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Does commercialization of smallholder horticulture reduce rural poverty? Evidence based on household panel data from Kenya

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Abstract

This study utilize two-wave household level panel data spanning 5 years on smallholder vegetable producers in Central and Eastern Kenya to assess the effects of commercialization of horticulture on two major poverty outcomes: household income and asset holdings. Methods that exploit panel nature of data to account for observed and unobserved heterogeneity in the sample are used, thus improving upon methods that make no such considerations or rely on cross-sectional data methods. Standards fixed effect, two-step fixed effects approach borrowed from Heckman (1976)'s framework and fixed effect instrumental variable approach find positive effects of commercialization of vegetables through export market pathway on per adult equivalent income. Controlling for heterogeneity and selection bias provides smaller effects of this market pathway compared to the naïve pooled OLS. Similarly, the naïve model overestimates the effect of commercialization through the domestic market pathway on per adult equivalent income. Fixed effect models reveal limited potential of income generated from export market pathway to raise household assets but find positive effect of income from domestic market pathway to improvement of household asset capacity. Results suggest the argument of commercialization of smallholder horticultural farming as "pro-poor" development strategy should look beyond household income to other household welfare aspects such as assets. Further, measuring effects of commercialization of agriculture can be improved by using panel data and addressing both heterogeneity and selection bias, to avoid overestimation of effects of agriculture on poverty. Further research should focus on intra-household distribution and utilization of income generated from the vegetable enterprises.

Keywords: Horticulture, commercialization, smallholders, poverty, assets.

1. Introduction

Commercialization of smallholder agriculture is viewed as an indispensible pathway towards economic growth and development in many developing countries that are agriculture dependent (von Braun et al., 1994; Pingali & Rosegrant, 1995; Pingali, 2007). Commercialization and diversification of horticulture and especially high-value crops has since the past two decades been identified as one of the fastest growing sectors in Sub-Saharan Africa (Gioè, 2006; Afari-Sefa, 2007; Henson & Jaffee, 2008). In Kenya, horticultural exports have been growing at 10-15 percent per annum over the last decade (GoK, 2010). As a result of this impressive growth, policy makers, donors and researchers perceive the rapid growth of the sub-sector as a viable "pro-poor" rural development strategy, assuming that the same growth is trickling down to rural smallholders, majority of whom are predominantly involved in horticultural business**.**

The argument of "pro-poorness" of commercialization of smallholder horticulture at micro-level however is often based on cross-sectional income studies, which report the economic status of the farmers at the time of survey and mostly lean towards export-oriented market participation (for example McCulloch & Ota, 2002; Asfaw, 2008; Maertens & Swinnen, 2009). Empirical studies that measure the extent to which the horticultural sub-sector has impacted on rural poverty based on other poverty outcomes such as asset and using panel data are non-existent. Given the argument that horticultural farming provides pro-poor strategy to rural development, estimation of medium-term or long-term livelihood impacts of commercialization of smallholder horticultural farming is of policy-relevance. This is especially important in Kenya, where, although agriculture is the backbone of the economy and mainly concentrated in the rural areas, poverty is predominantly rural with about 49.1% of rural population living under poverty line (IMF, 2012).

The aim of this study is to contribute to the literature on impact of commercialization of smallholder horticulture by assessing household welfare from both income and asset perspectives. To overcome the challenges of cross-sectional data, this study uses two-wave household level panel data spanning 5 years (2005 and 2010). Moreover, the study triangulates the analysis by using methods that exploit the panel nature of data to account for observed and unobserved heterogeneity in the sample, thus improving upon methods that make no such considerations or that rely exclusively on cross-sectional data methods. First, the study considers standard fixed effect approach that accounts for time invariant household effects. Second two-step fixed effect approach for estimating panel data model borrowed from Heckman (1976)'s framework is applied. In addition to accounting for time invariant household effects, the two-step procedure accounts for sample selection bias by inclusion of correction term in the poverty outcome model generated using commercialization (selection) model based on observable variables. Further at attempt to use fixed effect instrumental variable approach is made. In addition a naïve (pooled) ordinary least square method is applied and compared the estimates with those of the improved models.

The data was collected in selected districts of Eastern and Central regions of Kenya based on the share of vegetables produced for commercial purposes in the country. This study

distinguishes the contribution of impact of vegetable crops produced for export and those for domestic markets, treating production through these markets as independent farm enterprises unlike previous studies that have focused either on one market pathway. In this study these markets are referred as pathways for commercialization of horticulture- *export market pathway and domestic market pathway*. The contribution of vegetables sold through the traditional markets have largely been ignored in the past studies giving more emphasis on vegetables produced for the international market (for example McCulloch & Ota, 2002) and those for the modern domestic supply chains (domestic supermarkets) (for example Rao & Qaim, 2011).

The rest of the paper is organized as follows: first, a brief literature review of the effects of commercialization of smallholder horticulture on poverty and the methods applied is presented. Next, a description of data and descriptive analysis are provided. Empirical models are then presented followed by estimation results and lastly conclusions and recommendations.

2. Literature review

Impact of commercialization smallholder agriculture can be classified into three categories following Moti et al. (2009): first, second and third orders. First-order impacts are mainly income and employment effects that are directly reflected in household welfare. Following this classification, several studies on commercialization of agriculture have mainly concentrated on first order effects (for example Von Braun & Immink, 1994; Dorsey, 1999; McCulloch & Ota, 2002; Minot & Ngigi, 2004; Goletti, 2005; Sindi, 2008; Carletto, Kilic, & Kirk, 2009). The second-order effects include gender, health and nutrition and are usually dependent on the level of income attained through the level of commercialization (E. Kennedy, 1994; Niemeijer & Hoorweg, 1994). The third-order effects are beyond the household level and measured at the macro level and environmental effects (Seshan, 2005).

While most of the past studies agree that commercialization of smallholders provides direct and indirect income benefits to rural households and thus improve their livelihoods (for example Von Braun & Kennedy, 1994 and others mentioned above), others argue that transformation of subsistence agriculture to commercial enterprises result to adverse consequences (for example in the presence of market price distortions as in Barrett and Dorosh, (1996) or due to reallocation or resources from food to commercial crops as in Klasen (2006).

Studies that have analyzed poverty effects of smallholder horticultural farming by examining income generated either from the labour or from the product market (or expenditure as a proxy for income), have used different methodologies to measure effects of horticultural farming. These methods include; gross margin analysis (Minot & Ngigi 2004; von Braun & Immink, 1994; Rao & Qaim 2011); Comparison of mean income of those participating in commercialization of horticulture and non-participants; or use of ANOVA or regression analysis on income of participants and non-participants or using matched pairs of the same utilizing cross-sectional data (von Braun, Haen, & Blanken 1991). Gross margin analysis is

challenged as it cannot infer much about poverty impact since it does not measure the effects on total income (Minot & Roy, 2007).Comparison of mean income method is not able to establish the direction of causality, while the ANOVA analysis does not control for factors such as land size and use of irrigation and thus likely to produce biased estimates due to sample selection bias (Minot & Roy, 2007). Another set of methods are regression methods that control for various factors that may favor participation to horticulture for some farmers and not for others (McCulloch & Ota 2002;Asfaw, 2008; Maertens & Swinnen, 2009; and Afari-Sefa, 2007). Most of these studies are however based on cross-sectional data.

Panel data methods can produce better estimates of the income effects of commercialization since they are able to control for both observed and unobserved time-invariant household characteristics. A few exceptions of studies that utilize panel data methods to measure the impact of horticulture include von Braun and Immink (1994) and Carletto et al., (2009). von Braun and Immink (1994) examine the positive impact of export horticulture among small-scale farmers in Guatemala using two-wave panel dataset (1983-1985) and expenditure as a proxy for income. Carletto et al. (2009) study the similar farmers in the same country using panel data spanning over 20 years (1985-2005). The results for Carletto et al. (2009) contradicts other cross-sectional data based results reporting that, although the consumption status (as a proxy for income) for all household groups improved between 1985 and 2005, the extent of improvement among long-term adopters (that is, those that adopted early and stayed until 2005), was lower compared with the changes experienced by non-adopters. Equally using durable assets and housing conditions dimensions of poverty, households who adopted early and withdrew from snow pea production by early 1990 and increased their off-farm income portfolios, demonstrated the largest improvements in comparison to both stayers and non-adopters. In Kenya most of the studies use cross-sectional data to qualify smallholder horticulture as "pro-poor". Medium-term as well as long-term impact studies of commercial horticultural farming do not exist. Although income or expenditure dimensions of poverty are simple to calculate and easy to compare across regions and countries and time, they have been challenged for undermining the broader aspects of poverty beyond observed income and expenditure measurements (Alkire & Santos, 2010). Asset based poverty measurements on the other hand are commended for their ability to capture non-monetary facets of poverty and thus suitable to measure structural and stochastic poverty transitions than income snapshots because assets are accumulated over time and last longer (Moser & Felton, 2007). Empirical studies analyzing the poverty effects of commercialization of horticulture from asset perspective are lacking.

3. Data and sampling procedures

The study utilizes a two-wave panel dataset. The first wave was collected by International Centre of Insect Physiology and Ecology (ICIPE) as part of their project on Economic Impact Assessment of Horticulture in 2005/2006, while a follow up survey was conducted in the same households in 2011 by the author. A multi-stage sampling procedure was used to select the districts, sub-locations and smallholder vegetable producers. Five districts were purposively selected from the two major vegetable producing provinces (namely Nyeri,

Kirinyaga, and Murang'a of Central Province and Meru and Makueni districts of Eastern Province) (Asfaw, 2008). Probability Proportional to Size (PPS) sampling method was used to randomly select 21 sub-locations from the five districts from which a sampling frame was developed and further to select 539 households for the interviews. This sample was used as a sampling frame for the follow-up visits from which a sub-sample of 309 households was randomly selected and visited between July-August 2011. The districts are endowed with a generally favorable climate for horticultural production but differ in intensity and type of vegetable crop produced, agro-ecological characteristics and accessibility. Meru district is located at higher altitude mainly producing French beans. Nyeri, Kirinyaga and Murang'a districts are situated at middle altitude producing green beans, peas, potatoes, tomatoes, carrots and other domestically consumed vegetables. Makueni district is located at lower altitude mainly producing Asian vegetables (Asfaw, 2008).These selected districts represent approximately 50% of smallholders producing vegetables for export market (Mithofer et al. 2008 cited in Asfaw, 2008). Further, the area also has the highest horticultural commercialization incidences for domestic or local market vegetables (Sindi 2008). Similarly to the 2005/2006 survey, the 2011 survey involved recall data which was collected using a structured questionnaire administered by trained enumerators supervised by the author. The data provided information on household demographic characteristics, land use, agriculture production, household assets including livestock ownership, agriculture related assets, dwelling types, off-farm income, remittances and market access information including type and characteristics of vegetables markets, access to credit and farmer group membership.

From the information gathered on type and market for vegetable crops, households are classified according to market pathway through which they commercialize their vegetables: *export market pathway famers*[1] are households who produce vegetables for the international market; *domestic market pathway farmers* are households who produce vegetables that are primarily consumed in the domestic market; *non-sellers* are households who do not produce vegetables for sale. In some cases there were overlaps where households produced vegetables for both markets Figure 1 shows the number of households under each category. The left-side graph shows households participating in either market pathway (allowing overlaps[2]), while the right-hand side shows households specializing in one particular market pathway while the ones who overlap are classified as "*both export and domestic markets*".

Place Figure 1 here

4. Descriptive analysis

Table 1 presents the mean and standard deviations of selected household characteristics considered in this study. The statistics are provided for households specializing through

[1] International (export) market vegetables include French beans, snow peas, baby corns and Asian vegetables (*cucumbers, okra, aubergines, chilies, karella, valor and brinjals*). Domestic market vegetables include all other types of vegetables that are not produced mainly for the international market (these include tomatoes, cabbages, potatoes, peas, kales, onions, capsicum among others).

[2] Overlaps here means there are some households producing for both export and for domestic markets thus the number of households given in the left-side graph of Figure 1 are more than the survey sample.

export and domestic markets for each survey round. Also presented are the test for difference in means of these variables between export and domestic market pathways by year of survey. These are performed using t-values (for continuous variable) and z-test (for categorical variables).

Export market participants recorded less average age of household heads both in year 2005 and 2010. Age of the household head reflect risk preference and quality of family labour. Young farmers are more likely to adopt risky and high-labour intensive farm enterprises which have higher expected income such as high-value vegetables. Gender of the household head is dominated by males across both market pathways.

Annual household income is comprised of crop income, livestock income, business income from all household members, and income from off-farm activities by all household members and remittances received by all household members. In 2010, export market producers recorded significantly higher income than domestic market producers. A significant proportion of households are engaged in off-farm activities and small business especially among domestic market producers. Although not statistically significant, per adult equivalent income (per day) is higher for export market producers (1.4 in 2010 and 2.0 in 2010) than domestic market producers (1.3 in 2010 and 1.9 in 2010). Per adult equivalent asset index[3] on the other hand is greater for domestic market producers (1.01 in 2005 and 0.98 in 2010) compared to the export market producers (0.97 in 2005 and 0.96 in 2010). Overall an upward trend in per adult equivalent income is observed between the two survey rounds across participants of different market pathways while a downward trend is observed in per adult equivalent asset index.

Place Table 1 here

While the national figures shows an increasing trend of the volume of vegetables produced in the country, and especially those for export (GoK, 2010), horticultural smallholder farmers in the study area demonstrated a different picture. Figure 1 shows declining participation of farmers in the export market by almost a half (from 228 in 2005 to 117 in 2010). Similarly those participating in domestic market decreased but by a smaller percentage while a significant percentage (20% of total interviewed households) exited from horticultural business. A similar trend is demonstrated by the extent of commercialization illustrated as Horticultural Commercialization Index (HCI). The share of income derived from export market sales out of total household income given in Table 1 as "*HCI_1_export market"* decreased from 46.9% (2005) to 28% (2010). Similarly the share of export market sales out

[3] Household asset index was constructed using the Principal Component Analysis (PCA) approach following Rutstein & Johnson (2004), Irungu (2002), Henry et al. (2003) and Zeller et al. (2006). The index is however limited to the asset indicators that were collected during the two surveys. We identified 5 key categories of assets that were important for the study area. These assets are Livestock assets (include all types of livestock assets), Agricultural assets (includes hosepipes, water pumps, sprinklers and insecticides' pumps), productive durables (tractors, cars, ploughs, threshers, fridges, sewing machines and carts), consumer durables (TV, radio, motor-cycles, bicycles) and dwelling assets (iron roof, permanent wall, piped water, distance of 500m or less to water source)

of total crop sales (given as *HCI_2_export market*) decreased from 62.3% to 55.7%. On the other hand, the share of vegetables sales from the domestic market shows an increasing trend. For example, the percentage shares of vegetable income from the domestic market sales out of total household income (given as *HCI_1_domestic market)* increased from 15.3% in 2005 to 19.7%. The extent of commercialization of domestic market vegetables given by other Horticultural Commercialization Indices (*HCI_2_ domestic market and HCI_3_domestic market*) shows a similar increasing trend. The shift towards domestic market could be motivated by increased market potential for locally consumed vegetables especially in the urban areas as population continue to rise and also due to increase in demand for vegetables in the regional market (for example carrots in Uganda (USAID, 2011). On the other hand, decline in number of households participating in export market could be attributed to a number of factors. One reason could be increasing regulations in the international market especially private food safety and quality standards such as GlobalGap as has been observed in the recent studies (Muriithi et al.,2010). Second reason could be attributed to uncertainties in international market as a result of the global financial crisis in the year 2008, during which volume of exported vegetables and other products reduced drastically (HCDA, 2009). Third factor is the high spikes of food price in the recent past that has shifted the focus of rural producers to production of food crops not only to cope with the unexpected food shortfalls but also to benefit from high prices from sale of their produce especially maize. Other factors driving smallholder producers out of export production could be related to increasing costs of inputs (labour costs increased by about 50% between 2005 and 2010 due to increase in wage-rates in the economy), cost of fertilizers, pesticides and other chemicals (Gitau et al., 2012: Adekunle et al., 2012).

5. Empirical models

Consider a generic impact assessment specification;

$$Y_{it} = \theta_t + \mathbf{x_{it}}\boldsymbol{\beta} + Comm_{it}\gamma + M_i + \mu_{it}, \qquad i=1, 2,..,. N; \quad t=0, 1; \tag{1}$$

Where Y_{i_t} is the poverty outcome variable of interest (*per adult equivalent asset index or per adult equivalent income)* for i^{th} households at time *t* (*t=0 (2005) or t=1(2010);* $\mathbf{x_{it}}$ represents a vector of observable explanatory variables; $Comm_{it}$ is a measure of commercialization (a dummy or a continuous variable depending on the specification) for household *i* during year *t*, M_i represents a vector of time-invariant unobservable variables and μ_{it} is the error term. $\boldsymbol{\beta}$ and γ are the parameters to be estimated.

Key explanatory variables ($\mathbf{x_{it}}$) that are likely to affect these poverty outcomes include household demographic factors (gender of household head, dependency ratio, household size and education level of household head and highest education level in the household). Female headed household for example have been found to be disadvantaged in economic wellbeing of a household. High dependency ratio is also associated with low asset holdings. More educated household are likely to have more assets and high per adult equivalent income than

less educated ones. Another set of explanatory variables that might influence poverty outcomes are those related to diversity in household income sources. For example, rural households who have access to off-farm activities use them to smooth fluctuations in crop income (Fafchamps, Udry, & Czukas, 1998). Other non-farm income sources such as businesses and remittances are important means of *ex-ante* diversification (Reardon & Berdegué, 2002). Land endowments (size and quality) are also included. Annual rainfall and district dummies are included to account for unobservable location effects (agro-ecological zones). Also included in the model is a dummy indicating whether a household experienced economic shock between years 2005 and 2010, such as poor weather resulting to drought or floods, loss of employment, loss of the major income earner through death, injury or long illness or other non-natural shocks such as civil conflicts.

5.1 Estimation assuming commercialization is exogenous

To start with, commercialization of horticulture is assumed to be exogenous, that is, if observed characteristics of respondents are controlled for, there are no other factors that simultaneously affect commercialization and household poverty outcome. For each of the poverty outcome, the model we estimated using participants and non-participants of each market pathway. Include in the estimation is the market pathway variables and a set of exogenous controls. Pooled ordinary least squares (OLS) is then used to estimate the model as follows.

$$Y_{it} = \theta_t + \mathbf{x_{it}}\boldsymbol{\beta} + ExpoComm_{it}\,\gamma_1 + DomeComm_{it}\,\gamma_2 + T\alpha + \upsilon_{it} \qquad (2)$$

where $ExpoComm_{it}$ is the measure for commercialization through the export market pathway for household *i* at time *t,* whereas $DomeComm_{it}$ is the measure for commercialization through the domestic market pathway for household *i* at time *t.* The parameter θ_t denotes a time-varying intercept. Time dummy T (*T=1* if year of survey is 2010) is included to allow for time effects, while υ_{it} $(= \mu_{it} + M_i)$ is a composite error term which contains the measure of unobservable variables associated with the poverty outcome Y_i and is assumed in this specification to be uncorrelated with commercialization and with the exogenous control variables $\mathbf{x_{it}}$. The parameters γ_1 and γ_2 represents the effect of commercialization through export and domestic market pathways respectively on the poverty outcome, Y_i, controlling for exogenous control variables $\mathbf{x_{it}}$. The hypothesis is that commercialization of horticulture through either of the two market pathways have positive effects and thus expect γ_1 and γ_2 to be positive and significant. However, the estimate of the γ_1 and γ_2 would generally be biased when commercialization is not exogenous. Participation in commercialization of horticulture is likely to be non-random. For example, households with more resources or who possess better individual skills, ability and motivation can decide to participate and self-select into export market pathway while those with fewer resources are more likely to engage in domestic market pathway. Second, there might be geographical selection because farmers

who are far distant to the market face high transaction costs of delivering their produce to the market or traders who buy from such farmers. By ignoring such possibilities, the estimate of γ_1 and γ_2, be biased. This estimation can be referred as a naïve model.

5.2 Estimation controlling for selection of participation in commercialization

Assuming commercialization is endogenous, the following estimations are utilized (i) standard fixed (within) regression estimator and (ii) fixed effect model corrected for possible self-selection bias, (iii) fixed effect instrumental variable approach. In presence of unobserved heterogeneity that is believed to have been correlated with one or more covariates, fixed effects model is used. This way the problem of endogeneity is accounted for. The panel nature of our data allows us to estimate standard fixed effect regression model under the assumption of strict exogenity of covariates $\mathbf{x_{it}}$ conditional on the unobserved effect (Wooldridge, 2002, p. 266). In the fixed effect model, the error term is expanded to include both time-invariant individual-specific effects M_i and time-varying component μ_{it}. This differentiates the fixed effect equation from the naïve model equation (2) such that;

$$Y_{it} = \theta_t + \mathbf{x_{it}}\boldsymbol{\beta} + ExpoComm_{it}\gamma_1 + DomeComm_{it}\gamma_2 + T\alpha + M_i + \mu_{it} \quad (3)$$

A standard household fixed effect model can provide consistent estimates of commercialization parameter under the assumption that all unobservable M_i, that influence the outcome are time invariant and removed by within transformation or first differencing (Wooldridge, 2002). However there could be potential selection bias that obscures the causal relation between participation in commercialization of horticulture and poverty outcome because individual specific unobservable may change over time, for example, an individual might improve commercialization skills as a result of continuous farming of one vegetable crop or as a result of training on commercial farming- which happens often among farmers. This means that there could be correlation between commercialization through either market and the unobservable which lays within the time varying term μ_{it} hence providing bias results. It is therefore important to test and account for selection bias.

A more robust estimation that could account for selection bias is the Heckman framework for panel data. This involves estimating an equation for commercialization using probit model.

$$\Pr(Comm_{it,j} = 1 \mid \mathbf{Z_{it}}) = \phi(\mathbf{Z_{it}}\boldsymbol{\psi_t}) \ (j=\textit{Export market, Domestic market}) \quad (4)$$

where Z_{it} contains $\mathbf{x_{it}}$ and other variables that affects commercialization but not poverty outcome Y_{it}. From equation (4), inverse mills ratio ($\hat{\lambda}_{it,j} \equiv \lambda(Z_i\psi_t)$) for each pathway and for each year are obtained. The mills ratio are then included in equation (3), such that;

$$\begin{aligned} Y_{it} = \theta_t + \mathbf{x_{it}}\boldsymbol{\beta} + ExpoComm_{it}\gamma_1 + DomeComm_{it}\gamma_2 + \\ \hat{\lambda}_{it,ExporComm} + \hat{\lambda}_{it,DomeComm} + M_i + T\alpha + \mu_{it} \end{aligned} \quad (5)$$

While the two models described above may address the problem of endogeneity, in the latter, inverse mills ratios for the selection (commercialization) model are included to address the possibility of selection bias and thus provide consistent estimates of commercialization effects assuming a valid exclusion restriction of the selection model variables can be identified. Identification involves inclusion of some variables hypothesized to be statistically associated with commercialization ($Comm_{it,j}$) but not with outcome of interest (per adult equivalent income/ asset, Y_{it}). Transaction costs would generally affect the commercialization decision but not poverty outcome indicators. Thus, transaction costs variables are used to identify commercialization decision. These are variables related to information access; - access to extension contract, membership of a farmer's group, distance to the market, price of selected vegetable crops (French beans for export market and potatoes for domestic market pathways) Price variables used in the model are district mean value of prices for French beans and potatoes deflated[4] (2010 prices) or inflated (2005 prices) using consumer price index (CPI) to a common year (February, 2009) and not specific household prices.

In addition to the methods applied above, household fixed-effects instrumental variable technique is employed due to potential reverse causality of poverty outcomes affecting decision and extent of commercialization. If households with higher per adult equivalent income and asset choose to commercialize through certain market pathways, this may lead to simultaneity bias. The instrumental variables technique involves estimating commercialization equation (4) simultaneously with the poverty outcome equation (3). This can be expressed using an equation as follows:

$$Y_{it} = \theta_t + \mathbf{x_{it}}\boldsymbol{\beta} + (Comm_{it,j} = \mathbf{W}_{it}) + M_i + T\alpha + \mu_{it}$$

(*j=Export market, Domestic market*) t=*0,1 i=1, 2,.,n* *(6)*

where $\mathbf{x_{it}}$ represent vector of overlapping variables that affect the poverty outcome Y_{it} and possibly commercialization, while $\mathbf{W}_{it}$ include non-overlapping variables correlated with extent of commercialization but not with poverty outcome. Equation (6) is estimated using fixed effects two-stage least-square estimator (FE2SLS). Simultaneity bias is accounted for by using 2SLS to estimate equation (6) where all variables are subjected to within transformation (Cornwell et al., 1992). To identify commercialization equation, $\mathbf{W}_{it}$ will comprise transaction costs variables described in the previous section as those which are correlated with extent of commercialization through a particular market pathway but not directly influencing poverty outcomes. For example export market pathway is instrumented using access to extension services, membership in farmer group and district average price of French beans.

[4] French beans and potatoes were identified as the most important export domestic market vegetable crops respectively

6. Estimation results

This section provides estimation results from the models outlined earlier, with the fixed effect selection-bias corrected estimates (equation (5) presented first in Table 2 and Table 3. Table 2 present results of effects of commercialization on per capita income, while Table 3 presents effects of commercialization on per capita asset index. As explained earlier, the estimates were obtained by estimating equation (4) using probit model for each year and for each market pathway and including the inverse mills ratio in equation (5) which is estimated using fixed effects model[5]. The models are significant (*p<0.01)* based on F-test for null hypothesis that all coefficients of the covariates in each respective model are jointly equal to zero. Household fixed effects in both income and asset models reject the hypothesis that there is joint insignificance of covariates included in the model.

In Table 2, the inverse mills ratio for the export market is not significant but those of domestic market are significant. On the other hand, in Table 3 none of the inverse mills ratios is significant. This implies there is no evidence for self-selection into participation in our data sample in either market when considering per adult equivalent asset index based on observed variables. In particular, taking export market pathway for example, in absence of export market participation, there would be no significant difference in average between the current participants and non-participants of this market caused by observed effects. The most important results for this regression are the parameter estimates for commercialization through different pathways. In Table 2 we show results for four different model estimates which differ in measure of commercialization used as explained in the descriptive statistics (see Table 1).

Since of interest is commercialization impact estimates, household observables that may systematically correlate with commercialization are included. Moreover, both time-invariant and time-varying variables that are likely to influence poverty outcome are included. Examining these variables in Table 2 there is no significant influence on household per adult equivalent income by household human capital variables. The size of the household however has a negative and significant relationship with income per adult equivalent. Increase in household size by 1 adult equivalent member, decreases income per adult equivalent by about 13% other factors held constant. Business ownership and size of cultivated land have positive and significant influence on income per adult equivalent. Households involved in business activities have the propensity to increase their income per adult equivalent by about 28%, while increase in size of cultivated land by acre increases households' per capita income by

[5] The appropriateness of the fixed (within) effects model parameters against those of random effects (between) regression was tested. While fixed effect (within) regression assumes strict exogeneity of explanatory variables conditional on the unobserved individual effects, random effects model on the other hand assumes that there is no correlation between the unobserved effects with the covariates (Wooldridge, 2002). The latter model treats household constant terms as randomly distributed across the entire household sample. By assuming that household specific error term is uncorrelated with other unobservable variables, random effects model faces a challenge. For example, in our study context, household characteristics such as ability and farming skills are likely to be correlated with decision to participate in commercialization of horticulture and level of commercialization. We ran Hausman test to determine if violation of this assumption should invalidate the use of random effect model. In all the models, the test statistics for per capita income and per capita asset index is significant (p<0,05), which is interpreted as evidence against the validity of random effects.

about 12%. Rainfall also has a positive and significant influence on income per adult equivalent, albeit small effect. This emphasize the role of climate change indicators in modeling farm household behavior, an aspect that has been ignored in previous studies on impact of commercialization of horticulture on farm household income (such as McCulloch & Ota, 2002; Omiti et al., 2007). Access to off-farm employment and credit are also positively and significantly associated with per adult equivalent income.

Place Table 2 here

Based on the fixed-effects estimation corrected for selection bias, commercialization of horticulture through export market pathway has significant positive effect on per adult equivalent income. This is demonstrated using different commercialization measures as shown in Table 2 (estimations (1), (2), (3) and (4). Holding other variables constant, per adult equivalent income for a household commercializing through export market increased by 0.4 percent for every 1 percent increase in proportion of income generated from export vegetables out of total household income (*HCI_1_export*); 0.5 percent for every 1 percent increase in share of income generated from export vegetables out of total crop sales (*HCI_2_export*) and 0.6 percent for every 1 percent increase in share of income generated from export vegetables out of total value of vegetables produced (*HCI_3_export*). Similar results are reflected by the positive dummy that represents participation in export market pathway. Per adult equivalent income is approximately 34 percent higher for households commercializing through export market holding other variables constant. The findings on contribution of export-oriented production to household income is line with other studies that used income to measure poverty effects of commercialization of vegetables (McCulloch & Ota, 2002: Asfaw, 2008; Maertens & Swinnen, 2009). After controlling for potential selection bias on unobservable fixed effects, per adult equivalent income for households commercializing through domestic market pathway did not lead to significant increase in per adult equivalent income when the first three measures of commercialization through this market pathway (*domestic market dummy, HIC_1 domestic and HCI_2 domestic*) are considered. However a significant positive increase of 0.3 percent in per adult equivalent income for every 1 percent increase in proportion of income generated from domestic market out of total value of vegetables produced is observed.

The same household observables used to estimate the effect of commercialization on per adult equivalent income are used to estimate the effect of the same on per adult equivalent asset (see Table 3). Male household head and household size are negatively and significantly associated with per adult equivalent asset. Male headed households have the propensity to decrease assets by about 11% while increase in household size by 1 adult equivalent unit decreases per adult equivalent asset by about 20%. The results on gender are interesting since female-headed households are known to be more assets constrained than male-headed households. As expected, education and access to credit have positive and significant relationship with per adult equivalent asset index. The finding highlights the importance of credit in building of household assets as observed in other studies (such as Zeller et al., 2006). Although the shock dummy variable is not significant the negative sign may perhaps

be interpreted as use of assets to smoothen income short-falls when a household encounter a shock

Place Table 3 here

Looking at our estimates of interest, commercialization of vegetables through the export market pathway is negatively and significantly related to per adult equivalent asset. Per adult equivalent asset index is approximately 7.7 percent lower for households specializing in the export market holding other variables constant. The other measures of commercialization through the export market show positive but insignificant effect on per adult equivalent asset. Similarly, the first three measures of commercialization through the domestic market present positive but insignificant effect on per adult equivalent asset. However, *HCI_3_domestic market* shows a positive and significant impact of commercialization through domestic market on per adult equivalent asset. Increase in proportion of sales from vegetables out of value of total vegetable produced by 1 percent results to 0.1 percent in per adult equivalent asset. The negative relationship between commercialization through export market and per adult equivalent and the reverse of the same for the domestic market can be explained contextually based on our field observation. The observation made from the field is that income from export business is usually received in small amounts which are spread out the season or year. Since most of the smallholders do not use the formal money saving facilities such as commercial banks, they use the money to take care of immediate needs such a school fees, clothing among others. On the other hand, vegetables for domestic market are sold at once in large quantities which can generate enough cash to invest in lumpy assets.

Alternative specifications

In Table 4 and Table 5 estimates of pooled OLS (equation (2) on the left side of the table and those of standard fixed effects (equation (3) in the right side are presented. Table 4 presents estimates of effects of commercialization on per adult equivalent income while Table 5 presents estimates of effects of commercialization of vegetables on per adult equivalent assets.[6]

Place Table 4 here

Ideally, the results of standard household fixed effects model should give similar estimates as the ones estimates using the selection bias corrected fixed effect while considering the effect of commercialization of vegetables through the export market. This follows the fact that the selection term included in Table 2 and Table 3 are not significant. This is indeed reflected in Table 4 which shows positive and significant coefficients of commercialization through export market on per adult equivalent income. The dummy variable representing export market estimates that per adult equivalent income is approximately 32 percent higher in the export market commercializing household holding other variables constant (right side estimates of Table 4). Increase in share of export vegetable income out of total household income (*HCI_1_export market)* by 1 percent results to 0.5 percent increase in per adult

[6] Full regression results for the pooled OLS and standard fixed effect models are not given here but can be provided upon request.

equivalent income. Similar results are presented when considering commercialization as the share of export vegetable income out of total crop sold (*HCI_2_export market)*. On the other hand increase in the share of export vegetable income out of the value of total vegetables produced (*HCI_3_export market)* by 1 percent result to 0.7 percent increase in per adult equivalent income. Interestingly, pooled OLS also provide positive and significant estimates of commercialization effects on per adult equivalent income. The magnitude of the coefficients fall within the same as those of standard fixed effect except the dummy variables which estimate that per adult equivalent income is approximately 42 percent higher in export market commercialization household holding other factors constant.

Turning to the effect of commercialization through the domestic market on per adult equivalent income, standard household fixed effect estimates are insignificant except *HCI_3_domestic market*. This estimate implies that one percent increase in share of vegetable income generated from domestic market out of total value of vegetables produced results to about 0.4 percent increase in per adult equivalent income. This finding is similar to the ones estimated using selection bias corrected fixed effects model. The effects of domestic market pathway from the pooled OLS are not interpreted since they may be biased as indicated by significant coefficients of the selection bias term (*Inverse mills ratio (domestic*) in Table 2.

Next the effects of commercialization of vegetable on per adult equivalent asset are examined using pooled OLS and standard household effect models in Table 5.

Place Table 5 here

In line with the results presented in Table 3, standard household fixed effect model estimate negative and significant effect of commercialization through the export market on per adult equivalent asset as represented in. Per adult equivalent asset is approximately 5 percent lower in the export market commercialization households holding other factors constant. Pooled OLS on the other hand provide insignificant coefficients of the effect of export market on per adult equivalent asset. In contrast, income from sale of domestic market vegetables contributes positively to increase in per adult equivalent asset index (Table 5). One percent increase in share of vegetable income generated from domestic market out of total value of vegetables produced results to about 0.01 percent increase in per adult equivalent asset as given by standard fixed effect estimates. Pooled OLS also present positive and significant effects of commercialization through domestic market on per adult equivalent asset. The same explanation provided in the previous section for the negative relationship between commercialization through export market and per adult equivalent and the reverse of the same for the domestic market also applies here.

As mentioned in the previous section, attempt to estimate household fixed-effects instrumental variable technique is made due to potential reverse causality of poverty outcomes affecting decision and extent of commercialization. Three variables related to transaction cost in our study context- extension services, membership in farmer group and

district average price of French beans- are used to instrument the export market pathway. Looking at the results for the fixed effect instrumental variable approach (see

Table 6), a similar scenario can be observed as that depicted by the standard and self-selection fixed effect analysis. Commercialization through export market shows positive and significant effect on per adult equivalent income but insignificant effect on per adult equivalent asset index. Due to limitation of data, a good instrument for commercialization through the domestic market is not identified. As such only fixed effect IV model results for the export market pathway are presented.

Place

Table 6 *here*

Overall results shows returns from export market have limited potential to raise household asset endowments and thus alleviate rural asset poverty. The negative or insignificant impact of commercialization through the export market pathway on households' asset is not surprising. Barron and Rello (2000) in their study on the impact of tomato and agro-industry on rural poor in Mexico find that, although household income increased, it was not sufficient to provide investment in assets. The authors conclude that, income earned is fundamental for bare survival in villages in poverty-stricken regions, but cannot provide a solution for poverty alleviation since the income is not sufficient to contribute to capital formation or create the conditions for endogenous local development. Carletto et al. (2009) in their study on long-term effects of participation in export business among smallholder in Guetamala, find that those households who adopted snow peas production earlier, withdrew and increased their off-farm income portfolios, had the largest improvements of durable assets and housing conditions than households who stayed in the export business during the 20 years between the survey rounds.

7. Conclusions and recommendations

This study has descriptively analyzed the characteristics of smallholders participating in different market pathways and demonstrated how they have changed overtime. Furthermore, the study empirically analyzed the determinants of per adult equivalent income and assets in light of vegetable commercialization. In the case of Kenya, this study is the first to analyze the marginal effect of commercialization of smallholder horticultural farming through different market pathways on household asset accumulation. In addition, this study uses panel data and thus captures market behavior of smallholder horticultural farms over time.

The share of vegetable income to total household income decreased between 2010 and 2005. Overall there was a positive change in total household income and asset accumulation between the two survey rounds. However, while on average per adult equivalent income increased, per adult equivalent asset decreased.

Methods that use panel nature of data to account for observed and unobserved heterogeneity in the sample are utilized, thus improving upon methods that make no such considerations or that rely on cross-sectional data methods. Standard fixed effect that accounts for time invariant household effects, two-step fixed effects approach borrowed from Heckman (1976)'s framework that not only account for time invariant household effects but also for sample selection bias and fixed effect instrumental variable approach all find positive effects of commercialization of vegetables through export market pathway on per adult equivalent income. Controlling for heterogeneity and selection bias provides smaller effects of this market pathway compared to the naïve pooled OLS. Considering domestic market pathway, the naïve model overestimates the effect of commercialization on per adult equivalent income. Looking at per adult equivalent asset and using standard and selection bias corrected fixed effect models, income generated from export market pathway show negative or insignificant effects, implying limited capacity if this pathway to raise household assets. On the contrary positive effects of income generated from domestic market pathway on per adult equivalent asset index were observed.

This study suggests the need to measure poverty beyond household income or expenditure. Other livelihood aspects such as "household asset" should be considered to be able to qualify commercialization of smallholder horticultural farming or agriculture in general as a rural "pro-poor" development strategy. In addition measuring effects of commercialization of agriculture can be improved by using panel data and addressing both heterogeneity and selection bias. Not controlling for such may overstate the impact of agriculture on poverty outcomes. Further research should focus on intra-household distribution and utilization of income generated from the vegetables enterprises to provide better understanding on the relationship between commercialization of smallholder in horticulture and rural poverty.

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9. Figures and Tables

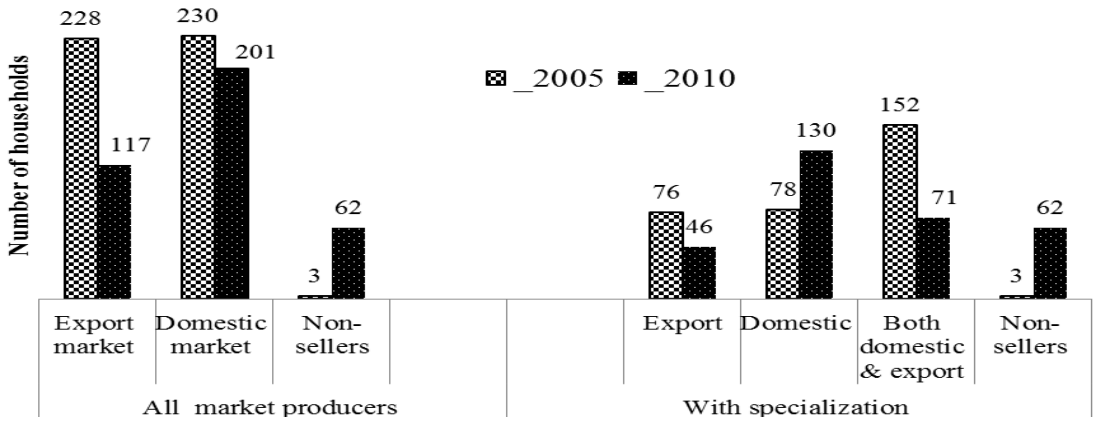

Figure 1: Number of households interviewed by market pathway and year of survey

Table 1: Selected household characteristics

		Year_2005				***Year_2010***				***Diff. (export-domestic)***	
Variable	Description	Export (n=76)		Domestic (n=78)		Export (n=46)		Domestic (n=130)			
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	_2005	_2010
Head age	Household head age (years)	43.3	10.2	50.1	13.0	47.9	12.3	51.1	12.2	-6.78***	-3.25
Male head	Household head gender (1=Male)	0.9	0.2	0.9	0.3	1.0	0.1	0.9	0.3	0.011	0.09*
Household size	Household size in adult equivalent)	4.4	1.9	4.7	2.3	5.0	2.3	5.3	2.3	-0.31	-0.3
Dependency	Dependency ratio	2.1	11.4	1.9	11.3	1.3	0.6	1.4	0.9	0.14	-0.05
Head education	Head education (years of schooling)	8.8	3.0	8.2	3.9	8.5	2.7	8.9	3.9	0.66	-0.38
Income	Household annual income ($)	1887	1706	1702	2884	3659	5001	2520	2470	184	1139**
Per capita income	Per adult equivalent income($ per day)	1.4	1.4	1.3	2.9	2.0	2.5	1.9	4.7	0.11	0.09
Household asset	Total household asset index	3.569	0.833	3.557	0.787	3.740	0.917	3.876	0.665	0.01	-0.14
Per capita asset	Per adult equivalent asset index	0.973	0.521	1.010	0.815	0.963	0.772	0.984	0.825	-.037	-0.02
Land fertility	Fertile land (1=yes)	0.38	0.48	0.33	0.47	0.43	0.50	0.30	0.46	0.048	0.13*
Cultivated land	Land cultivated (acres)	2.28	1.81	2.27	3.41	1.82	1.99	2.17	1.99	0.012	-0.36
Owned land	Total land owned (acres)	3.50	4.24	3.55	7.08	1.89	1.99	3.02	3.28	-0.51	-1.13**
Off-farm	Off-farm employment(1=Yes)	0.36	0.48	0.49	0.50	0.13	0.34	0.24	0.43	-0.13*	-0.11
Remittances	Remittances (1=Yes)	0.26	0.44	0.18	0.39	0.20	0.40	0.40	0.49	0.08	-0.20*
Business	Business	0.13	0.34	0.21	0.41	0.41	0.50	0.42	0.49	-0.07	-0.002

	ownership(1=Yes)										
Credit	Access to credit (1=Yes)	0.42	0.50	0.12	0.32	0.80	0.40	0.42	0.50	0.31***	0.38***
Rainfall	Rainfall (annual , mm)	1119.3	414.6	1090.2	386.5	1744.9	317.0	1404.5	467.4	29.16	340.4***
Shock	Economic shock (1=yes)	0.39	0.49	0.47	0.50	0.35	0.48	0.47	0.50	-0.08	-0.12
HCI_1_export market		46.9	28.4	-	-	28.71	22.8				
HCI_1_domestic market		-	-	24.0	26.1	-	-	26.6	26.8		
HCI_2_export market		62.3	30.9	-	-	55.73	35.6		-		
HCI_2_domestic market		-	-	40.7	33.3	-	-	59.7	39.2		
HCI_3_export market		98.6	9.3	-	-	93.75	11.5				
HCI_3_domestic market		-	-	96.6	13.3	-	-	75.5	21.9		

Note: *Note: Significance at 10% probability level or below; the figures are means for continuous variables and proportions for categorical variables;* ***HCI*** *is abbreviation for Horticultural Commercialization Index*

HCI_1= [*Vegetable sales, household,i;year, t/ Total household income, household,i;year,t]*100*

HCI_2= *[Vegetable sales, household,i;year, t/ Total crop sales, household,i; year, t]*100*

HCI_3= *[Vegetable sales, household,i;year, t / Total value of vegetable crops produced, household,i;year, t]*100*

Table 2: Household fixed effects (selection-bias corrected) estimates of commercialization effects on household income

	Per adult equivalent income (log)			
	(1)	***(2)***	***(3)***	***(4)***
Export market (dummy)	0.335*** (0.134)			
Domestic market (dummy)	-0.102 (0.127)			
HCI_1_export market		0.004* (0.002)		
HCI_1_domestic market		-0.003 (0.003)		
HCI_2_export			0.005*** (0.002)	
HCI_2_domestic			0.001 (0.002)	
HCI_3_export				0.006*** (0.002)
HCI_3_domestic				0.003* (0.002)
Head education	0.011 (0.022)	0.010 (0.022)	0.012 (0.022)	0.009 (0.022)
Household size	-0.13*** (0.024)	-0.13*** (0.024)	-0.13*** (0.024)	-0.13*** (0.024)
Off-farm	0.171* (0.117)	0.169 (0.118)	0.175* (0.116)	0.170* (0.116)
Business	0.28*** (0.104)	0.284*** (0.107)	0.293*** (0.104)	0.284*** (0.104)
Cultivated land	0.13*** (0.053)	0.121** (0.053)	0.125** (0.053)	0.119** (0.053)
Credit	0.192* (0.117)	0.187* (0.117)	0.165 (0.117)	0.135 (0.118)
Rainfall	0.003***	0.003***	0.003***	0.003***

	(0.001)	(0.001)	(0.001)	(0.001)
Year dummy (1=2010)	-1.88***	-1.87***	-1.84***	-1.79***
	(0.562)	(0.564)	(0.564)	(0.564)
Shock	0.161	0.170	0.176	0.173
	(0.130)	(0.130)	(0.131)	(0.130)
Mills ratio(export)	0.070	-0.005	0.015	0.041
	(0.076)	(0.065)	(0.067)	(0.070)
Mills ratio(domestic)	-0.390**	-0.387**	-0.349*	-0.279*
	(0.188)	(0.181)	(0.183)	(0.190)
Constant	-2.889**	-3.050**	-3.022**	-3.231**
	(1.399)	(1.392)	(1.385)	(1.389)
District fixed effects[a]	Yes	Yes	Yes	Yes
Number of observations	618	618	618	618
R^2 (within)	0.27	0.26	0.26	0.27
F(23,286)	4.5***	4.4***	4.5***	4.6***

Note: Significance at 0.01(***), 0.05(**), 0.1(*) probability level; Standard errors in bracket. Household fixed effects reject the null hypothesis that there is joint insignificance in all the cases above. ***Gender of household head, head age, dependency ratio, remittances, total land owned and land fertility*** *are also included in the above analysis but not shown in the table.* [a]D***istrict dummies*** *included in estimation to control for geographical location effects*

Table 3: Household fixed effects (selection-bias corrected) estimates of commercialization effects on household assets

	Per adult equivalent asset (log)			
	(1)	***(2)***	***(3)***	***(4)***
Export market (dummy)	-0.077*			
	(0.038)			
Domestic market (dummy)	0.007			
	(0.036)			
HCI_1_export market		0.0001		
		(0.001)		
HCI_1_domestic market		0.001		
		(0.001)		
HCI_2_export market			0.00002	
			(0.001)	
HCI_2_domestic market			0.001	
			(0.001)	
HCI_3_export market				0.0003
				(0.001)
HCI_3_domestic market				0.001**
				(0.001)
Male head	-0.110*	-0.121*	-0.114*	-0.116*
	(0.072)	(0.072)	(0.072)	(0.072)
Head age	-0.013	-0.012	-0.013	-0.014
	(0.011)	(0.011)	(0.011)	(0.011)
Head age (squared)	0.0002*	0.0001	0.0002*	0.0002*
	(0.000)	(0.000)	(0.000)	(0.000)
Head education	0.012**	0.012**	0.012**	0.012*
	(0.006)	(0.006)	(0.006)	(0.006)
Household size	-0.20***	-0.20***	-0.20***	-0.20***
	(0.007)	(0.007)	(0.007)	(0.007)
Cultivated land	-0.017	-0.014	-0.014	-0.017
	(0.015)	(0.015)	(0.015)	(0.015)
Rainfall	0.00003	-0.00001	0.00001	-0.00003
	(0.000)	(0.000)	(0.000)	(0.000)

Year dummy (1=2010)	0.078	0.099	0.083	0.126
	(0.158)	(0.159)	(0.159)	(0.158)
Mills ratio(export)	-0.035	-0.011	-0.014	-0.019
	(0.021)	(0.018)	(0.019)	(0.020)
Mills ratio(domestic)	0.024	0.037	0.042	0.066
	(0.053)	(0.051)	(0.052)	(0.053)
Shock	-0.038	-0.044	-0.039	-0.037
	(0.036)	(0.037)	(0.037)	(0.036)
Constant	1.019***	0.960**	0.966***	0.966***
	(0.393)	(0.392)	(0.391)	(0.390)
District fixed effects[a]	Yes	Yes	Yes	Yes
Number of observations	618	618	618	618
R^2 (within)	0.82	0.82	0.82	0.82
F(23,286)	56.0***	55.1***	55.2***	56.2***

Note: Significance at 0.01(***), 0.05(**), 0.1(*) probability level; Standard errors in bracket. Household fixed effects reject the null hypothesis that there is joint insignificance in all the cases above. ***Dependency ratio, remittances, off-farm employment, total land owned, land fertility and access to credit.*** [a]D***istrict dummies*** *included in estimation to control for geographical location effects*

Table 4: Effects of commercialization on household per adult equivalent income

	Per adult equivalent income							
	Pooled OLS estimates				*Household fixed effects (standard) estimates*			
	(1)	***(2)***	***(3)***	***(4)***	***(1)***	***(2)***	***(3)***	***(4)***
Export market (dummy)	0.417***				0.32***			
	(0.083)				(0.109)			
Domestic market (dummy)	0.217***				-0.029			
	(0.082)				(0.122)			
HCI_1_export market		0.005***				0.005**		
		(0.002)				(0.002)		
HCI_1_domestic market		0.001				-0.003		
		(0.002)				(0.003)		
HCI_2_export market			0.006***				0.005***	
			(0.001)				(0.002)	
HCI_2_domestic market			0.005***				0.002	
			(0.001)				(0.002)	
HCI_3_export market				0.007***				0.007***
				(0.001)				(0.002)
HCI_3_domestic market				0.006***				0.004**
				(0.001)				(0.002)

Note: *Significance at 0.01(***), 0.05(**), 0.1(*) probability level; Standard errors in bracket. Household fixed effects reject the null hypothesis that there is joint insignificance in all the cases above.*

Table 5: Effects of commercialization of vegetables on household per adult equivalent asset

	Per adult equivalent asset							
	Pooled OLS estimates				*Household fixed (standard) effects estimates*			
	(1)	***(2)***	***(3)***	***(4)***	***(1)***	***(2)***	***(3)***	***(4)***
Export market (dummy)	0.008				-0.045*			

	(0.024)				(0.031)			
Domestic market (dummy)	0.045**				0.004			
	(0.023)				(0.034)			
HCI_1_export market		0.0002				0.0001		
		(0.000)				(0.001)		
HCI_1_domestic market		0.001*				0.001		
		(0.001)				(0.001)		
HCI_2_export market			0.0004				0.00003	
			(0.000)				(0.000)	
HCI_2_domestic market			0.001***				0.001	
			(0.000)				(0.001)	
HCI_3_export market				0.001**				0.0003
				(0.000)				(0.001)
HCI_3_domestic market				0.001***				0.001*
				(0.000)				(0.001)

Note: Significance at 0.01(***), 0.05(**), 0.1(*) probability level; Household fixed effects reject the null hypothesis that there is joint insignificance in all the cases above.

Table 6: Fixed effect instrumental variable effects of commercialization on per adult equivalent income and asset

	Per adult equivalent income (log)							
	(1)		***(2)***		***(3)***		***(4)***	
Export market (dummy)	0.498*	(0.280)						
HCI_1_export market			0.015	(0.011)				
HCI_2_export market					0.015*	(0.009)		
HCI_3_export market							0.011**	(0.006)
Number of observations	618		618		618		618	
R-squared	0.246		0.201		0.144		0.163	
F(1,288)	0.457		0.770		1.652		2.051	
Wald chi2(20)	96.8***		90.3***		85.6***		88.3***	
	Per adult equivalent asset index (log)							
Export market (dummy)	0.081	(0.080)						
HCI_1_export market			0.002	(0.003)				
HCI_2_export					0.002	(0.002)		
HCI_3_export							0.002	(0.002)
Number of observations	618		618		618		618	
R-squared	0.805		0.807		0.794		0.791	
F(1,288)	3.110*		0.566		0.264		2.36	
Wald chi2(20)	1766***		1779***		1673***		1646***	

Note: Export market instruments= Extension contact, distance to market, group member; *Significance at 0.01(***), 0.05(**), 0.1(*) probability level; [a]Makueni district is used as the base. Standard errors are given in brackets.*