Determinants and welfare effects of smallholder participation in horticultural markets in Zambia

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Abstract

We examine smallholder participation in horticultural markets in Zambia, with two main questions in mind: 1) who participates in horticultural markets? and 2) how does participation affect household income and other welfare outcomes? To control for self-selection bias in the estimation of impacts, we used an endogenous switching framework on nationwide representative data over two agricultural seasons pooled, but controlling for district-level fixed effects. We found that participation is associated with labour availability, farm size, lagged productive assets, social capital through blood kinship links to the chief or headman, level of community participation in the government's input subsidy programme, and high rainfall variability measured by its coefficient of variation. Participation significantly increased income by 285% overall, increasing to over 300% for female-headed households, those cultivating less than one hectare and the extremely poor. These findings provide an empirical foundation to support Zambian policy-makers' crop-diversification and poverty-reduction agricultural policy objectives.

Key words: Market participation, welfare effects, self-selection, endogenous switching

1. Background

Rapid urbanisation and sustained urban income growth are driving a transformation of African agrifood systems (Tschirley *et al*. 2014). In this process, new opportunities and challenges emerge for linking African smallholder farmers to expanding and changing urban food markets. A particularly intriguing outgrowth of this transformation is the opportunities being created in domestic horticultural markets. Like meat and dairy, horticultural products have a high income elasticity of demand in sub-Saharan Africa (SSA), hovering around 0.7 and 0.8 (Seale *et al*. 2003). Yet, unlike these other higher value foods, horticultural products have proved resistant to retail consolidation by the rise of supermarkets in the region (Weatherspoon & Reardon 2003; Tschirley *et al*. 2014). As a result, traditional retail markets, which have substantially lower barriers to entry for smallholder producers than supermarkets, remain the primary source of horticultural products for urban consumers (Hichaambwa *et al*. 2009; Tschirley & Hichaambwa 2010a). Horticultural products also lend themselves to a wide array of value-added processing, including canning, juicing and the production of sauces and preserves. Demand growth for these products, therefore, offers opportunities to trigger significant multiplier effects through investments in domestic food manufacturing.

Due to its high labour intensity, high production value per unit land area and short production cycles, horticultural production may provide the greatest opportunity of any set of crops for land-constrained, poor smallholder farmers to escape poverty through agricultural commercialisation. According to Tschirley *et al*. (2012), a relatively market-oriented smallholder in Zambia might sell one to two metric tons of maize at a price ranging from US$0.12 to US$0.25 per kg, depending on the year and sales channel. Total gross revenue thus ranges from US$120 to US$500, nearly all of it occurring immediately after harvest. In contrast, the average smallholder producing tomatoes may produce 10 to 15 metric tons (on less land) over several months and sell it at an average price of US$0.30 to 0.35/kg, for a total gross value of US$3 000 to US$5 250 – 10 to 30 times higher than typical maize sales values.

Despite the potential benefits of horticultural production and commercialisation for smallholders in SSA, the welfare impacts across countries have been mixed. In Kenya there is considerable consensus that the promotion of smallholder horticulture has been a pro-poor development strategy (Muriithi *et al*. 2014). Conversely, the evidence has not been conclusive in Zambia. Tschirley *et al*. (2012) found that smallholder horticultural markets in Zambia are quite concentrated, with the top 20% of sellers accounting for over 80% of sales. Moreover, only about 18% of horticultural producers in Zambia sell, with the probability of selling rising steadily with landholding size. The opposite was found to be true in Kenya, where the proportion of smallholder households selling fresh produce was much higher (about 80%) and that participation in horticultural markets increased among smaller land owners (Tschirley *et al*. 2012).

Against the background of on-going economic dynamism and food system transformation, coupled with persistently high rural poverty rates (~80%) and declining land availability (Hichaambwa & Jayne 2012; 2014), this article seeks to answer two questions: 1) What are the socio-economic determinants of smallholder participation in horticultural markets in Zambia? and 2) What are the welfare impacts for smallholder households that participate in horticultural markets? This article will help to inform on-going debates on strategies to beneficially link African smallholders to rapidly evolving urban food markets. It will contribute particularly to the empirical information available to policy makers and other agricultural development stakeholders on the available opportunities offered by high-value crops, especially fresh fruits and vegetables, in smallholder income growth and broad-based rural poverty reduction. This is important because income growth and broad-based poverty reduction have been quite elusive, in spite of significant agricultural growth in some African countries, such as Zambia.

The rest of the paper is organised as follows. Section 2 outlines our conceptual model and estimation strategy. Section 3 describes the data used in this study, along with descriptive statistics. The estimation results are presented in section 4. Section 5 offers concluding remarks.

2. Conceptual framework and estimation procedure

Our conceptual framework is centred on the endogenous switching framework of Lokshin and Sajaia (2004), which also was applied by Rao and Qaim (2010), Abdulai and Huffman (2014) and Khonje *et al*. (2014) in studying the impacts of market channel participation and technology adoption. Participation in horticultural markets can be viewed as a binary choice issue by smallholder households as they try to maximise utility or net returns from their farming activities. Utility is determined by Z, a vector of variables that influence the ability and the cost of adjusting to an enterprise/market option with new requirements. In Zambia's horticultural sector, these requirements include the adoption of the necessary horticultural crop and risk management practices, and learning to navigate unregulated and chaotic horticultural produce markets (Hichaambwa & Tschirley 2010; Tschirley & Hichaambwa 2010a; 2010b; 2012; Tschirley *et al*. 2012). Some variables in Z also determine the relative returns that smallholder households could earn from horticultural sales, as well as from other crop sales or farm activities.

The probability that smallholder households participate in horticultural markets is determined by the expected utility of participation, I^*_h, against the expected utility of producing and selling other crops or farm produce, I^*_c. In making this decision, smallholder households evaluate both the costs and benefits of participation and will only participate if $I^*_h > I^*_c$. However, I^*_h and I^*_c cannot be observed, so what is observed is actual participation in horticultural markets, I, with $I = 1$ if $I^*_h > I^*_c$ and $I = 0$ if $I^*_h \leq I^*_c$. Therefore, participation in horticultural markets can be represented as:

$$I = Z\alpha - \upsilon, \tag{1}$$

where α is a vector of parameters determining this participation and υ is an error term with zero mean and variance σ^2.

Since smallholder households are heterogeneous in their characteristics, not all of them will participate in horticultural markets. For those who do, participation is expected to result in higher farm returns and household incomes (Tschirley *et al*. 2012). Farm household income is determined by various socio-economic factors that influence the capacity to produce and market different types of commodities. Hence producing and marketing certain types of commodities may influence smallholder household income. We hypothesised that producing and marketing horticultural products has an important positive effect on income due to its high-value nature, as well as possible continuous cash inflows during the year that can be reinvested multiple times in the household's income-generating activities. In order to evaluate income effects, we build on a model:

$$y = X\beta + \gamma I + \mu, \tag{2}$$

where y is the household income, X is a vector of farm, household and contextual characteristics, and I is the horticultural markets participation dummy. The coefficient γ captures the impact of horticultural market participation on household income. However, because smallholder households self-select into the group of participants, this coefficient may be biased. When more efficient farmers, whose incomes are higher anyway, are more likely to participate in horticultural markets, the income effect especially would be over-estimated. Rao and Qaim (2010) suggest that, in order to correct for such bias, Heckman selection or instrumental variable approaches could be used. Yet these approaches still assume that the income functions would differ only by a constant term between participants and non-participants. In reality, differences between the groups may be more systematic, that is, there may be interactions between horticultural market participation choice and the other income determinants captured in X. Rao and Qaim (2010) further suggest that the propensity score matching used by Maertens and Swinnen (2009) can deal with structural differences, but only to the extent that these differences are based on observable characteristics. When there are unobserved factors that simultaneously influence farmers' production and marketing decisions and household incomes, such as individual skills, ability or motivation, then propensity score matching may still result in biased estimates.

An approach that can account for systematic differences across groups is switching regression (Maddala, 1983). A switching regression model treats market participation as regime shifters; this can be represented as follows:

$$y_h = \beta_h X + \mu_h,$$
$$y_c = \beta_c X + \mu_c, \quad (3)$$
$$I^* = Z\alpha - \upsilon,$$

where y_h and y_c represent smallholder household income for participants and non-participants in horticultural markets respectively, and I^* is a latent variable determining which regime applies. The variable sets X and Z are allowed to overlap, but proper identification requires that at least one variable in Z does not appear in X.

Endogenous switching is a potential concern whenever the dependent variable of the model is a function of a decision to self-select into one of two (or more) regimes. Standard regression techniques result in inconsistent estimators if unobserved factors affecting the response are correlated with unobserved factors affecting the regime choice (Heckman 1978).

We used the conditional mixed process (cmp) of Roodman (2011) to estimate the full information maximum likelihood (FIML) endogenous switching regression. To measure the impact of smallholder participation in horticultural markets, we estimated the conditional expectation of income that participants would have without participation in horticultural markets (Maddala 1983; Lokshin & Sajaia 2004; Rao & Qaim 2010).

To further control for endogeneity arising from time-invariant unobserved factors, we employed a meso-scale implementation of the Mundlak-Chamberlain device (Mundlak 1978, Chamberlain 1984). This approach generally involves including, as additional regressors, the time averages of all time-varying variables in order to control for unobserved heterogeneity, which is time invariant (Wooldridge (2010) refers to the resulting estimator as the Correlated Random Effects estimator). Because we did not have a household-level panel, but did have observations from both survey years for the same districts, we included district averages of all time-varying household variables. This approach thus controls for district-level unobserved factors that may otherwise bias estimation results.

3. Data and descriptive statistics

This study used two nationally representative datasets on rural farm households in Zambia. First was the 2008 Supplemental Survey, containing 8 090 interviews with respect to the 2006/2007 agricultural season carried out by Zambia's Central Statistical Office (CSO) in conjunction with the Ministry of Livestock (MAL) and Michigan State University's Food Security Research Project (see Megill (2004) for sampling details). The second was the Rural Agricultural Livelihoods Survey (RALS) conducted in 2012 by the Indaba Agricultural Policy Research Institute in conjunction with CSO and MAL, with 8 721 household interviews with respect to the 2010/2011 agricultural season. The two datasets were pooled to account for some variation over time for analysis, with the time dimension being controlled for by season-specific measures of localised rainfall and its distribution as measured by the coefficient of variation. The modules for collecting data on smallholder horticultural production and marketing were very similar for these two surveys. Commodity prices and/or values were all inflated to 2012 levels using the CSO consumer price indices.

Total household income in the survey data was estimated as the total farm income (consumption and sales) plus all non-farm income, including that earned from wage labour, formal and informal business activities, pensions, remittances and other payments relating to all household members over the whole reference year. This income value was then converted to US dollars using an exchange rate adjusted for inflation, using 2005 as the base year. It was from this figure that the income per capita per day was derived. The poverty status of households in the sample was defined as follows: those earning less than US$1.25 per capita per day were classified as being in severe poverty; those earning

US$1.25 up to less than US$2.00 per capita per day were classified as being in moderate poverty; and those earning US$2.00 per capita per day as being non-poor.[1]

The variables captured in the data and used in this analysis were classified into household demographic characteristics, farm assets and social capital, marketing accessibility and behaviour, local rainfall conditions, and the local indicators of governmental activity within the agricultural sector.

3.1 Demographic characteristics

Demographic characteristics included the sex, age and educational level of the household head, the number of household adult equivalents and participation in off-farm income activities. The first three give an indication of the human capital endowment of the household through the head. Female-headed households in the rural parts of Zambia tended to face greater social barriers to income and asset accumulation than their male-headed counterparts (Farnworth *et al*. 2011). While older household heads may be more experienced and achieve better farming outcomes, younger and more educated ones may be amenable to change from the maize monoculture that has characterised Zambian agriculture since independence, may adopt new farming ideas and navigate the horticultural marketing system. Horticultural production is labour intensive and it is expected that households with more adult equivalents would be in a better position to meet this requirement. Participation in off-farm income gives households additional sources of capital to acquire inputs for horticultural production, especially since most government support in the sector is centred on maize.

3.2 Farm assets

Wealth and differential access to capital are often-cited factors for farmers achieving different farming outcomes (Carter 2000). We used farm size and the total value of productive assets (implements and livestock) owned in the year prior to the survey year to measure this factor. These variables were also included in the income equation.

3.3 Social capital

Social capital is captured through household head blood relationship to the local chief or headman and household head polygamously married. Having close ties to village authorities may be important in helping these households gain an advantage over other households in terms of resource access (Chapoto *et al*. 2011), and anecdotal evidence shows that polygamously married households tend to be wealthier.

3.4 Market access and behaviour

Due to perishability and the lack of cold chains in Zambia, access to markets is very important in horticultural production and marketing. We measured market access as the number of hours to the nearest urban centre (with at least 75 000 inhabitants), as well as distance to the nearest tarred/paved road in kilometres. Where markets are accessible, price variation can be extreme. According to Tschirley *et al*. (2012), the ratio of maximum to minimum prices within a single day can exceed 3:1 for tomato and leafy vegetables, based on varying quality and sudden changes in supply; day-to-day changes in average prices frequently exceed 20%; and the ratio of seasonal high to seasonal low prices for many products approaches 10:1 (based on weekly average prices). We captured price variation

[1] Because income-based poverty measures do not incorporate the value of services provided by durable capital such as housing, such measures may be considered partial measures of poverty (relative to expenditure-based methods). However, for this study, the available data limits our analysis to income-based measures.

using the lagged four-year annual average coefficient of variation of the prices of tomato, cabbage, rape and Chinese cabbage (the predominantly consumed vegetables in Zambia), as well as for maize, the main staple food, for comparative purposes. These were computed from the CSO's district-level retail price database.

3.5 Weather conditions

Weather conditions, especially the amount of rainfall and its distribution, play a very important role in the level of crop production and productivity in Zambia, such that whether the country records a bumper harvest of its staple food crop, maize, is dependent on this factor (Burke *et al*. 2010). District rainfall data was obtained from the TAMSAT African Rainfall Climatology and Time-Series dataset (Maidment *et al*. 2014), and its distribution was captured from its coefficient of variation.

3.6 Main policy environment

The main government policy instruments in the agricultural sector are focused on maize input subsidies and maize market (price and quantities) subsidies. These public investments are likely to alter the incentives to participate in horticultural markets. The effects of these polices are measured as:

- The percentage of households in a standard enumeration area (SEA), the primary survey sampling units, receiving inputs from the Farmer Input Support Programme (FISP), and
- Lagged district maize purchases in thousand metric tonnes by the Food Reserve Agency (FRA).

Endogenous switching regression requires that at least one variable in the selection equation is not included in the income equation. We ran simple Probit and linear regression models with participation in horticultural markets and household income respectively to see which variables significantly affected participation but not income. These were found to be hours to the nearest urban centre, relative horticultural-to-maize price variability, seasonal rainfall total and its variation. Out of these we selected the relative horticultural-to-maize price variability and rainfall variation as the exclusion variables, while hours to the nearest urban centre and seasonal rainfall were not selected, because the former is an important study variable, whereas seasonal rainfall is an important parameter in smallholder agriculture in Zambia.

Following the analysis, we ran two simulations showing the impact of selected variables on horticultural market participation, and market participation on household income. In the first instance we ranked hours to the nearest urban centre, kilometres to the nearest tarred road, FRA district maize purchases and ratio of the price variation of horticulture to maize into two equal groups (the bottom and top halves) and estimated the comparative proportion of smallholder participation in horticultural markets for each to demonstrate how participation changes as one moves from one group to the other. In the second simulation, since the log income was used in the income equation, the predicted log income of market participants with and without market participation were converted to antilog to derive an estimate of household income in monetary terms, and to compare the two to estimate the impact of market participation of the whole sample of market participants, as well as this sample disaggregated by sex of the household head, land cultivated and poverty status.

Table 1 presents the descriptive statistics of the sample households. The table shows that Zambian smallholder households are generally poor, with a mean total household income of US$1 845 per annum or US$358 per capita per annum. Extreme poverty rates (per capita income of less than US$1.25 per day) average 80%, while moderate poverty rates (per capita income of less than US$2.00 per day) average at about 90%. The majority of households cultivate less than a hectare of land and their value of productive assets (farm machinery and livestock) is approximately US$700 per household. Slightly less than one fifth of the households participate in horticultural markets, although about half grow horticultural crops. Roughly three quarters of smallholders are engaged in some form of off-farm income-generating activities. The demographic characteristics reflect those of the country in general, in that about one quarter of the households are female headed, and most of the household heads are younger than 45 years and look after a household of less than an equivalent of six adult members.

Table 1: Descriptive statistics of the study sample

Variables	Mean	p^{th} percentile			
		25	50	75	95
Outcome variables					
Percentage of households selling horticultural crops	18.3	n/a	n/a	n/a	n/a
Household total income (2012 ZMW)	9 275	1 981	4 193	8 993	31 751
Household per capita income (2012 ZMW)	1 799	400	839	1 784	5 975
Percentage extremely poor	81.4	n/a	n/a	n/a	n/a
Percentage moderately poor	89.8	n/a	n/a	n/a	n/a
Demographic characteristics					
Percentage female-headed households	23.9	n/a	n/a	n/a	n/a
Age of household head	34.4	20.5	30.0	44.0	70.0
Number of household adult equivalents	4.6	2.9	4.4	5.9	8.5
Level of education of household head in years	5.7	3.0	6.0	8.0	12.0
Percentage of households earning off-farm income	77.6	n/a	n/a	n/a	n/a
Farm assets					
Farm size (ha)	2.7	0.8	1.5	2.8	7.9
Total land cultivated (ha)	1.5	0.5	1.1	1.9	4.1
Lagged hh productive assets (2012 ZMW '000)	6.9	0.3	0.9	3.5	25.4
Social capital					
Percentage of households related to chief/headman	46.9	n/a	n/a	n/a	n/a
Percentage of household heads polygamously married	9.6	n/a	n/a	n/a	n/a
Market accessibility and behaviour					
Hours to nearest urban centre	10.4	5.8	9.7	13.4	22.0
Distance to tarred road in hundred km	18.0	0.2	9.6	27.3	61.4
Lagged four-year mean maize price variation	0.195	0.170	0.209	0.228	0.266
Lagged four-year mean horticulture price variation	0.288	0.242	0.286	0.334	0.385
Horticulture-maize relative price variations	1.76	1.22	1.41	1.72	3.61
Policy environment					
District lagged FRA maize purchases (MT'000)	2 506	465	1 454	3 853	8 271
Percentage of households in SEA receiving FISP fertiliser	23.2	n/a	n/a	n/a	n/a
Weather conditions					
Total annual rainfall (mm)	842	776	846	903	994
Coefficient of variation of total annual rainfall	1.00	0.96	1.02	1.08	1.14
Weighted sample	3 086 040				

Source: CSO/MAL/IAPRI (2008; 2012) and authors' computations
Note: n/a denotes not applicable; US$1 = 2012 ZMW5.027

Table 1 also shows that Zambian smallholder households live in areas with relatively poor infrastructure. As a result, they are on average located about 10 hours on available transport from the nearest urban centre, and 18 km from the nearest tarred/paved road. Given the perishability of horticultural products, this may have important implications for the smallholders' capacity to participate in horticultural markets.

Table 2 shows the differences in these parameters between participants and non-participants in the horticultural market. The *t*-values suggest that smallholders that participate in horticultural markets are significantly different from non-participants in virtually all of the variables of interest. Of particular interest to this study is that the horticultural market participants are, on average, younger, better educated and more likely to be male headed, and have greater farm asset values than non-participants. They also tend to have more land under cultivation and live in closer proximity to markets than non-participants. Although causal relationships cannot be identified with descriptive statistics, smallholders that participate in horticultural markets earn more total household income than non-participants and are less likely to be poor.

Table 2: Characteristics of the sample by horticultural market participation

Variables	Mean values by market participation		
	Participants	Non-participants	Difference
Outcome variables			
Household total income (2012 ZMW)	12 440	8 567	3 873***
Household per capita income (2012 ZMW)	2 126	1 726	400***
Percentage extremely poor	76	83	-7***
Percentage moderately poor	87	90	-3***
Demographic characteristics			
Percentage female-headed households	17.6	25.4	-7.8***
Age of household head	32.7	34.7	-2.0***
Number of household adult equivalents	5.1	4.5	0.6***
Level of education of household head in years	6.1	5.6	0.5***
Percentage of households earning off-farm income	77.6	77.6	0.0
Farm assets			
Farm size (ha)	3.51	2.49	1.02***
Total land cultivated (ha)	1.9	1.4	0.5***
Lagged hh productive assets (2012 ZMW '000)	11	6	5***
Social capital			
Percentage of household heads related to chief/ headman	49.9	46.2	3.7***
Percentage of household heads polygamously married	11.7	9.2	2.5***
Market accessibility and behaviour			
Hours to nearest urban centre	8.6	10.8	-2.2***
Distance to tarred road in hundred km	13.9	19	-5.1***
Lagged four-year mean maize price variation	0.189	0.197	-0.008***
Lagged four-year mean horticulture price variation	0.282	0.289	-0.007***
Policy environment			
District lagged FRA maize purchases (MT'000)	2 546	2 497	49***
Percentage households in SEA receiving FISP fertiliser	26.4	22.5	3.9***
Weather conditions			
Total annual rainfall (mm)	823	847	-24***
Coefficient of variation of total annual rainfall	1.02	1.00	0.02***
Weighted sample	564 942	2 521 099	

Source: CSO/MAL/IAPRI (2008; 2012) and authors' computations.
Note: US$1 = 2012 ZMW5.027; *** denotes significance at 1% level

4. Econometric analysis

The descriptive analysis in the previous section revealed differences in household income, as well as in demographic characteristics, farm assets, social capital, market accessibility, policy and weather influence between the horticultural market participants and non-participants. To properly analyse the determinants and impacts on income of participation, we applied an endogenous switching regression model with district-level time averages as additional controls (viz. the meso-level Mundlak-Chamberlain device, as described in section 2). The income equations were estimated with the selection equation to explain smallholder households' participation in horticultural markets, with market accessibility and behaviour as the exclusion variables. In the following, we first discuss the determinants of participation before focusing on income and poverty effects of participation.

4.1 Determinants of participation in horticultural markets

Table 3 shows the average partial effects (APE) and standard errors (SE) of the determinants of smallholder households' participation in horticultural markets for two alternative model specifications: (1) a standard Probit model, and (2) the selection equation from the switching regression, both of which include district-level CRE controls (time averages of the district-level means of all the time-varying household-level explanatory variables). Overall, the results are similar to one another.

Table 3: Determinants of horticultural market participation from Probit

Explanatory variables	Standard Probit		Joint Probit	
	APE	SE	APE	SE
Demographic characteristics				
= 1 if female-headed household	-0.035***	0.009	-0.033***	0.009
Age of head in years	-0.002**	0.001	-0.002**	0.001
Age of household head squared	0.000	0.000	0.000	0.000
Number of household adult equivalents	0.011***	0.002	0.010***	0.002
Level of education of hh head in years	0.001	0.001	0.001	0.001
= 1 if household earning off-farm income	-0.003	0.008	-0.003	0.008
Farm assets				
Household farm size (ha)	0.001**	0.001	0.002**	0.001
Lagged hh productive assets (2012 ZMW' million)	0.175**	0.070	0.361***	0.096
Social capital				
= 1 if household related to chief/headman	0.043***	0.007	0.043***	0.007
= 1 if household head polygamously married	0.010	0.012	0.009	0.012
Market access and behaviour				
Hours to nearest urban centre	-0.005***	0.001	-0.005***	0.001
Distance to nearest tarred road in tens of km	-0.001***	0.000	-0.001***	0.000
Relative horticultural-to-maize price variation	-0.010***	0.003	-0.008***	0.003
Key government policy instruments				
% households in a SEA receiving FISP fertiliser	0.001***	0.000	0.001***	0.000
Lagged FRA district maize purchases in MT'000	-0.008***	0.002	-0.008***	0.002
Weather conditions				
Total annual rainfall in cm	-0.001	0.001	-0.001	0.001
Annual rainfall distribution/variation	0.514***	0.131	0.482***	0.121
Observations	16 907		16 907	

Source: CSO/MAL/IAPRI (2008; 2012) and authors' computations.
Note: *, ** and *** denote significance at 10%, 5% and 1% respectively; This selection equation is jointly estimated with the income regime equations shown in Table 5.

The descriptive statistics provide some indicative attributes of households that participate in horticultural markets compared to those that do not. This table goes further to establish which of these attributes is significantly correlated to participation, controlling for district fixed effects in order to better inform policy options to enhance participation. Starting with demographic characteristics, we found that, consistent with our descriptive statistics, female-headedness and age of the household head were significantly and negatively correlated with participation in horticultural markets. On average, being female headed decreased the probability of a household's participation in horticultural markets by 3.3 percentage points, all other factors held constant. Increasing the age of the household head by one year on average decreased the probability of participation by 0.2 percentage points. As expected, labour availability denoted by number of household adult equivalents was significantly and positively related to the households' participation in horticultural markets. Keeping all other factors constant, increasing the household adult equivalents by one increased the probability of participation by one percentage point on average. We found no significant relationship between the educational level of the household head and engagement in off-farm income-generating activities and participation in horticultural markets. However, Chapoto *et al*. (2012) found a slightly significant positive correlation between educational level of the household head and the probability of a household being consistently among the top 50% of horticultural sellers.

We found farm size, productive assets and kinship ties to the local chief or headman to be significantly and positively correlated with participation in the horticultural markets, with a unit increase in the factors leading to an increase in the probability of participation of 0.1, 36.1 and 4.4 percentage points respectively on average, all other factors held constant.

As hypothesised and shown by the descriptive analysis, access to markets and relative horticulture-to-maize market price variation were found to be significantly and negatively correlated with horticultural market participation. Increasing the time to reach the nearest urban centre by one hour and increasing the distance to the nearest tarred/paved road by ten kilometres decreased the probability of market participation by 0.5 and 0.1 percentage points respectively, all other factors held constant. This is similar to the findings of Chapoto *et al*. (2012) and Tufa *et al*. (2014). There was a significant and negative relationship between horticulture-maize relative price variability. Increasing the horticultural price variation to ten times that of maize was associated with a decrease in the probability to participate in horticultural markets of eight percentage points, all other factors held constant.

Table 4 shows the simulated impact of market accessibility, lagged FRA district maize purchases and horticultural price variation on horticultural market participation by comparing the mean values as well as the percentage of smallholder households selling horticultural crops in the bottom and top half groups of each variable. Movement from the bottom to the top remoteness group reduces horticultural market participation by 39%, while moving from the bottom to the top group of horticultural price variation reduces horticultural market participation by 17%. These further underline the importance of market accessibility and price variation for horticultural market participation. The effect of distance to the nearest tarred/paved road is much less, reducing horticultural market participation by only 14%. This could be because the tarred/paved roads improve the speed of transportation of the perishable produce to urban markets.

With regard to FRA maize purchases, one of the government policy instruments, Table 4 shows a reduction of 7% in horticultural market participation moving from the bottom half to the top group of lagged district maize purchases. Furthermore, Table 3 shows a significant and negative relationship of these maize purchases with horticultural market participation. Government purchases of maize at higher than market pan-territorial prices tend to encourage maize mono-cropping and, as a consequence, may discourage horticultural production and marketing by shifting available land away from other crops. Increasing FRA purchases by 100 000 metric tons is associated with a decrease in the probability of participating in horticultural markets of 0.8 percentage points on average, all other factors held constant.

In the case of FISP, Table 3 shows a significant and positive relationship with horticultural market participation. Field experience shows that smallholder farmers use proceeds from horticultural sales to meet the farmer cost contribution to the FISP input packs, and in other cases, farmers apply the fertiliser received to maize in their horticultural fields. Thus, although not specifically designed to support horticultural production, FISP appears to beneficially influence participation in the horticulture market.

Rainfall remains the most important environmental factor that affects agricultural production and productivity in Zambia, including horticulture, as most smallholder households lack access to irrigation. Even in years of normal overall rainfall levels, intra-seasonal distribution (i.e. variability of daily rainfall throughout the season) has a great impact on production. For example, the 2014 bumper maize harvest was attributed largely to good distribution (smaller coefficient of variation) of rainfall, rather total amounts received (Zulu & Sitko, 2014). It is therefore not very clear why we find a significant negative correlation between rainfall variability and horticultural market participation. One possible explanation is that horticultural disease pressures, which are high and impede production in the rainy season, tend to reduce in rainy seasons with pronounced dry spells, thus leading to increased production and marketing. Another plausible explanation is that more smallholder farmers engage in horticultural production as they respond to the poor performance of field crops being adversely affected by the dry spells in the rainy season. In addition, the shorter growing season for horticulture compared with most field crops may make horticulture less vulnerable to intra-seasonal rainfall variability.

Table 4: Impact of accessibility, FRA maize purchases and price variation on market participation

Variable	Level	Mean value	% selling horticulture	% change from bottom to top group
Hours to the nearest urban centre	Bottom half	5.6	22.7	-
	Top half	15.3	13.8	-39.2
	Total	10.4	18.3	
Kilometres to the nearest tarred road	Bottom half	0.9	19.7	-
	Top half	34.9	16.9	-14.4
	Total	18.0	18.3	
MT'000s of FRA district lagged maize purchases	Bottom half	0.6	18.9	-
	Top half	4.5	17.7	-6.5
	Total	2.5	18.3	
Horticulture-maize relative price coefficient of variation	Bottom half	1.18	20.2	-
	Top half	2.34	16.4	-23.0
	Total	1.76	18.3	

Source: CSO/MAL/IAPRI (2008; 2012) and authors' computations.

4.2 Determinants of household income

This section examines household income variations between horticultural market participants and non-participants with the use of an endogenous switching model. The results, shown in Table 5, indicate that there were structural differences between the participants and non-participants. First, household female headship had a negative and significant influence on household income in both types of households, but the effects were much larger for non-participants. This suggests that, although female-headed households face greater constraints to income generation than their male counterparts, the magnitude of these constraints is lessened through participation in horticultural markets.

The age of the household head had a significant quadratic effect, with income increasing in age up until age 65, a possible indicator of returns to experience. Household endowments of labour (measured by household adult equivalents) and land size had positive significant effects on income, with the effect being much more pronounced among non-participants. This suggests that the constraints posed by limited land and labour access, which are pervasive problems in Zambian smallholder agriculture, were somewhat mitigated through participation in the horticultural market. Farm size affected household income positively and significantly for both market participants and non-participants, while the value of productive assets only positively and significantly affected household income among the non-market participants, which suggests that resource endowments are not as much of a constraint to increasing smallholder income through participation in horticultural markets as not participating in these markets.

It is important to note that all of these variables (except education of the household head) also significantly affected the probability of participation in horticultural markets. This suggests a case of joint determination of income and participation. Therefore, to unravel the effects of participation on income, Table 5 reports estimates for the covariance terms (lnσ, σ and ρ). Since σ is not statistically different from zero in both equations, there is exogenous switching or self-selection of the market participants, and it was important that selection bias in this model was controlled for (Maddala 1986, in Rao & Qaim 2010). The ρ terms are statistically significant for both participants and non-participants, further indicating that self-selection occurred in decision making to participate in horticultural markets (Abdulai & Huffman 2014). The negative sign of the ρ among market participants indicates positive selection bias, suggesting that smallholder households with above-average income have a higher probability of participating in horticultural markets. Thus, horticultural market participants have above-average incomes among both participants and non-participants, but are better off as participants. The significance of the correlation coefficient (ρ) shows that self-selection would be an issue if not controlled for. The model fulfils the necessary condition for consistency, i.e. ρ for participants is less than ρ for non-participants. Participants therefore earn higher incomes than they would earn if they did not participate in horticultural markets.

Table 5: Full information maximum likelihood parameter estimates for total household income

Explanatory variables	With participation		Without participation	
	Coefficient	SE	Coefficient	SE
Demographic characteristics				
= 1 if female-headed household	-0.262***	0.067	-0.282***	0.029
Age of head in years	0.021***	0.006	0.022***	0.003
Age of household head squared	-0.000**	0.000	-0.000***	0.000
Number of household adult equivalents	0.093***	0.011	0.110***	0.006
Level of education of hh head in years	0.069***	0.006	0.086***	0.004
= 1 if household earning off-farm income	0.387***	0.050	0.607***	0.029
Farm assets				
Household farm size (ha)	0.009*	0.006	0.010**	0.004
Lagged household productive assets	0.624	0.418	5.148***	1.030
Social capital				
= 1 if household related to chief/headman	-0.208***	0.049	-0.078***	0.024
= 1 if household head polygamously married	0.117*	0.071	0.101***	0.038
Market access				
Hours to nearest urban centre	-0.001	0.007	0.003	0.003
Distance to nearest tarred road in tens of km	-0.002	0.002	-0.004***	0.001
Key government policy instruments				
Percent hhs in a SEA receiving FISP fertiliser	0.001	0.001	0.005***	0.001
Lagged FRA district maize purchases	0.054***	0.013	0.040***	0.007
Weather conditions				
Total annual rainfall in cm	0.005	0.007	-0.005	0.004
Constant	8.704***	1.047	4.326***	0.563
lnσ	0.087	0.055	0.049***	0.013
σ	1.091	0.060	1.050***	0.014
ρ	-0.663***	0.067	0.029	0.123
Number of observations			16 907	

Source: CSO/MAL/IAPRI (2008;2012) and authors' computations.
Note: *, ** and *** denote significance at 10%, 5% and 1% respectively; The dependent variable is log household income. These regime equations are jointly estimated with the selection equation shown in the right-most column of Table 3; District effects are included but not shown

4.3 Impacts of horticultural market participation on income

Following the joint income and selection equation, we used the predicted income with and without market participation by the market participants to assess the impact of participation on income and, consequently, on poverty. Since our dependent variable is log income, we took the anti-log of the predicted values to convert it to actual average income in Zambian kwacha (ZMW). The results are shown in Table 6 by different categories of participants.

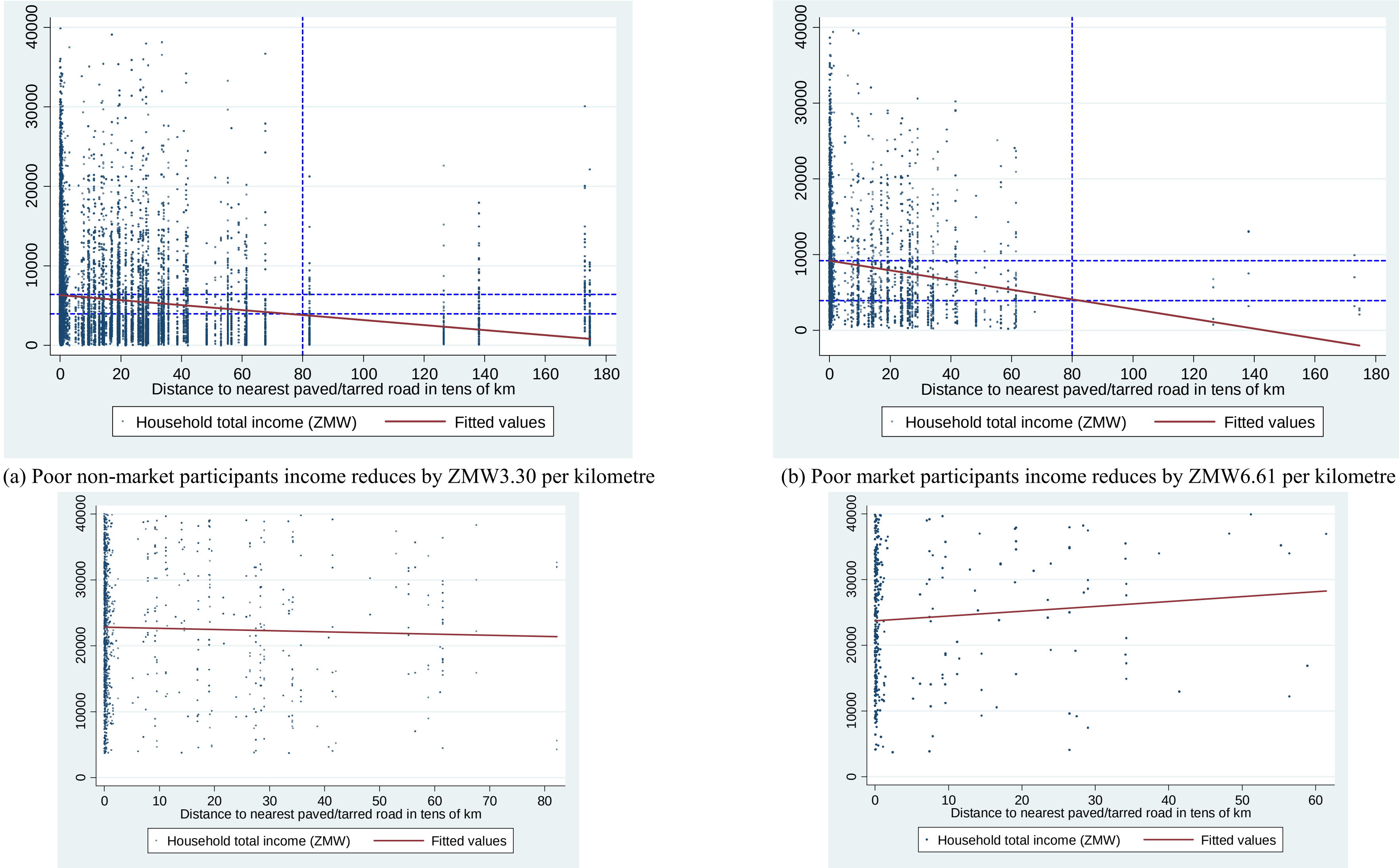
Table 6 shows a significant net positive income change from participation in horticultural markets. The increase in income due to participation in horticultural markets is 242% among all horticultural sellers. It is important to note that the increase in income is higher for female-headed households than male-headed households (274% compared to 236%) and for farmers with smaller land sizes (250% to 261% for those cultivating 2 ha or less compared to 182% for those cultivating over 5 ha). In addition, the increase in income is much more for the poor households, ranging from 252% for the extremely poor through to 247% for the moderately poor and 184% for the non-poor. Taken together, these results suggest that horticultural market participation can help overcome the barriers to income generation faced by socially marginalised and land-constrained households, thereby enabling significant poverty reduction.

Table 6: Simulated impact of horticultural market participation on income and poverty

	Weighted sample	Predicted income (2012 ZMW)		
		Without participation	With participation	% change
All horticultural sellers	564 942	17 395	4 524	285***
By gender of household head				
Male	465 560	18 715	4 991	275***
Female	99 382	12 354	2 857	332***
By cultivated land				
Cultivating under 1 ha	190 703	16 089	3 920	310***
Cultivating 1-2 ha	197 772	17 025	4 323	294***
Cultivating 2-5 ha	149 580	18 387	5 152	257***
Cultivating more than 5 ha	26 887	26 034	8 462	208***
By poverty status				
Extremely poor	430 322	16 025	4 056	295***
Moderately poor	61 565	20 940	5 379	289***
Non-poor	73 055	24 113	7 430	225***

Source: CSO/MAL/IAPRI (2008; 2012 and authors' computations.
Note: US$1 = 2012 ZMW5.027; *** Denotes significance difference at 1% level

Figure 1 plots the relationship between distance to the nearest tarred road in kilometres and household income among the poor smallholder households and shows that income reduces by ZMW3.30 and ZMW6.61 per kilometre away from the nearest tarred road for non- and horticultural market participants respectively. This strengthens the recommendation that infrastructure development to increase market accessibility will not only increase smallholder participation in horticultural markets, but also is a pro-poor development in as far as income growth and poverty reduction are concerned.



(a) Poor non-market participants income reduces by ZMW3.30 per kilometre

(b) Poor market participants income reduces by ZMW6.61 per kilometre

(c) Non-poor non-market participants

(d) Non-poor market participants

Figure 1: Relationship between household income and distance to nearest paved/tarred road

Source: CSO/MAL/IAPRI (2008; 2012) and authors' computations.

5. Conclusions

In the context of on-going transformation in Africa's economic and demographic landscapes, a growing literature has come to question the feasibility of pursuing a smallholder-led poverty-reduction strategy (e.g. Collier & Dercon 2014). Given the lack of positive movement in rural incomes and poverty levels across much of the continent, this sentiment is understandable. However, because the majority of Africa's population remains rural and poverty levels are particularly high among this population, any strategy aimed at achieving economic growth and poverty reduction will require improvements in the conditions of smallholder agriculture. Thus, identifying demonstrably effective investment areas, with high returns in terms of smallholder incomes, is critical.

Our results have shown that, in the case of Zambia, enhancing conditions for smallholder participation in horticultural markets offers significant income-earning opportunities, particularly for poor and land-constrained farmers. We found that, on average, horticultural marketing leads to a 242% increase in total household income, holding other factors constant. Such income gains are more pronounced for smaller farms (nearly 261% income increases for farms smaller than 1 hectare) and for poorer households (about 252% increases for households earning less than US$1.25 per capita per day). Furthermore, participation in horticultural markets appears to reduce the gender gap in rural household income: female-headed households that market their horticultural output are relatively less disadvantaged than their male-headed counterparts, as compared with female-headed households that do not market horticulture.

Why then do only 18% of households participate in these markets as suppliers? Our analysis highlights several factors limiting horticultural market participation. Most important of these are remoteness (i.e. distance from infrastructure and markets) and price volatility. Policies and investments designed to improve accessibility in high-potential horticulture production areas, namely those in proximity to urban markets, coupled with improved market information systems, could have important enabling impacts on horticultural market development in smallholder areas. These investments will likely trigger a beneficial cycle of market development. Furthermore, better transportation and communication infrastructure will lower the costs of spatial arbitrage, which should also help to decrease localised price variability. Price variability would be expected to decrease, with developed and well-functioning markets that facilitate spatial and seasonal arbitrage by supply chain actors, shifting the supply of commodities from relatively high- to low-supply areas and seasons.

Horticulture market developments, involving both hard and soft market infrastructure, will contribute to increased smallholder participation in the horticultural supply chains. This, in turn, will increase the chances of smallholders to increase income and move out of poverty on the one hand, and will increase the supply of high-quality fresh produce at competitive prices to urban consumers on the other. Rapid urbanisation and mounting land pressures in SSA will increasingly act as both obstacles and opportunities to utilise smallholder agriculture to reduce poverty and create economic growth. Under these conditions, strategies need to be developed to maximise returns where labour/land ratios are high and increasing. Horticulture market development appears to be an effective tool.

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