early adopters were more educated, had fewer Hass avocado trees, and were more credit-constrained than were dis-adopters. Laggards also owned less of the improved avocado variety (Hass) in comparison with dis-adopters and early adopters. With regard to households headed by men, dis-adopters had bigger families, their household heads were older, they were closer to the local market, their household heads less likely to be dependent on farming as their main occupation, and they were less satisfied with avocado farming in comparison to early adopters. In terms of contract farming conditional on group membership, the gender variable was positive but not significant.

The finding follows the previous random-effects estimation which showed that households headed by men were more likely to participate in both groups and in contracting. The number of improved avocado trees and risk preference were also likely to positively influence contract farming.

While we found useful insights into the dynamics of smallholder participation in high-value markets, we acknowledge limitations in our analysis. One was the short period between surveys, which may not have allowed us to answer critical policy questions regarding adoption dynamics. Second was the lack of an adequate sample of households headed by women to model dynamics. A third limitation was the comparison between households headed by women and households headed by men, which may not have been a perfect gender indicator: in fact, the management of farm plots depends upon the gender of the decision-maker rather than of the head of the household. More research is required to close these gaps.

Even with these caveats, the results suggest important implications. Primary among these is that larger orchards of improved avocado varieties (Hass) can increase and sustain smallholders' participation in high-value markets, both through contracts and group membership. Efforts in this direction are evident, and, driven mainly by international demand, the Murang'a County government is already promoting adoption of the improved avocado variety. Another significant implication is that policy measures to discourage farmers from abandoning high-value markets should include improvement of household-level education, including quality extension services and other training platforms. Social networks that build trust among community members, as well as between traders and farmers, may also be considered to encourage non-adopters to participate in production for high-value markets.

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Conflict of Interest

The authors declare that they have no conflicts of interest.

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Appendix

Table A1: Comparison of Farm Household, Social Capital, and Village Level Characteristics across Contract-Farming-Adoption Groups

	Early adopters (n=264)		Dis-adopters (n=148)		Late adopters (n=272)		Non-adopters (n=664)		F-test
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
Household and farm characteristics									
Household size (adult equivalent)	1.88	0.58	2.12	0.79	1.95	0.60	1.97	0.69	4.09***
Gender of household head (1=Male, 0=Female)	0.82	0.39	0.77	0.42	0.85	0.36	0.74	0.44	5.5***
Age of household head (years)	64.67	11.75	65.07	13.06	62.63	10.81	63.72	13.15	1.75
Education of household head (years of schooling)	8.27	3.45	7.86	3.99	8.51	4.03	7.66	3.88	3.78**
Farming main head occupation (1=Yes 0=No)	0.73	0.45	0.59	0.49	0.73	0.44	0.61	0.49	7.15***
Resource constraints									
Number of Hass avocado trees	12.41	18.84	11.55	19.55	8.26	15.58	4.341	10.53	24.14***
Number of Fuerte avocado trees	4.72	7.69	6.43	10.48	4.60	6.93	3.89	7.69	4.30***
Owned cultivated land (hectares)	0.81	0.66	0.75	0.86	0.64	0.53	0.60	0.60	8.64***
Major farm assets and furniture (in 1000s of Kenyan shillings))	77.99	154.27	67.45	116.39	72.41	268.98	53.05	125.90	1.77
Access to off-farm income (1=Yes 0=No)	0.69	0.46	0.76	0.43	0.67	0.47	0.74	0.44	
Credit-constrained household (1=Yes, 0=No)	0.11	0.31	0.10	0.30	0.14	0.35	0.14	0.35	1.2
Livestock owned in TLU	1.64	1.44	1.50	1.25	1.51	2.21	1.37	1.74	1.64
Hired labor (1=Yes, 0=No)	0.70	0.46	0.73	0.45	0.40	0.49	0.42	0.49	17.56***
Market access									
Distance to local market (kilometers)	3.99	11.09	3.21	5.11	2.93	2.29	2.65	2.05	1.94
Distance to market (walking minutes)	42.51	28.95	37.91	19.70	41.48	32.51	37.35	26.20	1.5
Social capital networks									
Trust neighbors (1=Yes, 0=No)	0.37	0.48	0.36	0.48	0.31	0.46	0.35	0.48	0.72
Cooperate with other avocado farmers (1=Yes, 0=No)	0.08	0.27	0.07	0.25	0.07	0.26	0.03	0.17	2.14*
Avocado production perceptions									
Stability for avocado farming (1=Stable, 0=otherwise)	0.90	0.30	0.84	0.37	0.88	0.33	0.78	0.41	8.36***
Avocado working conditions (1=Strenuous 0=Otherwise)	0.76	0.43	0.75	0.43	0.79	0.41	0.78	0.41	0.57
Keep avocado related records (1=Yes, 0=No)	0.20	0.40	0.15	0.36	0.08	0.27	0.05	0.22	9.61***
Risk preference (1=Yes, 0=No)	0.80	0.40	0.69	0.47	0.76	0.43	0.70	0.46	2.13*

Note: Statistical significance at *p<0.1, **p<0.05, ***p<0.01. [a]1348 observations from 674 households.

Table A2: Comparison of Farm Household, Social Capital, and Village-Level Characteristics of Sample Households across Different Categories of Avocado Production and Marketing Groups

Group member dynamics	Early adopters (n=446)		Dis-adopters (n=225)		Late adopters (n=121)		Non-adopters (n=556)		F-test
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
Household and farm characteristics									
Household size (adult equivalent)	1.889	0.603	2.072	0.712	1.999	0.577	1.979	0.704	4.200***
Gender of household head (1=Male, 0=Female)	0.823	0.382	0.818	0.387	0.934	0.250	0.692	0.462	16.100***
Age of household head (years)	63.939	11.787	64.818	12.618	63.058	10.653	63.520	13.228	0.670
Education of household hear (years of schooling)	8.327	3.652	7.800	3.757	8.661	4.337	7.612	3.913	4.340***
Farming main head occupation (1=Yes 0=No)	0.717	0.451	0.636	0.482	0.702	0.459	0.606	0.489	5.170***
Resource constraints									
Number of Hass avocado trees	10.80	17.71	10.68	18.70	7.61	20.27	3.55	6.20	24.52***
Number of Fuerte avocado trees	4.49	6.18	4.50	8.13	4.68	8.41	4.45	8.94	0.03
Owned cultivated land (hectares)	0.742	0.597	0.600	0.487	0.611	0.460	0.638	0.739	3.600**
Major farm assets and furniture (in 1000s of Kenyan shillings))	77.373	239.534	53.263	92.219	57.780	87.314	57.578	134.454	1.550
Access to off-farm income (1=Yes 0=No)	0.666	0.472	0.738	0.441	0.686	0.466	0.761	0.427	4.180***
Credit-constrained household (1=Yes, 0=No)	0.110	0.313	0.116	0.320	0.157	0.365	0.147	0.355	1.390
Livestock owned in TLU	1.524	1.378	1.371	1.172	1.774	2.987	1.397	1.836	2.050
Hire labor (1=Yes, 0=No)	0.605	0.490	0.509	0.502	0.361	0.484	0.457	0.499	5.660***
Market access									
Distance to local market (kilometers)	3.317	8.076	3.639	6.219	2.920	2.323	2.578	1.948	1.310
Distance to market (walking minutes)	41.520	29.008	41.540	30.273	40.217	32.062	36.302	23.812	1.850
Social capital networks									
Trust neighbors (1=Yes, 0=No)	0.348	0.477	0.369	0.484	0.314	0.466	0.347	0.476	0.410
Cooperate with other avocado farmers (1=Yes, 0=No)	0.072	0.259	0.035	0.186	0.117	0.324	0.029	0.167	3.460**
\Avocado production perceptions									
Stability for avocado farming (1=Stable, 0=otherwise)	0.881	0.324	0.867	0.341	0.851	0.357	0.773	0.419	7.970***
Avocado working conditions (1=Strenuous 0=Otherwise)	0.778	0.416	0.791	0.407	0.793	0.407	0.764	0.425	0.320
Keep avocado related records (1=Yes, 0=No)	0.148	0.356	0.134	0.342	0.066	0.250	0.050	0.219	5.370***
Risk preference (1=Yes, 0=No)	0.749	0.435	0.770	0.423	0.817	0.390	0.687	0.465	1.980

Note: Statistical significance at *p<0.1, **p<0.05, ***p<0.01. [a]*1348 observations from* 674 households.