Social Networks and Commercialisation of African Indigenous Vegetables in Kenya: A Cragg's Double Hurdle Approach

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Social Networks and Commercialisation of African Indigenous Vegetables in Kenya: A Cragg's Double Hurdle Approach

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Abstract: This paper employs a two-stage *Cragg's* double-hurdle model to assess the effects of market information networks on commercialisation decisions of smallholders of African Indigenous Vegetables (AIVs). We explore sources of market information and social networks for information exchange as determinants of the decision to sell and how much volume to sell. The paper is based on household survey data collected in Western Kenya from 202 farmers, using multistage sampling. Findings show market information networks to have positive effects on the second stage decision of volumes sold. Bridging social capital depicted by information received from people outside farmers' own village had the likelihood of increasing volumes of AIVs sold. Other determinants of commercialisation were farm size and household size which reported positive marginal effects while age, livestock units and off-farm income reported negative marginal effects. We recommend the need to have policy frameworks that strengthen network linkages for farmers aimed at promoting market information exchange, as this will have a positive effect in the commercialisation of indigenous crops.

ABOUT THE AUTHORS

Catherine Mwema is currently a member of a consortium of researchers in Germany and East Africa working under the Horticultural Innovation and Learning for Improved Nutrition and Livelihood in East Africa (HORTINLEA), multi-disciplinary programme, with an aim of addressing food security and alleviating poverty. Catherine's research interests are in collective action, market linkages and inclusive value chains. Previously, Catherine worked with CGIAR under Markets, Institutions and Policy in Africa, where she focused on socioeconomic research for development of smallholder agriculture.

Wibke Crewett is a policy analyst and senior researcher at Humboldt-University in Berlin. She holds a PhD in Agriculture from Humboldt-University which she gained for her research on rangeland management policy in Central Asia. Her field of interest is the holistic study of agrarian institutions from land law to local level collective action groups in a wide range of contexts. Previous projects have taken her to Usbekistan, Kyrgyzstan, India, Tanzania and Indonesia. Currently she works on bioeconomy and climate change policies in Germany.

PUBLIC INTEREST STATEMENT

Lack of, or poor access to market information are among challenges hindering smallholder access to markets. This is largely contributed to lack of a well-functioning public extension system in most emerging economies. Social networks could offer opportunities for access to market information and subsequently increased commercialization. African indigenous vegetables (AIVs) are rich in nutrients to contribute to food and nutritional security, but their perishable nature necessitates farmers to access markets promptly. We, therefore, aim to assess how social networks affect commercialisation of AIVs among smallholders. We find bridging social capital—networks outside farmers own village—to have a high likelihood of increasing volumes of AIVs sold. The findings of this study are important to contribute to policy frameworks aimed at improving commercialisation of indigenous crops.

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1. Introduction

African Indigenous Vegetables (AIVs) also referred to as African Leafy Vegetables (ALVs) were once considered as poor man's crop consumed in rural areas. They have increasingly become an important crop in both urban and peri-urban areas. In Kenya, there is evidence that the demand for indigenous vegetables has been growing (Abukutsa-Onyango, 2007; Ngugi & Nyoro, 2007; Weinberger, Pasquini, Kasambula, & Abukutsa-Onyango, 2011). This has been exacerbated by the increased nutritional awareness of AIVs especially among urban dwellers (Kimiywe, Waudo, & Mbithe, 2006; Muhanji, Roothaert, Webo, & Mwangi, 2011). The increasing demand of AIVs needs to be encouraged and exploited for the benefit of smallholders. It is therefore important to identify and address the major constraints to commercialisation of AIVs so that indigenous vegetables can continue to play a significant role in the livelihoods of smallholders. Generally, AIVs have been found to have higher levels of various nutrients than conventionally cultivated species (Shackleton, Pasquini, & Drescher, 2009). For instance, AIVs contain up to 80% of the recommended daily requirement of iron and 18–54% of the daily requirement of protein (Abukutsa-Onyango, 2007). Spider plant, African nightshade, Cowpeas, vegetable Amaranth and Pumpkin leaves are some of the most consumed AIVs in Kenya (Irungu, Mburu, Maundu, Grum, & Hoescle-Zeledon, 2008; Onyango & Jasper, 2007). Consumption of AIVs contributes immensely in addressing the nutritional security of food systems among both rural and urban dwellers. Similarly, commercialisation plays an imminent role in making AIVs accessible to consumers particularly in urban and peri-urban areas.

Despite the benefits from agricultural commercialisation, smallholders still face numerous challenges in accessing input and output markets. Among other challenges, high transaction costs have been found to hinder commercialisation efforts of smallholders (Key, Sadoulet, & De Janvry, 2000; Okoye et al., 2016; Ouma, Jagwe, Obare, & Abele, 2010). Cost of searching and obtaining market information is one of the transaction costs that constrain agricultural commercialisation (Key et al., 2000). Access to market information is an important determinant in agricultural commercialisation (Ochieng., Knerr, Owuor, & Ouma, 2015; Omiti, Otieno, Nyanamba, & Mc Cullough, 2009). Market information allows farmers to take informed marketing decisions that are related to supplying necessary goods, searching for potential buyers, negotiating, enforcing and monitoring contracts. Necessary information includes information on consumer preferences, quantity demanded, prices, produce quality, market requirements and market opportunities (Ruijs, Schweigman, & Lutz, 2002). Information asymmetry creates welfare losses for market actors (Martey, 2014) and may acts as barriers to entry for potential players hence creating market imperfections. Of equal importance, is the source of market information because it determines the accuracy and accessibility of information.

Public extension is an important source of information among rural farmers. However, most smallholders experience limited access to public extension services (FAO, 2013; Mwema & Crewett, 2019; Shiferaw, Obare, Muricho, & Silim, 2009) which limits access to market information. Private sources of market information are on the other hand beyond the reach of smallholders (FAO, 1999). Market information is therefore gathered through personal networks based on mutual trust and by personal visits to markets (FAO, 1999; Lyon, 2000; Mwema & Crewett, 2019). Networks of farmers and farmer groups play a pivotal role in knowledge and information exchange (Martey, 2014; Mwema & Crewett, 2019; Ngugi & Nyoro, 2007). The role of Non-Governmental Organisations (NGOs) in disseminating information has also been found vital (Shiferaw et al., 2009).

Previous studies have assessed determinants of market participation, taking into account the effects of access to market information as a binary variable (Ochieng. et al., 2015; Okoye et al., 2016). Some

studies have applied proxies to estimate effects of various sources of information on commercialisation; for instance, group membership, ownership of mobile phones, radio ownership, access to extension officers (Martey, 2014; Mather, Boughton, & Jayne, 2013). The challenge with using such proxies is that they may not depict actual access to information, resulting in biased estimation. To overcome these assumptions; we asked respondents from whom they received market information; and which source of market information they considered most important. The survey likewise asked the respondents the number of people they talked to inside and outside the villages on market information.

We then applied a double-hurdle model to assess the effects of the information networks in the commercialisation of AIVs. Besides information networks, we controlled for other determinants of commercialisation which include household characteristics, farm characteristics, demographic and socioeconomic variables. The first stage of the double hurdle assessed the decision to sell, and the second stage the extent of volumes sold.

This paper contributes to the literature on agricultural commercialisation through incorporating network effects in understanding determinants of agricultural commercialisation. It builds on literature strands on agricultural commercialisation in Kenya which most have focused on cereals particularly maize (e.g Mather et al., 2013; Omiti et al., 2009), with others focusing on horticultural crops for export (e.g Muriithi & Matz, 2014) and livestock (e,g Bellemare & Barrett, 2006). We focus on AIVs largely consumed by the domestic market. The findings of this paper will have policy implications targeted on strengthening institutional frameworks to facilitate agricultural commercialisation of indigenous crops.

This study aims to address two key objectives 1) To assess the effects of market information networks on the decision to sell 2) To assess the effects of market information networks on the intensity of AIVs sold among smallholders. The rest of the paper is organised as follows: A discussion on smallholder commercialisation and concepts of social networks from which this study draws on. Data and methods, presentation of the results, discussion of the findings and finally, conclusion and policy recommendations.

1.1. Smallholder commercialisation
Commercialisation of agri-food systems is vital for economic development. Smallholders form the majority of farmers in most developing countries. In Kenya, 80% of Fresh Fruits and Vegetables (FFV) farmers comprise of smallholders (GoK, 2012). Commercialisation can therefore achieve the goal of sustainable economic development when smallholders are engaged as part of the solution. Most smallholders focus on a subsistence level of production, access to better paying markets for agricultural products is thus important in enhancing and diversifying the livelihoods of smallholder farmers (Barrett, 2008). As a result, changing smallholder production practices from highly subsistence towards market-oriented levels.

Commercialisation has been considered with respect to both on-farm sales and market sales (Bellemare & Barrett, 2006; Okoye et al., 2016). For highly commercialised staple crops, the interest has been to assess market integration of smallholders in off-farm markets as compared to on-farm markets (Abu, Issahaku, & Nkegbe, 2016; Omiti et al., 2009). In this study, AIVs are majorly sold on-farm due to among other reasons, their perishable nature and high domestic consumption. We, therefore, consider both on-farm and off-farm markets as centres of commercialisation.

In most studies, commercialisation is usually viewed as a two-stage decision process (Abu et al., 2016; Bellemare & Barrett, 2006; Omiti et al., 2009). Households first decide whether to sell AIVs and secondly, they determine how much volume to sell (intensity of commercialisation). The two-stage double-hurdle model has been used in previous studies due to the model's ability to recognise separate processes for the two stages (Achandi & Mujawamariya, 2016; Komarek, 2010; Mather et al., 2013). Sales volume has been used to depict the intensity of commercialisation (Bellemare &

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Barrett, 2006; Mather et al., 2013). Similarly, in this study, we use sales volume measured in kilograms as the dependent variable for the second stage, depicting the intensity of commercialisation.

1.2. Concept of networks

A network is defined by individual members and the links among them through which resources like information flow (Maertens & Barrett, 2013). Network members could be groups, organisations as well as individuals (Wasserman & Faust, 1994). Social networks are an investment, as people make and maintain relationships with an eye towards current or future benefits (Sobel, 2002). Wasserman and Faust (1994) suggest that one could study the impact of social networks to either behavioural, social, political or economic orientation.

Strands of literature have classified the various forms of social relations as either bonding or bridging social capital (Bourne, Gassner, Makui, Muller, & Muriuki, 2017; Grannovetter, 1973; Woolcock, 2001). Bonding social capital develops from ties between actors in the same subgroup, often between family members, neighbours and friends (Woolcock, 2001). Bridging social capital develops from ties between subgroups or different actors, for instance between acquaintances (Granovetter, 1973). Studies have endeared to understand the role played by various forms of networks particularly in the adoption of technologies (Bandiera & Rasul, 2006; Bourne et al., 2017; Maertens & Barrett, 2013).

Granovetter (1973) on the "theory of weak ties" found out that most people learned information leading to their current jobs through acquaintances rather than close friends. He concluded that a high level of homogeneity exists among bonding social capital. As a result, bridging social capital could be a greater source of information diffusion than bonding (Granovetter, 1973). Bridging social capital is important as it provides access to resources and opportunities that do not exist within a closed circle of friends, family or neighbourhood (Bourne et al., 2017; Granovetter, 1973). Bonding social capital, on the other hand, represents higher levels of trust where actors have belief in other actors to act in an agreed manner (Bourne et al., 2017). Bandiera and Rasul (2006) found the influence of family and friends (bonding social capital) to have a greatest positive influence on the adoption of technologies up to the point where many people in the network have adopted.

In determining the influence of social networks on adoption of sunflower—a new crop in Mozambique; Bandiera and Rasul (2006) found adoption decisions were more correlated within family and friends and uncorrelated among individuals of different religions. On the other hand, Muange *et al.* (2014) found out that it is information networks outside a farmer's village rather those inside the village that determined intensity of exposure to improved cereal varieties in Tanzania. On innovation networks, Spielman, Davis, and Negash (2011) found Public service providers to play the most prominent role in smallholder innovation processes. However, their role was less evident with respect to developing marketing links or transmitting price information to smallholders (Spielman et al., 2011). Using a two-stage regression model, Landry, Amara, and Lamari (2002) found out that research networks influenced both innovation decision and extent of innovation while business networks only influenced innovation-decision. Maertens and Barrett (2013) used a probit model to assess determinants of learning networks on adoption of a new variety, *Bacillus thurigiensis* (Bt) cotton in India. They found out that social networks for learning are structured along land classes, educational levels and income levels (Maertens & Barrett, 2013).

In agricultural trade, Fafchamps and Minten (2002) found out that more networked traders in Madagascar had higher profit margins compared to less networked. We aim to assess the effects of social networks in commercialisation decisions of smallholders.

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2. Data and methods

This paper is based on data from a household survey conducted in Kenya in 2015, as part of the HORTINLEA programme. The HORTINLEA programme is an interdisciplinary research project with the aim of addressing food security and poverty alleviation in East Africa. The household survey was conducted in September to October 2015. It covered five selected Counties in Kenya engaged in the production and marketing of AIVs. Respondents in the counties were selected using multi-stage sampling. This paper focuses on data from one of the Counties where the survey was conducted—Kakamega County. The study site, Kakamega County is majorly a rural area with most farmers producing at a small scale. It covers an area of approximately 3050.3 Km^2. The altitudes of the County range from 1,240 m to 2,000 m above sea level. The main crops grown are sugarcane, maize, beans, cassava, sweet potatoes and horticultural crops. The County has high rainfall, almost evenly distributed all year round. The rainfall ranges from 1280.1 mm to 2214.1 mm per year with an average humidity of 67%.

During sampling, the first step was to select divisions in Kakamega County. The selection was based on information from the respective agricultural officers on the intensity of AIV production. A total of ten divisions were selected. From each of the selected divisions, locations were randomly selected. Subsequently, households within the locations were randomly selected. A total of 202 AIV farmers were interviewed using a structured questionnaire. The survey captured socio-economic characteristics, crops and livestock production and marketing, incomes and expenditures, among others. The survey incorporated questions related to market information access, social networks in market information sharing, and market sales from whence this paper focuses on. Data collected in the survey was entered and cleaned in SPSS. Data exploration and descriptive analysis were conducted in SPSS 20. Econometric modelling and analysis were performed in STATA 13.0.

2.1. Model description

A number of econometric choice models have been applied to study participation behaviour among farming households. These models have been applied depending on the nature of data available and the question at hand. In binary dependent variables, where data is collected to assess if there is participation or not; Probit and logit models are commonly used. Censored regression model also called the tobit model (Tobin, 1958) are commonly used to model the intensity of participation (Bellemare & Barrett, 2006). However, a key limitation with the tobit model is that it assumes that variables that determine the probability of adoption (incidence of adoption) also determine the level of adoption (intensity of adoption). *Cragg's* independent double-hurdle model has the ability to relax these assumptions by allowing separate stochastic processes for the incidence and intensity of adoption (Cragg, 1971); and has therefore been applied in a number of studies (Achandi & Mujawamariya, 2016; Komarek, 2010; Mather et al., 2013). In the double-hurdle model, two distinct decisions for participation and intensity of participation are observed and determined by a different sets of explanatory variables. Double hurdle is based on two stages, the first stage is a binary variable of participation represented by one; and otherwise, represented by zero. The second stage is a continuous variable of the volumes sold. We assess the case of AIV commercialisation decisions among smallholders in Kenya.

The first hurdle which is the farmer's decision to sell can be represented by:

$$d_i^* = z_i^* \propto + \varepsilon_i \tag{1}$$

Where d_i^* is a latent variable indicating whether or not the farmer participates in AIV marketing, it takes the value of 1 if the farmer participates and 0 if otherwise. α is a vector of unobserved parameters to be estimated. Z_i is a vector of observed independent covariates that explain an individual's decision and ε_i is an unobserved error term.

The second hurdle which is the intensity of participation is indicated by:

$$y_i^* = x_i^* \beta + \mu_i \tag{2}$$

Where y_i^* is the volume of AIVs sold and follows continuous numbers. X_i is a vector of covariates that explain this amount. β is a vector of unobserved parameters to be estimated and μ_i is an error random variable.

The model allows for possible differences between factors that affect participation ($z_i^* \propto, \varepsilon_i$) and factors that affect the intensity of participation ($x_i^* \beta, \mu_i$).

We used *craggit* estimation for the double-hurdle model applying robust standard errors (Burke, 2009; Cragg, 1971; Wooldridge, 2002). Marginal effects were then calculated for each of the explanatory variables by differentiating each of the equations with respect to each explanatory variable (Mutlu & Gracia, 2006; Yen & Su, 1995).

Calculating marginal effects involves examining the derivatives of the conditional mean functions (Wooldridge, 2002). A basic marginal effect function for an independent variable can be stated as follows:

$$\partial P(y > 0 \mid x_1)/\partial x_j = \gamma_j \varphi(x_1 \gamma_1) \tag{3}$$

where y contains non-zero elements, φ is the standard normal probability distribution function, γ_1 represents the coefficient on x_1.

Diagnostic tests for the existence of multicollinearity were conducted using the Variance Inflation Factor (VIF). Table 1 presents the VIF which ranges from 1.05 to 1.19, with a mean of 1.10. These values indicate that there is no evidence of multicollinearity in the estimated model, as the values are way below the critical VIF of 10.

The double-hurdle model was estimated using robust standard errors to correct for heteroscedasticity. Similarly, the log likelihood reported a significant *p*-value (Prob>chi^2 = 0.0005) indicating that the data fitted well to the model.

2.2. Descriptive statistics of variables in the double-hurdle model

Table 2 presents a description of the variables used in the model and their descriptive summary statistics. The dependent variable for the first and second stages of the double-hurdle model, as well as the independent variables are presented in Table 2.

Table 1. Multicollinearity tests—VIF	
Variable	**VIF**
HHsize	1.19
Farmsize	1.17
educ_yrs	1.13
AGE	1.12
Gender	1.11
mktinfo_soure	1.08
TLU	1.08
offfarmINC_share	1.08
ALVINC_share	1.06
outvill_network	1.06
vill_network	1.05
Mkt_dist	1.05
Mean VIF	1.10

Table 2. Descriptive statistics			
Variable names	**Definition**	**Mean/%[a]**	**S.D**
Dependant variables			
AIV_Participation	Participation in AIV marketing (1 if yes)	58.9	0.493
AIV_volume	Volumes sold in KGs	324.92	711.48
Independent variables			
Farmsize	Land owned (in acres)	1.1	1.50
Mkt_dist	Distance to the market (in KM)	2.66	4.8
vill_network	Number of people in the village talked with on market information	7.48	23.46
outvill_network	Number of people outside the village talked with on market information	3.54	7.03
HHsize	Number of household members	6.79	2.38
AGE	Age of the household head (in years squared)	54.52	12.83
educ_yrs	Number of years of formal education	9.34	7.16
Gender	Gender of the household head (I if Male)	90.0	0.30
ALVINC_share	share of AIVs income to household income	0.06	0.18
offfarmINC_share	share of off-farm income to household income	0.66	0.37
TLU[1]	Tropical Livestock Unit	0.2	0.941
mktinfo_source	Source of important market information (1if farmer-based)	42.2	0.48

[a] Mean for continuous variables and percentages (%) for categorical variables
1. Tropical Livestock Units (TLU) are calculated as follows: 1 TLU = {1.0 * Cattle + 1.0 * Donkey + 0 .1 * Goats + 0.1 * Sheep + 0.01 * Chicken}.

   The dependant variable for the first hurdle is defined by 1, if a farming household participates in AIV marketing and 0 otherwise. The statistics show 59% of the farmers sold AIVs. In exploring the type of AIVs sold, we found Cowpea leaves to be the most common-traded AIVs, sold by 84% of the households. Seventy-nine per cent of the households sold African Nightshade and 51% sold Amaranth. Other traded AIVs were Spider plant (39%), Ethiopian Kales (7%), Jute Mallow (6%) and Pumpkin leaves (2%).

   The second hurdle's dependant variable is continuous, defined by the volumes of AIVs sold in kilograms. The average volumes sold by sellers were 375 kilograms (KGs) annually. In exploring the market channels, most farmers sold AIVs to multiple market channels (both on-farm and off-farm). The majority (75%) sold AIVs on-farm to consumers and middlemen, 40% sold to retailers in open markets while 10% sold to wholesale markets. Less than 5% sold to hotels and schools.

   Market information networks are key independent variables in this study. To capture their effects, we included the number of people a farmer talked to on market information, inside and outside the village. Farmers reported to talk to an average of 7.48 people living inside their villages. Similarly, the farmer talked to an average number of 3.54 people who reside outside the village. We hypothesise that, outside village networks will have positive effects on commercialisation.

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We included the sources from which farmers sought the most important market information (Mktinfo_source), as presented in Figure 1. The sources of market information were further categorised into institutional sources, farmer-based sources and traders as depicted in Figure 1.

More than half of the respondents (58%) sought most important market information from institutional sources especially extension officers and NGOs. Farmer-based information exchange was likewise important with almost 40% seeking most important market information from fellow farmers. These were mainly members of farmer groups (30%), and to a lower extent neighbours (6%) and relatives (2%). Traders and middlemen were least considered as sources of important market information (3.9%); therefore, they were dropped from the double-hurdle analysis due to non-convergence. Recent studies have shown access to extension services to have negative effects on commercialisation (Awotide, Karimov, & Diagne, 2016; Martey, 2014). We, therefore, expect farmer-based information sources to have a significant influence on commercialisation as compared to institutional sources.

Household characteristics are important determinants influencing commercialisation decisions. Studies have incorporated various household characteristics in participation models; for instance, household size, age, education, gender (Fischer & Qaim, 2013; Martey, 2014; Ochieng. et al., 2015; Ouma et al., 2010). We expect market participation to increase with education level and to decrease with household size. We likewise expect commercialisation to be high among female-headed households as the majority of AIV producers in Kenya are women (Shackleton et al., 2009; Weinberger et al., 2011). Age could either influence commercialisation positively or negatively. As a proxy for experience (Martey, 2014), age could reflect a positive relationship with AIV commercialisation. Contrarily, if one considers labour demands for production and marketing of AIVs which are easily met by younger farmers, opposite results can be expected.

Distance to the market, a proxy for market access (Chamberlin & Jayne, 2013) is hypothesised to have negative effects on commercialisation. Land ownership depicting access to productive assets (Barrett, 2008) is expected to have a positive effect on commercialisation. Alternative enterprises and income sources are expected to have a negative effect on AIV commercialisation, particularly off-farm income and livestock units (Awotide et al., 2016).

On descriptive statistics presented in Table 2, the average household size was 6.79 while the average age of the household head was 54.5 years. The mean years of formal schooling for the household head was 9.34, which translates to a completed level of primary education. Only 10% of the households were female-headed. The distance to the nearest market was almost 3 km (2.66). On income share; the average share of AIV income to the household income was 6% while off-farm income contributed the biggest share (66%). The average land size owned by the households

Figure 1. Sources for important market information.
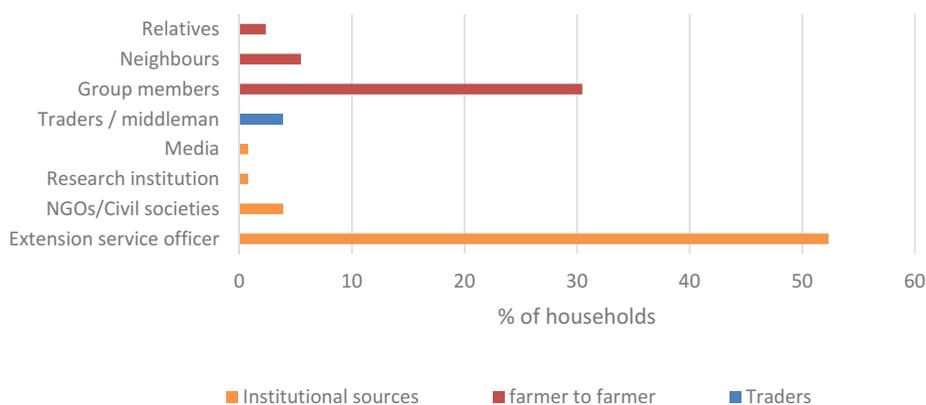
was generally small (1.1 acres), representing less than half a hectare (0.45 ha). The average livestock ownership (TLU) was 0.2.

3. Results

In this section, we present the findings of the double-hurdle model used to assess the determinants for selling AIVs and volumes of AIVs sold. Table 3 illustrates the marginal effects and robust standard errors for the estimated double-hurdle model.

As hypothesised, outside the village network (outvill_network) had a positive and significant effect on the decision to intensify AIV commercialisation. Outvill_network represents the number of people residing outside the village that the farmer talked to on market information. Each additional person outside the village that a farmer talked to on market-related information, increased the likelihood of intensifying commercialisation at 0.05 significance level. However, no significant marginal effects for outvill_network were reported in the first stage decision. In both stages, the number of people residing inside the village that the farmer talked to on market information (vill_network) did not report significant marginal effects.

Contrary to apriori expectations, sources of the market (Mktinfo_source) coded as 1 for farmer-based sources and 0 for institutional sources reported insignificant marginal effects. Though they depicted a positive sign which points to a positive direction with respect to farmer-based information sources.

Household size (HHsize) measured by the number of family members living together had a positive and significant marginal effect on the decision to sell, reported at the 0.05 significance level. Households with younger heads were more likely to determine both the decision to commercialise and to intensify AIV commercialisation. Age was negative and significant at in the first stage and second stage, at 0.01 significance level.

	Stage 1: Decision to sell AIVs		Stage 2: Decision on volumes of AIVs to sell	
Table 3. Marginal effect estimates for the double-hurdle model				
	Marginal effects	**Robust std. errors**	**Marginal effects**	**Robust std. errors**
Farmsize	1.6960**	0.7460	394.6546	709.6801
Mkt_dist	0.1077**	0.0470	−30.8719	97.2791
vill_network	0.0272	0.0167	21.7733	13.8656
outvill_network	0.0138	0.0145	52.0028**	29.5967
HHsize	0.1549***	0.0512	118.8141	169.7727
AGE	−0.0183**	0.0090	−22.1710***	7.9129
educ_yrs	0.0327	0.0239	27.9290	23.0854
Gender	−0.4777	0.3873	−287.7737	1426.2
AIVINC_share	4.2348***	1.4050	1788.962*	4077.123
offfarmINC_share	0.1017	0.3085	21,072.91*	11,390.45
TLU	−0.2105*	0.1203	−2232.9*	13,416.19
Mktinfo_source	0.0985	0.2428	557.2347	861.2595
n = 170	*Wald chi^2(12) = 35.09*		*Log likelihood = −779.4592*	*Prob > chi^2 = 0.0005*

*** 0.01 significance, **0.05 significance, *0.1 significance

Marginal effect for market distance (Mkt_dist) was positive and significant at 0.05 significance level on the decision to sell AIVs. Implying households further from markets were more likely to sell AIVs. However, the marginal effect reported in the second stage was insignificant.

Farm size measured by acreage of land owned had a positive and significant effect on the decision to sell, at 0.05 significance level. The marginal effect of farm size on the intensity of commercialisation was however insignificant.

The marginal effects for the share of household income contributed by AIVs was positive and significant (p-value<0.01) for both stages—decision to commercialise and to intensify commercialisation. Households were more likely to participate in AIV commercialisation if the share of income contributed was high. Off-farm income was negative and significant on the decision to intensify commercialisation. A unit increase in the share of off-farm income was more likely to decrease the volumes of AIVs sold at 0.1 significance level.

In both commercialisation and intensity of commercialisation decisions, marginal effects for tropical livestock unit (TLU) were negative and significant. Households with smaller herd sizes were more likely to sell AIVs (*p*-value<0.1) and to increase the volumes of AIVs sold (*p*-value<0.05).

4. Discussion

This paper aimed to assess the effects of market information networks on commercialisation decisions of AIV smallholders. We found networks outside the farmers' village to increase the likelihood of intensifying commercialisation. Farmer networks have been found important sources of information (Bourne et al., 2017). In particular, farmers with higher bridging social capital (people outside the village) have been found to have heterogeneous access to information resulting to the adoption of technologies and innovations (Bourne et al., 2017; Maertens & Barrett, 2013). These findings are consistent with the "theory of weak ties" as presented by Granovetter (1973) that posits that people are more likely to benefit more from their weak ties referred to as bridging social capital, than strong ties (bonding social capital). Information received within members of the same village could be redundant due to homogeneity of information. Network connections outside the village, therefore, offers an opportunity to new information that could lead to intensifying commercialisation. Farmers who talked to people outside their own villages would get leads on potential market opportunities beyond their villages. Likewise, they would get price information from other villages which could be more competitive than prices in their own villages. As a result, enabling farmers to make more informed decisions on where to sell and how much to sell.

Households with large family sizes were more likely to sell AIVs; but the marginal effects on the volumes sold were not significant. This is plausible as large families can provide farm labour required in production of AIVs. These findings support results presented by Omiti et al. (2009). Insignificant marginal effects in the second stage implies that once a household has made the decision to participate in AIV marketing, household size then has no significant effect on increasing the volumes sold. This could be explained by the fact that farmers who decide to intensify commercialisation may hire farm labour, and not necessarily depend on family labour only.

Households with younger heads were more likely to sell AIVs and increase the volumes of AIVs sold. Labour demands in production and marketing activities of AIVs can easily be offset by younger farmers. Intensifying commercialisation by increasing volumes sold becomes an even tough hurdle for older farmers as it implies more energy required for production. Our results support the findings by Okoye et al. (2016) who argues that young farmers tend to have a stronger social network and have established a good level of credibility within their network. Martey (2014) found similar results contrary to their expectations, which had envisioned older farmers to be more experienced and therefore more likely to commercialise.

Contrary to expectations, distance to the market reported positive and significant effects on the decision to sell, the results were however insignificant on the decision to intensify commercialisation. This finding is contrary to most findings in literature (Achandi & Mujawamariya, 2016; Komarek, 2010; Ochieng. et al., 2015). In this study, most farmers sell their indigenous vegetables on-farm to reduce the transactions costs of delivering to the open markets. Farmers distanced far from the market take the decision to sell on-farm, particularly to consumers and local traders. These factors may have therefore contributed to the positive relationship between market distance and the decision to sell. These findings support results presented by Okoye et al. (2016), where on-farm sales were positively determined by the distance to the market.

Households with large land sizes were more likely to make the decision of selling AIVs. Such households can allocate land to AIVs for both subsistence and selling the surplus. As found in other studies, land as a productive asset significantly determines commercialisation decisions of smallholders (Awotide et al., 2016; Martey, 2014; Mather et al., 2013). However, the land size was not a significant determinant in the intensification decision. Due to small land sizes in the study area (0.45ha), leasing land especially along the river banks for intensified commercialisation is common. This could explain why the size of a farm owned was not a significant determinant in the second hurdle as they have an option of leasing in land for intensified commercialisation.

Share of income generated from other enterprises besides AIVs had significant negative effects on AIV commercialisation. The likelihood of commercialising and intensifying commercialisation of AIVs decreased, with marginal increases in livestock owned. This is plausible due to competing interests between livestock and crop farming, as found in other studies (Awotide et al., 2016; Martey, 2014; Omiti et al., 2009). Limited resources in terms of farm sizes in the study area could explain the negative relationship between livestock production and AIV commercialisation.

Similarly, off-farm income decreased the likelihood of intensifying AIV commercialisation. These findings follow hypothesised apriori expectations, and could be explained by the opportunity cost of time which is higher among households with alternative income sources (Awotide et al., 2016; Ouma et al., 2010). These findings corroborate a study in Ghana (Martey, 2014), and another study in Nigeria (Awotide et al., 2016).

5. Conclusion and policy recommendations

This paper sought to assess the effects of market information networks in commercialisation of AIVs among smallholders in Kenya. Using a *Cragg's* double hurdle, we modelled the determinants of commercialisation as a two-stage: the decision to sell and intensity of volumes sold. We assessed the actual access to market information and its effects on commercialisation decisions. We, therefore, make a contribution to smallholder commercialisation literature by incorporating network effects in commercialisation decisions. We focus on indigenous vegetables which are rich in nutrients with potential to contribute significantly to food and nutritional security.

The findings reveal information networks to be important determinants in commercialisation of AIVs, particularly the decision to intensify commercialisation. Farmers with higher bridging social capital depicted by the number of people living outside the village they talked to; reported a higher likelihood of increasing volumes of AIVs sold. From these findings, we conclude that once the first decision on whether to sell AIVs has been crossed, farmers with stronger bridging social capital have a greater likelihood for intensifying AIV commercialisation. It is therefore important to build networks for smallholders, either through groups or intra-village associations. However, more research is needed in this field to further categorise the networks, and understand which networks are important for market access and commercialisation.

We recommend policy frameworks that strengthen network linkages among farmers, as they are more likely to increase levels of commercialisation for indigenous crops. For instance, creating and supporting intra-village farmer associations. Similarly, due to small land sizes in the area,

there is a need for policy to support intensive and sustainable farming systems to encourage commercialisation. We found young people to be more likely to commercialise AIVs, we recommend market development programmes offered by the government and development agencies to be more targeted towards the youth.

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