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Smallholder Participation in the Commercialisation of Vegetables: Evidence from Kenyan Panel Data

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Abstract

This paper describes the participation of smallholders in commercial horticultural farming in Kenya and identifies constraints and critical factors that influence their decision to participate in this industry by selling their produce. The study employs panel survey data on smallholder producers of both international (export) and domestic market vegetables and controls for unobserved heterogeneity across farmers. We find that participation of smallholders in both the domestic and export vegetable markets declined and that this trend is associated with weather risks, high costs of inputs and unskilled labour, and erratic vegetable prices, especially in the international market. Different factors are at play in determining a household's market choice for the commercialisation of vegetables: credit is important only when vegetables are (also) exported, livestock ownership is negatively related to production for the domestic market, and distance to the nearest market town positively related to all pathways of commercialisation, for example.

Keywords: horticulture, commercialisation, smallholders, Kenya

JEL classification: O10, Q12, Q13, Q17

1. Introduction

The horticultural sub-sector is one of the major contributors to agricultural Gross Domestic Product in Kenya with most actors being smallholder farmers. This dominance of smallholders is threatened, however, due to challenges emerging alongside new production and market opportunities. In recognition of the need to sustain the industry's growth and development, the government of Kenya enacted the National Horticultural Policy with the aim of overcoming the factors hindering the sub-sector from reaching its potential (GoK, 2012). This paper contributes to the objective of strengthening the sub-sector by identifying constraints and determinants of market participation among smallholder horticultural farmers in the rural areas of Kenya.

Existing studies investigating the decisions of smallholders to participate in the commercialisation of horticulture use static frameworks that fail to allow for changes in decision-making over time which may be induced by evolving market forces, institutional innovations, or other developments (McCULLOCH and OTA, 2002; MINOT and NGIGI, 2004; OMITI et al., 2007). We add to this literature by using data from a panel household survey with rounds in 2005 and 2010 in selected vegetable producing districts of Kenya. The structure of our data allows an identification of the trends and determinants of commercialisation of smallholder horticultural farmers over the 5-year period. Furthermore, we distinguish the drivers of commercialisation through the export and through the domestic market channels as they have different characteristics and requirements instead of focusing on a single market as done in other studies (e.g. McCULLOCH and OTA, 2002; RAO and QAIM, 2011). In addition, and similarly to OLWANDE and MATHENGE (2011), who focus on the determinants of simultaneous participation in both markets, we also investigate commercialisation jointly through both market channels. Finally, we incorporate weather-related indicators, which are important determinants of the marketing behaviour of farmers and not captured in the literature thus far.

As mentioned above, one advantage of our study over the existing literature is that we are able to use panel data and, thus, to control for unobserved heterogeneity across farmers. Furthermore, we look at both the decision to commercialise through a certain market channel and at the extent of this commercialisation. When investigating the latter we pay

attention to possible selection into each market pathway. The remainder of the paper is structured as follows: Section 2 reviews the literature our study relates to and presents the conceptual framework. Section 3 presents the data we use, while Section 4 outlines our empirical strategy. Section 5 discusses the results, Section 6 concludes.

2. Review of the related literature and conceptual framework

The earliest studies investigating smallholder market participation used farm household models to explain their market response to changes in relative prices (STRAUSS, 1984), while the studies that followed focused on understanding the roles of transaction costs and market failures in smallholder decision-making (e.g. DE JANVRY et al., 1991; FAFCHAMPS, 1992; GOETZ, 1992). Specifically, the developed theoretical frameworks found transaction costs to create barriers to household participation in crop markets, and food and labour market failures to be key constraints of participation in these markets. The role of transaction costs has further been manifested theoretically and empirically in later studies (OMAMO, 1998; KEY et al., 2000; HENNING and HENNINGSEN, 2007; BARRETT, 2008; VOORS and D'HAESE, 2010).

A major contribution to the literature on the commercialisation of agriculture is a review of case studies conducted in ten countries in Africa, Asia, and Latin America by VON BRAUN and KENNEDY (1994), in which the authors identify endogenous and exogenous drivers of commercialisation. Endogenous factors are related to farm and farmer characteristics, e.g. resource endowments (social, physical, human, and financial capital), the dependency ratio, household size, age and gender of the household head. Further endogenous factors mentioned in other studies include the access to information (OMITI et al., 2007), household ownership of assets (HELTBERG and TARP 2002; BOUGHTON et al. 2007), financial savings and their substitutes, social capital, and group membership (MOTI et al., 2009; OKELLO et al., 2009).

Important exogenous factors driving the commercialisation of agriculture include urbanization, population growth, globalisation, technological change, rising per capita income, changes in consumer preferences, increased awareness of nutrition, and changes in macroeconomic policies (VON BRAUN AND KENNEDY, 1994; JAFFEE, 2005; PINGALI et al., 2005; NGUGI et al., 2006; OMITI et al., 2007; SINDI, 2008; VIRCHOW, 2008). The globalisation of markets, for instance, has induced a global and interconnected production and distribution

of food. However, it has also brought with it concerns related to food quality and safety, leading to the development of regulations on public and private food production and marketing practices, which may impede the commercialisation of agriculture, especially in developing countries (JAFFEE, 2005; ADEKUNLE et al., 2012). Climate change, defined as unpredictable annual rainfall patterns and temperature changes, has been cited in recent studies as a factor that increasingly determines the types of crops that farmers choose to produce and sell (VIRCHOW, 2008; KRISTJANSON et al., 2012).

Furthermore, a farmer's attitude to risk has been documented as a determinant of the extent of his involvement in agricultural commercialisation (FAFCHAMPS, 1992; VON BRAUN et al., 1994; DERCON, 1996; ELLIS 2000). In addition, policies to enhance commercialisation among smallholders have been suggested in past studies. These include government investment in extension services and research; secure property rights to land and water; improvement of the transportation and communication infrastructure; upgrading rural markets, credit services, and other public goods such as better education, health, and sanitation services (VON BRAUN et al., 1994; PINGALI and ROSEGRANT, 1995; MINOT and NGIGI, 2004; PINGALI et al., 2005).

An empirical analysis of the determinants of commercialisation by smallholders must address the problem of self-selection, which arises as households face different commercialisation decisions: a discrete decision whether to participate in a market or not, and decisions related to the volume of produce to sell or buy, conditional on participation in these markets (GOETZ, 1992; BOUGHTON et al., 2007). While all determinants of the volume to be sold or bought affect the discrete decision (whether or not to participate in markets), the opposite is not necessarily true (GOETZ, 1992), which offers an angle for our empirical strategy. As such, variables not included in the continuous regression model allow identification of the market participation equation, which in turn permits accounting for the selection bias (STRAUSS, 1984).

To address the problem of selection, GOETZ (1992) applies a two-step model beginning with a Probit model for the decision to buy or sell, and then using a switching regression that allows households to choose which option to go for. Studies that apply the approach of GOETZ (1992), which we also partly follow in this study, include HOLLOWAY et al. (2001), HELTBERG and

TARP (2002), and BOUGHTON et al. (2007). While we focus on sellers of agricultural produce, we enrich the strategy suggested by GOETZ (1992) by differentiating between fixed and proportional transaction costs as suggested by KEY et al. (2000) to identify the discrete decisions for participation in each of the markets.

KEY et al. (2000) estimate structural supply functions and production thresholds based on censoring models with unobserved censoring thresholds. Their model differentiates between the effects of fixed and proportional transaction costs and suggests that fixed transaction costs may be used to identify the market participation equation. Transaction costs reduce the price per unit received by households that sell produce in the market and increase the price paid by households that buy the same produce from the market. As such, transaction costs create a kinked price schedule for the difference between the prices faced by sellers and buyers due to the transaction costs being subtracted from or added to the market price, respectively (DE JANVRY et al., 1991). KEY et al. (2000) demonstrate that market participation decisions are determined by both proportional and fixed transaction costs, while the volume of marketed produce (conditional on market participation) is only affected by proportional transaction costs. Fixed transaction costs can therefore be excluded from the decision model for the extent of commercialisation.

Generally, transaction costs include information or search costs, negotiation costs, monitoring costs, and certain aspects of transport and storage costs (KIRSTEN et al., 2009). The transaction costs that are mainly household-related and not commodity specific, for example those related to market information access and to the ability to negotiate are referred to as fixed transaction costs. Once a household decides to commercialise, it will incur costs of transferring produce to the market. In horticultural markets, such costs may include certain aspects of transportation costs and barriers such as market fees. These are referred to as proportional transaction costs.

Transaction costs are not always observable. However, certain variables that are likely to determine the outcome of commercialisation decisions and the extent of commercialisation can be used as indicators of transaction costs. In this study, we use various proxies for fixed and proportional transaction costs. Fixed transaction costs are measured by indicators for the access to information and by a proxy for market price information for selected vegetable

crops. Indicators for the access to information include whether the household has access to extension services, owns a mobile phone, and whether it has access to the media through ownership of a TV and/or radio. As market price information itself is difficult to measure, we follow HELTBERG and TARP (2002) and combine the prevailing market prices with other selected market information access instead. As proxies for proportional transaction costs, on the other hand, we use ownership of a means of transport (car, bicycle or motorcycle), the type of road, and the distance to the nearest market.

In Kenya, vegetable production is highly dependent on irrigation and YARO (2013) and HERTEL and ROSCH (2010) demonstrate that climate and weather risks also play a role in shaping commercialisation decisions of farmers. We quantify weather risk using a coefficient of variation (CoV) for the temporal variability of rainfall as a measure of relative humidity or precipitation over the past year and a weather shock given by the annual rainfall during the year before the survey.

3. Data

The study utilises two-wave panel household survey data collected in five districts that were purposefully selected from the two major vegetable producing provinces (namely Nyeri, Kirinyaga, and Murang'a in the Central Province and Meru and Makueni in the Eastern Province (ASFAW, 2008). The International Centre of Insect Physiology and Ecology (ICIPE) collected the first round of data during the 2005/06 growing season, while a follow up survey was conducted by one of the authors of this study in the same households in 2011. For the initial round, a multi-stage sampling procedure was used to select districts, sub-divisions and small-scale vegetable producers. Overall, 21 sub-locations were randomly selected in the five districts using a probability proportional to size (PPS) sampling procedure and a total of 539 vegetable producer households randomly chosen. Of these, 439 households produced market vegetables for export either exclusively or in conjunction with the production of vegetables to be sold in the domestic market, while 100 farming households were purely domestic market vegetable producers (ASFAW, 2008). Using the PPS sampling procedure, a total sample of 309 households was randomly selected for the second round of interviews based on the list of households that were interviewed in 2005/06. Similarly to the first round enquiring about 2005, the 2011 survey involved recall data referring to 2010 that were collected using a structured questionnaire encompassing topics

such as household demographics, land use, agricultural production, ownership of assets and livestock, off-farm income, remittances, credit, membership in farmers' groups, and questions on market access by type.

Using the information on the type of vegetable being produced and the channel through which these vegetables are usually being sold, households are classified according to the market pathway through which they commercialise their vegetables. *Export market farmers* produce vegetables for the international market, while *domestic market farmers* produce vegetables primarily for the domestic market.[1] *Non-sellers* are households that do not produce vegetables for sale. Some households produce vegetables for both markets and are thus categorised as *both domestic and export markets farmers*. It is important to note that the latter would not also be counted as *export market farmers* and *domestic market farmers* separately, but solely as farmers supplying both markets. Based on this classification, Table 1 describes the sample under investigation.

Table 1: Description of the sample by district and market channel

		Households categorised by market pathway and year of survey							
		Domestic market sellers (%)		Export market sellers (%)		Both Domestic & Export markets (%)		Non-sellers (%)	
District	*No. of households*	*2005*	*2010*	*2005*	*2010*	*2005*	*2010*	*2005*	*2010*
Kirinyaga	88	31	31	28	18	38	24	3	27
Makueni	26	15	58	38	0	46	8	0	35
Meru	78	19	37	38	23	42	17	0	23
Murang'a	27	30	30	4	26	67	22	0	22
Nyeri	90	27	57	11	6	62	32	0	6
Total	***309***	***25***	***42***	***25***	***15***	***49***	***23***	***1***	***20***

Source: Authors' calculations based on the survey data.

[1] International (export) market vegetables comprise French beans, snow peas, baby corn, and Asian vegetables including cucumber, okra, aubergine, chillies, karella, valore, and brinjal. Domestic market vegetables comprise all other types of vegetables that are not produced primarily for the international market such as tomatoes, cabbage, potatoes, peas, kale, onions, capsicum, etc.). It is important to note that, although we classify vegetables as being produced for export or for the domestic market, some crops that were exclusively exported in the past and are classified as 'export vegetables' for our purposes, for example French beans, are increasingly being consumed domestically, especially in urban areas. However, the share of the domestic market is very small and our data not detailed enough to allow a separation between produce sold domestically and internationally. The same applies to vegetables such as garden peas and carrots that are mainly produced for the domestic market with a small percentage of fresh-shelled peas and baby carrots being exported.

3.1 Market channels and their participants

Table 1 reveals that approximately 19% of households have left the commercial production of vegetables across all districts between 2005 and 2010, which is a significant share.[2] In Figure 1 we look at the dynamics of switching market channels between the two survey rounds in more detail. Out of the 76 households that specialise in export market vegetables in 2005, for example, only 25% specialise in the same crops in 2010, 20% diversify into domestic market crops as well, another 20% shift exclusively to domestic market vegetables, while 36% move out of the vegetable business entirely.

The fact that some export producers diversify into the simultaneous production of domestic market vegetables or shift to it entirely may be an indication of spill-over effects of skills gained from producing export vegetables to the production of domestic market crops. Most smallholder producers for export markets have received training on good agricultural practices as groundwork for compliance with the GlobalGap standards at some point since 2000 by exporters and non-governmental organizations (NGOs) (NARROD et al., 2009).[3] However, lack of adequate resources limits compliance with the standard, especially after the withdrawal of the initial support by the NGOs, forcing some farmers to stop producing vegetables for the international market (OUMA, 2008). In addition to the lack of resources for maintaining their position in the export supply chain, the shift of smallholders to the domestic market may be motivated by an increased potential of the domestic market. This is especially the case in urban areas due to an increasing population and a growing demand for vegetables in the regional markets (DIAO and DOROSH, 2007; RAO and QAIM, 2011; USAID, 2011).

[2] Seasonal production is common among smallholder vegetable producers and mainly due to climatic conditions. To ensure that this production practice was not confused with farmers who discontinued commercialising their produce, only farmers who stated they had not produced vegetables for sale over at least the past year were considered as having exited a market.

[3] The GlobalGap standard is a set of guidelines that reflect a harmonisation of the existing safety, quality, and environmental requierments of the major European retailers of vegetables and fruits, and are a response to increasing consumer interest in the safety of food and environmental issues (GLOBALGAP, 2008).While most private standards are relevant for the horticultural sector in Kenya, they are stricter than GlobalGap and adopted mainly by large-scale farmers. GlobalGap standards, however, are relevant to all types of farmers, including smallholders producing for the export market.

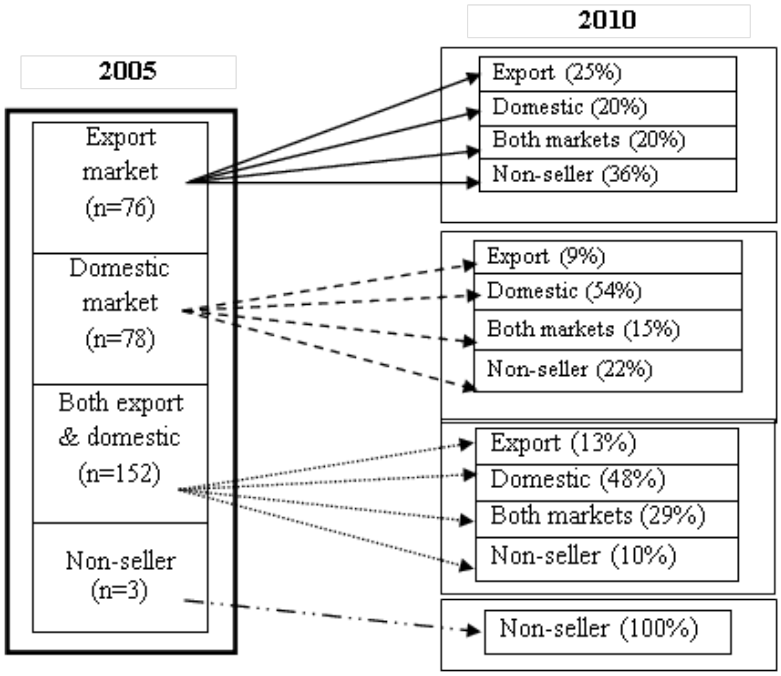

Figure 1: Changes in market channels of smallholder commercialisation between 2005 and 2010

Source: Authors' calculations based on the survey data.

Addressing the question of why some farmers leave commercial horticultural farming, over 40% of the vegetable non-sellers mention low returns, mainly attributed to low farm productivity and to low but highly erratic vegetable market prices. The Horticultural Crops Development Authority (2010) notes that income from horticultural exports has decreased since 2008 due to the global economic crisis. In addition, it mentions declining ground water levels hindering adequate irrigation, which is also cited as a key constraint by about 36% of the surveyed farmers. High costs of inputs (seeds, fertilizer and labour costs) are given as another major constraint, which is in accordance with the literature. Labour costs, for example, are observed to have increased by over 30% between 2005 and 2010 according to our data and an increase in the costs of fertilizers, pesticides, and other chemicals is also mentioned by GITAU et al. (2012) and ADEKUNLE et al. (2012). Further reasons for exiting from the vegetable business given by the surveyed farmers include the costs of maintaining GlobalGap standards and other production and marketing requirements, as well as more widespread crop pests and diseases.

3.2 Smallholder vegetable producers

Table 2 presents a comparison of selected demographic and socio-economic characteristics between export and domestic market farmers including tests for equality of means. We also compare households that specialise in the production of either of these markets exclusively to those supplying both markets. On average, the age of the household head for those commercialising through the export market is lower and the difference statistically significant, which may be an indicator of less risk aversion among producers for the export market or of more flexibility in adapting to specified agricultural practices. Ownership of agricultural assets and livestock, however, is not significantly different across groups of vegetable producers with the exception of exporters being statistically significantly more likely to own oxen.[4] A statistically significantly larger proportion of export market suppliers compared to suppliers of the domestic or both markets own fertile land (40%), while statistically significantly more domestic than export market suppliers are engaged in small businesses. The average distance to the nearest market town is lower for export market suppliers than domestic market suppliers and the difference statistically significant. This is possibly related to the fact that export vegetables are harvested more frequently (on average twice per week) than domestic market vegetables (mostly once a week or less) and export market suppliers therefore likely to be closer to towns. Possibly due to higher initial investment, exporters are more likely to have taken out credit, the difference in means being statistically significant. Surprisingly, even though export vegetable producers are found to be younger and therefore possibly more interested in technological products, they are statistically significantly less likely to own a TV, radio or phone than domestic vegetable producers. This may be due to the fact that younger farmers have had less time to accumulate those types of assets. Most export market suppliers are members of PMOs (63%) and comply with GlobalGAP standards (56%), which is to be expected.

[4] The agricultural and livestock asset indices are based on a principal component analysis following IRUNGU (2002), HENRY et al. (2003), RUTSTEIN and JOHNSON (2004), and ZELLER et al. (2006). Agricultural and livestock assets are two of the five key categories of non-land assets identified as important for the study area. Livestock assets include all types of livestock including cattle, small ruminants and poultry, while agricultural assets include delivery pipes, water pumps, sprinklers, and insecticide pumps. The other categories of non-land assets are dwelling assets (e.g. type of housing), consumer assets (e.g. radio, TV) and productive assets (e.g. sewing machine).

Table 2: Characteristics of households by vegetable output market

	Total observations (n=618)		Export market suppliers (E) (n=122)		Domestic market suppliers (D) (n=208)		*t-test (E-D) diff.*	Both markets suppliers (B) (n=223)		*t-test (E-B) diff.*	*t-test (D-B) diff.*
	Mean	SD	Mean	SD	Mean	SD		Mean	SD		
Household head gender (*1=male*)	0.91	0.29	0.95	0.22	0.90	0.30	*0.05*	0.91	0.29	*0.04*	*-0.01*
Household head age (*years*)	48.7	12.5	45.0	11.2	50.7	12.5	*-5.7****	46.9	12.0	*-1.85*	*3.87****
Head education (*years of schooling*)	8.69	3.46	8.70	2.88	8.62	3.95	*0.08*	8.87	3.20	*-0.17*	*-0.25*
Household size (*adult equivalent*)	4.91	2.23	4.74	2.14	5.09	2.32	*-0.35*	4.87	2.19	*-0.13*	*0.22*
Oxen ownership	0.03	0.18	0.06	0.24	0.02	0.13	*0.04***	0.03	0.16	*0.04**	*-0.01*
Agricultural assets (*index*)	1.04	0.42	1.03	0.44	1.07	0.41	*-0.04*	1.07	0.40	*-0.04*	*-0.01*
Livestock (*index*)	0.13	0.14	0.13	0.16	0.14	0.16	*0.00*	0.13	0.12	*0.00*	*0.00*
Fertile land (*binary:1=Yes*)	0.28	0.45	0.40	0.49	0.31	0.46	*0.09**	0.20	0.40	*0.20****	*0.11****
Off-farm work (*binary: 1=Yes*)	0.31	0.46	0.27	0.45	0.33	0.47	*-0.06*	0.34	0.48	*-0.07*	*-0.01*
Remittances (*binary:1=Yes*)	0.27	0.45	0.24	0.43	0.32	0.47	*-0.08*	0.20	0.40	*0.04*	*0.12****
Business (*binary:1=Yes*)	0.29	0.45	0.24	0.43	0.34	0.47	*-0.10**	0.24	0.43	*0.00*	*0.09***
Distance to nearest market town *(Km)*	3.96	4.57	2.84	3.27	3.93	4.10	*-1.10***	5.18	5.61	*-2.34****	*-1.25****
Road type (binary: *1=good*)	0.50	0.50	0.48	0.50	0.55	0.50	*-0.07*	0.43	0.50	*0.04*	*0.11***
Total land owned (*acres*)	3.14	4.45	2.92	5.46	3.49	5.26	*-0.57*	2.79	2.71	*0.13*	*0.70**
Land cultivated (*acres*)	2.22	2.10	2.11	1.88	2.21	2.61	*-0.10*	2.19	1.68	*-0.08*	*0.02*
Credit (*binary:1=Yes*)	0.38	0.49	0.57	0.50	0.31	0.46	*0.26****	0.35	0.48	*0.21****	*-0.05*
Annual rainfall (*mm, lagged*)	1073.7	116.7	1084.1	123.2	1059.0	111.8	*25.2**	1109.7	89.4	*-25.6***	*-50.8****
CoV (*monthly precipitation, %*)	54.2	8.0	57.3	9.3	53.6	7.38	*3.70****	52.1	7.16	*5.20****	*1.50***
Vegetable contact (*binary:1=Yes*)	0.46	0.50	0.82	0.39				0.76	0.43	*0.06*	
Member farmer group (*binary:1=Yes*)	0.43	0.50	0.63	0.48				0.68	0.47	*-0.05*	
Member farmer group (*years*)	1.80	3.76	3.43	5.22				2.14	3.39	*1.28****	
GlobalGap compliant (*binary:1=Yes*)	0.30	0.46	0.56	0.50				0.49	0.50	*0.07*	
Extension contact (*binary: 1=Yes*)	0.53	0.50	0.73	0.45	0.55	0.50	*0.18****	0.69	0.46	*0.04*	*-0.14****
Transport facility (*binary: 1=Yes*)	0.61	0.49	0.59	0.49	0.55	0.50	*0.04*	0.48	0.50	*0.11***	*0.08**
Own TV (*binary: 1=Yes*)	0.49	0.50	0.43	0.50	0.53	0.50	*-0.11**	0.47	0.50	*-0.04*	*0.06*
Own Radio (*binary: 1=Yes*)	0.94	0.24	0.93	0.26	0.97	0.18	*-0.04**	0.93	0.25	*-0.01*	*0.03*
Own phone (*binary: 1=Yes*)	0.78	0.41	0.70	0.46	0.84	0.37	*-0.13***	0.74	0.44	*-0.04*	*0.09***
French beans price ($/Kg)	0.49	0.16	0.50	0.16	0.47	0.15	*0.02*	0.52	0.17	*-0.03*	*-0.05*
Snow peas price ($/Kg)	0.74	0.11	0.74	0.13	0.74	0.10	*0.00*	0.76	0.11	*-0.02*	*-0.02*
Cabbage price ($/Kg)	0.18	0.18	0.13	0.07	0.22	0.22	*-0.10*	0.18	0.17	*-0.05*	*0.05*
Maize price ($/Kg)	0.26	0.07	0.24	0.09	0.26	0.01	*0.02**	0.24	0.01	*-0.01*	*0.01*
Maize area (%)	21.86	18.67	19.50	19.49	24.46	18.68	*-4.95***	19.09	17.80	*0.42*	*5.37****
Annual export vegetable sales ($)	442.4	1064	1050.3	1780				615.43	966.0	*398.9****	
Annual domestic vegetable sales ($)	317.7	709.6			388.7	483.5		517.5	1025		*-128.8**
HCI_export (%)	18.02	24.65	40.05	27.75				28.02	22.42	*12.02****	
HCI_domestic (%)	15.45	21.72			25.63	26.47		18.91	18.66		*6.71****

Notes: Significance at 0.01(***), 0.05(**), 0.1(*) probability levels. The sum of export, domestic, and both markets do not add up to the total (n=618) as non-sellers are included in the total. The tests for equality of means are based on paired data with unequal variances. HCI is abbreviated for Horticultural Commercialization Index.

Source: Authors' calculations based on the survey data.

The extent of commercialisation can be measured in multiple ways. A simplistic measure is the cash derived from the sale of vegetables and Table 2 indicates that the income from the sale of export vegetables is higher ($442.4) than that derived from the sale of domestic vegetables ($317.7).[5] Similarly, when we consider households specializing in the supply for either market as well as those who supply both markets, the sale of export vegetables appears to generate more income than domestic vegetables. This comparison, however, does not scale the income generated from vegetable sales to the amount of produce or other income. For this reason we define a horticultural commercialisation index (*HCI*) at the household level and for a given year: the ratio of income from vegetable sales to total household income. Considering the total sample, the picture emerging from the simplistic measure considered above is supported: the income derived from the sale of vegetables to the export market (*HCI_export*) contributes an average of 18% to annual total household income, while income from vegetables sales to the domestic market (*HCI_domestic)* contribute about 15% to annual total household income.

4. Empirical strategy

As described in Section 2, participation in the commercialisation of horticulture involves a two-step decision problem: a household decides whether or not to commercialise and then sets the extent of commercialisation conditional on participation. Because vegetable sales through either the domestic or export market are only observed for a subset of the population, which is likely to be non-random due to the decision of a household to participate in the commercialisation of vegetables or not, a sample selection problem arises. We apply the two-step regression framework developed by HECKMAN (1976) to address the self-selection of households into being non-sellers, domestic market producers, export market producers, or producers for both markets. The two principle market pathways (export and domestic markets) and their mixture each have a separate participation equation and a regression equation for the extent of commercialisation.

[5] Monetary measures from the 2010 data are deflated, while those from the 2005 data are inflated, to February 2009 using the consumer price index data available from the Kenya Bureau of Statistics. In 2005, one US-Dollar was equal to approximately 75 Kenyan shillings (Ksh), Ksh. 79 in 2010 and Ksh.79.9 in February 2009, our base period. See http://www.knbs.or.ke/consumerpriceindex.php for the data. Retrieved October 21, 2012.

To begin with, a naive regression equation for the level of commercialisation would be given by:

(1) $$Y_{ijt} = \mathbf{X_{ijt}}\boldsymbol{\beta} + C_i + \mu_{ijt}$$

where Y_{ijt} is a measure for the extent of commercialisation through market channel *j* (export market, domestic market, both markets) of household *i* in time period *t*. The logarithmic value of the ratio of the share of income derived from vegetable sales in relation to total household income (*HCI*) is our measure of *Y*. ***X*** represents a set of observed, time variant independent variables that influence the level of commercialisation, C_i represents time-invariant household characteristics to control for unobserved heterogeneity across households and μ is a statistical error term.

Recall that *Y* is observed only if the binary selection indicator *S* is positive and suppose that, for each market channel and time period*, S* is determined by a Probit equation:

(2) $$S_{ijt} = 1(\mathbf{W}_{ijt}\boldsymbol{\gamma} + \upsilon_{ijt} \geq 0) \qquad \upsilon_{ijt} \mid W \sim Normal(0,1)$$

where ***W*** is a vector of observed variables that influence *S,* and ***X*** a subset of ***W***. The error term υ_{ijt} is assumed to be independent of ***W*** (and therefore ***X***), and to follow a normal distribution. The problem arises if μ and υ are correlated, which is the case if the decision to participate is not random and therefore not orthogonal to the decision on the extent of participation, thus providing biased estimates if Ordinary Least Squares (OLS) are used to estimate equation (1).

Some of the farmers in our sample switch from one market channel to another or to not commercialising between survey rounds as described in Figure 1. For this reason, we apply the Chamberlain approach of the Heckman framework for panel data (WOOLDRIDGE, 2002: 582–583: GREENE, 2012; 926). As indicated above, the first stage involves formulating a Probit model for *S* and then saving the inverse Mills ratios, $\hat{\lambda}_{ijt}$, that account for the selection for each observation. In the second step, a pooled OLS is applied to the selected sample by adding $\hat{\lambda}_{ijt}$ to equation (1) and interacting it with a dummy variable for the observation being from the 2010 survey round:

(3) $$Y_{ijt} = \mathbf{X_{ijt}}\boldsymbol{\beta} + \psi_1 \hat{\lambda}_{ijt} + \psi_2 (d2010_i * \hat{\lambda}_{ijt}) + \mu_{ijt}.$$

We furthermore adopt an alternative strategy to estimate equation (3) as suggested by WOOLDRIDGE (2005): individual level fixed effect estimation in the second step may be used without interactions between the inverse Mills ratio and the survey round indicator leading to:

(4) $$Y_{ijt} = \mathbf{X_{ijt}}\boldsymbol{\beta} + \psi_1 \hat{\lambda}_{ijt} + C_i + \psi_2 d2010_i + \mu_{ijt}.$$

An important requirement is that ***X*** is a strict subset of ***W*** such that any element of ***X*** is an element of ***W***. There need to be some elements of ***W***, however, that are not elements of ***X***, which is known as the exclusion restriction (WOOLDRIDGE, 2002) or the identification condition (MADDALLA, 1983). As explained in Section 2, following KEY et al. (2000) the selection equation is identified by excluding fixed transaction cost indicators from the regression equation investigating the extent of commercialisation. The proxy variables for fixed transaction costs we use are access to extension services, ownership of a mobile phone, access to media through ownership of a TV and/or radio, and market prices for the most important vegetables.[6] ***X*** contains various exogenous variables that are related to the commercialisation of horticulture. These include demographic characteristics (gender, age, and education of the household head, household size), farm characteristics (sizes of land owned and cultivated, land quality), asset ownership (agricultural assets, livestock), income sources (off-farm work, remittances, business), and proxies for proportional transaction costs (ownership of a means of transport, distance to the nearest market, condition of the road to the nearest market). Maize prices and the proportion of land allocated to maize production are also included as control variables to account for competition between food self-sufficiency and the commercial production of vegetables.

In addition, lagged annual rainfall and the coefficient of variation (CoV) of rainfall are included as measures of weather shock and weather risk, respectively. The CoV is the

[6] Product prices are at the division level (the next lowest administrative unit after district) but obtained from the surveyed households. To minimise reporting bias they are averaged at the division level. Furthermore, for 2010, the price data are validated by comparing them to market prices in the division at the time of data collection. Note that we include prices of some vegetable crops despite the theoretical risk of reverse causality with the dependent variable, which is in practice unlikely to be a problem due to our sample being entirely made up of small-scale farmers who are unlikely to influence market prices with their decision to commercialise or not.

percentage ratio of the standard deviation of a rainfall series to its mean. The CoV is preferred over mean annual rainfall as a measure of relative humidity, especially when there is high variability in monthly rainfall for different households or rainfall stations (MISHRA, 1991; BRONIKOWSKI and WEBB,1996). We calculate the annual CoV based on monthly rainfall estimates at the household level. Specifically, we use geographical information system (GIS) coordinates for each of the interviewed households to generate household-specific satellite-image derived rainfall estimates with data from the archives of the US Agency for International Development Famine Early Warning Systems Network.[7]

5. Results

The regression results for commercialisation through the export and domestic market channels are presented in Table 3 and Table 4, respectively. Table 5 displays the results for households that supply both markets. In each table the results for estimating equation (4) investigating the extent of commercialisation including household fixed effects are presented in column (1), while those for estimating equation (3), i.e. the pooled OLS without controlling for unobserved heterogeneity across households, are displayed in column (2). In addition, the first stage estimates as specified in equation (2) are provided by survey year: in column (3) for 2005, and in column (4) for 2010. It is important to note that the estimation of the selection equations for Tables 3 and 4 contains the total sample, i.e. including households that do not produce commercially anymore in 2010 and households that produce for both markets.

5.1 Commercialisation through the export market

Table 3 presents the estimates for commercialisation through the export market channel. The dependent variable is the logarithmic value of the proportion of export vegetable sales to total annual household income in columns (1) and (2) and whether a household commercialises or not in 2005 or 2010 in columns (3) and (4), respectively. The estimate for the inverse Mills ratio is statistically significant only in the specification including fixed

[7] We use the Rainfall Estimates (version RFE 2.0) available from http://earlywarning.usgs.gov (accessed last July 11, 2013). The results are robust as they are validated using rainfall data obtained from weather stations of the Kenya Meteorological Department located in or near the study sites. The results are not presented here but available from the authors.

effects. This provides evidence for self-selection into commercialisation being an issue, at least when the unobserved heterogeneity across households is controlled for.

The proportional transaction cost indicators (distance to the nearest market town, road type, and ownership of a means of transport) do not appear to exert statistically significant effects on the extent of commercialisation through the export market. Surprisingly, the distance to the nearest market town is positively and statistically significantly related to the binary decision to commercialise through this market pathway in 2010 as displayed in column (4). A possible explanation based on MINOT and NGIGI (2004) and on observations during the collection of the 2010 data is that households closer to market towns tend to engage more heavily in non-farm activities such as small businesses compared to households that are further away from market centres and whose livelihood opportunities are limited to farm enterprises. Furthermore, because it is costly for farmers to transport their harvest to markets, vegetable traders collect produce directly from farms or at designated collection centres close to the farms so distance is not an impediment to commercialisation. SINDI (2008) also finds a positive association between the distance to the nearest transitable road (a measure of proximity to the nearest market town) and horticultural commercialisation and states that rural areas with good conditions for growing horticultural crops often have poor road access, especially due to the heavy rainfall in these areas.

Most of the fixed transaction cost proxies that measure a household's access to information, i.e. ownership of a TV, radio, phone and access to extension services, yields a statistically significant coefficient in the selection model. Unsurprisingly, however, the prices of French beans and snow peas are positively and statistically significantly related to the binary decision to commercialise through the export market in 2010.

With respect to demographic factors, the age of the household head yields a negative and statistically significant coefficient for both the decision for and the extent of commercialisation through the export market. Similarly, the years of education of the household head and household size exhibit a negative and statistically significant relationship with the extent of commercialisation through the export market channel in column (1). The former may be explained by alternative income-generating opportunities with higher levels of education. The latter is not surprising as increases in household size

have been found to intensify the pressure on land (VON BRAUN and KENNEDY, 1994), thereby reducing the volume of marketable surplus as subsistence needs become a priority over commercial activities.

Table 3: Determinants of vegetable commercialisation through the export market

	ln (Horticultural Commercialization Index, HCI)		*Selection equation (export=1)*	
	Household FE	Pooled OLS	2005	2010
	(1)	(2)	(3)	(4)
Household head gender	0.58 (0.54)	-0.17 (0.22)	-0.24 (0.32)	0.57* (0.34)
Household head age	0.001 (0.03)	-0.01** (0.01)	-0.03*** (0.01)	-0.02** (0.01)
Head education	-0.10* (0.05)	0.001 (0.02)	-0.02 (0.03)	-0.02 (0.03)
Household size	-0.35** (0.17)	-0.07 (0.10)	0.05 (0.15)	-0.17 (0.17)
Household size squared	0.02* (0.01)	0.004 (0.01)	-0.003 (0.01)	0.02 (0.01)
Total land owned	-0.08 (0.09)	-0.03 (0.02)	-0.04 (0.03)	-0.08 (0.05)
Land cultivated	0.04 (0.09)	0.09** (0.04)	0.0005 (0.06)	0.01 (0.07)
Fertile land	-0.78*** (0.20)	0.16 (0.13)	-0.43** (0.22)	-0.14 (0.20)
Oxen ownership	-0.81 (0.60)	0.48 (0.38)	0.13 (0.73)	-0.05 (0.58)
Agricultural assets	0.43 (0.36)	0.13 (0.17)	0.17 (0.27)	0.44 (0.27)
Livestock	-1.50* (0.82)	-2.13*** (0.56)	0.46 (0.90)	1.48 (0.93)
Off-farm work	0.15 (0.22)	-0.45*** (0.14)	-0.48*** (0.19)	-0.69*** (0.25)
Remittances	0.71*** (0.25)	-0.04 (0.15)	-0.01 (0.24)	-0.52*** (0.19)
Business	0.04 (0.20)	-0.36*** (0.14)	-0.13 (0.23)	-0.29 (0.19)
Maize price	0.48 (0.90)	-0.15 (0.57)	-0.91 (0.94)	1.76** (0.88)
Maize area	-0.37* (0.22)	-0.004 (0.00)	-0.01** (0.00)	-0.01 (0.01)
Annual rainfall	0.003 (0.00)	0.001 (0.00)	-0.003 (0.00)	0.0002 (0.00)
CoV	-0.04** (0.02)	0.003 (0.01)	-0.05* (0.03)	-0.01 (0.02)
Credit	-0.08 (0.22)	0.23 (0.16)	0.46* (0.25)	1.05*** (0.20)
Distance to market town	0.003 (0.02)	-0.001 (0.01)	0.005 (0.02)	0.06** (0.02)
Road type	0.02 (0.20)	0.14 (0.12)	0.19 (0.21)	-0.10 (0.22)
Transport facility	-0.11 (0.29)	0.13 (0.13)	-0.22 (0.21)	0.004 (0.21)
Extension contact			0.13 (0.23)	0.25 (0.18)
Own TV			-0.27 (0.20)	-0.28 (0.21)
Own Radio			-0.04 (0.36)	-0.41 (0.42)
Own phone			-0.16 (0.21)	0.31 (0.55)
French beans price			-1.08 (0.69)	5.11** (2.29)
Snow peas price			-0.92 (1.55)	15.89*** (4.39)
2010-dummy	0.27 (0.44)	-0.40 (0.28)		
IMR ($\hat{\lambda}$)	-0.62** (0.33)	0.52 (0.42)		
IMR*2010-dummy		-0.32 (0.43)		
Constant	3.36 (3.09)	3.61*** (1.36)	10.41** (4.30)	-14.8*** (4.53)
District FE	No	Yes	Yes	Yes
Number of observations	345	345	309	309
R-squared; Pseudo R-squared	0.53	0.23	0.15	0.30
F(24,74) ; F(29, 315)	3.42***	3.17**		
LR Chi-squared			53.7***	121.5***
Log likelihood			-150.88	-144.263

Note: Significance at 0.01(***), 0.05(**),and 0.1(*) probability levels. Standard errors are given in parentheses. *HCI* is the ration of income obtained from vegetable sales to total household income in a given year. The inverse Mills ratios generated as part of the models displayed in columns (3) and (4) are used to estimate both the fixed effects and the pooled OLS models.

The area of cultivated land exhibits a positive relationship with the extent of commercialisation based on the pooled OLS results in column (2), but not when we control for the unobserved heterogeneity across households in column (1). During data collection for the second round it was observed that in some districts, for example in Meru, large farms often engage in other commercial activities such as tea, coffee and dairy farming rather than in vegetable production. This may also explain the non-existent relationship between the size of land owned and the extent of and decision to commercialise through the export market channel that is in line with McCulloch and Ota (2002) and Sindi (2008). This is not surprising considering that the returns per unit area of export crops are higher compared to other crops. For example, Minot and Ngigi (2004) estimate that French beans have over twice the gross product value per unit area compared to domestically consumed vegetables such as potato and cabbage. Land quality (the *fertile land* indicator variable) exhibits a negative and statistically significant relationship with the decision to commercialise and the extent of commercialisation through the export market, which is unexpected. It should be noted that low land productivity is observed across the entire sample (only 28% of the sample households report access to fertile land as displayed in Table 2). It is therefore not surprising that most farmers depend on fertilisers, especially those supplying to the export market, which may explain the negative sign on the coefficient of land quality here. Similarly, livestock assets are negatively and statistically significantly related to the extent of commercialisation along the export market pathway. Qualitative information from the field suggests that farmers increasingly diversify their farm income sources by engaging in dairy farming, thus creating competition for labour and land resources. This was most pronounced in the Central province because of higher prices of milk and an increased number of milk traders in the area.

The three included measures of non-farm income, namely access to off-farm employment, remittances, and business ownership, yield mixed results. Off-farm employment and remittances are negatively and statistically significantly related to participation in the export market, while business ownership is not related to the choice of this market in a statistically significant way. When household fixed effects are included, remittances are positively and significantly associated with the extent of commercialisation, however, which is not surprising. Off-farm employment business ownership may compete with the production and marketing of export vegetables for labour, while remittances provide an alternative source

of income, which makes households less likely to at all engage in risky farm enterprises such as the production of export market vegetables. On the other hand, remittances provide a source of capital that may enable scaling up the production, e.g. by paying for inputs such as fertilisers, hence encouraging a larger extent of commercialisation conditional on participation.

The price of maize, a staple crop in Kenya, has been increasing over the past few years. As such, land and labour resources may increasingly be allocated to maize production. In light of this, two variables related to maize production – the fraction of the cultivated land area that is allocated to maize production and maize prices at the division level - are included as explanatory variables. While the coefficient on the price of maize is statistically significant and positive for the decision to participate in 2005, the area allocated to maize production exhibits a negative and statistically significant relationship with the binary decision in 2010 and the extent of commercialisation through the export market if household fixed effects are included. The former may be an indication of high prices encouraging the choice of commercialisation *per se*, while the latter supports the argument of food sufficiency taking priority over the commercial production of vegetables.

Lagged average annual rainfall is not associated with the extent of commercialisation through the export market pathway in a statistically significant way in either specification. However, as expected, weather variability (*CoV*) is negatively and statistically significantly related to the decision to commercialise in 2005, and to the extent of commercialisation when the unobserved heterogeneity across households is controlled for. Erratic rainfall patterns are likely to reduce the output levels and, thus, may impact negatively on the production of vegetables for commercial purposes.

Credit is positively and significantly associated with the decision to commercialise. This finding is consistent with ASHRAF et al. (2009), who find that credit increases the participation of smallholder horticultural growers in an export-crop production program. Although membership in PMOs and the adoption of GlobalGap standards, our proxies for institutional involvement, are not included in the above specification as they are potentially endogenous to the binary decision, they are observed to play a significant role in determining the extent

of commercialisation.[8] Farmers that are organised in these kinds of institutions are more likely to enter a marketing arrangement with commercial produce buyers as they can collectively meet the required volumes. Between 2000 and 2005, farmers invested in measures to achieve compliance with GlobalGap requirements jointly through PMOs, received training together, and also carried out internal monitoring and coordination, thus reducing transaction costs incurred by exporters to facilitate compliance with these requirements (OKELLO et al., 2009). Compliance with GlobalGap standards is cited as a means of enhancing horticultural product acceptability in the international markets in the literature as well (ASFAW, 2008; MURIITHI et al., 2010a).

5.2 Commercialisation through the domestic market

Table 4 presents the estimation results for the determinants of the decision for and the extent of commercialisation through the domestic market channel. The table is organised in the same way as Table 3, i.e. columns (3) and (4) display the results for the selection equation in 2005 and 2010, respectively, while the estimates for the extent of commercialisation with and without household fixed effects are shown in columns (1) and (2), respectively. In contrast to the results for the export market channel, the inverse Mills ratio is not statistically significant in either specification, which ameliorates our concern for potential selection bias among producers for the domestic market.

Among the proportional transaction cost proxies, only distance to the nearest market town appears to influence the decision to commercialise through the domestic market pathway in a positive and statistically significant way. This may be due to the same reasons as in the selection equation for the export market: Greater proximity to market towns offers alternative income-generating activities. In line with our previous explanation, access to good roads (as perceived by the farmer) exerts a positive and statistically significant influence on the extent of commercialisation when household fixed effects are not included in column (2) due to better transport facilities for the produce. As for the proportional transaction costs and in line with the selection equation for the export market pathway, ownership of a TV or phone, and access to extension services do not exhibit statistically

[8] The correlation coefficients between the Horticultural Commercialisation Index for the export market *(HCI_export)* and group membership and GlobalGap compliance are both positive and statistically significant at the 1%-level.

significant relationships with the decision to commercialise through the domestic market channel. However, contrasting the estimates for the export market, ownership of a radio is positively and statistically significantly related to the decision to commercialise through the domestic market pathway. The price of cabbage, one of the main locally consumed vegetables, exhibits a negative and statistically significant coefficient for the decision to commercialise through the domestic market in 2005, but of opposite sign in 2010. A possible explanation for this may be embedded in the recent increases in the prices of locally consumed vegetables. However, none of the other produce prices yield statistically significant coefficients.

With respect to demographic characteristics, the age of the household head exhibits a statistically significant (and negative) coefficient for the decision to commercialise through the domestic market channel only in 2010. The rest of the demographic characteristics are not statistically significant. The sizes of land owned and land cultivated are not related to the decision for or the extent of commercialisation through the domestic pathway in a statistically significant way. However, land quality exhibits a statistically significant and positive relationship with the extent of commercialisation based on the pooled OLS results, but not when we control for the unobserved heterogeneity across households. The livestock asset index and agricultural assets are positively and statistically significantly related to the decision to commercialise through the domestic market pathway in 2005 or 2010, respectively, which may reflect a household's concentration on agricultural activities in general and a diversification into other agricultural activities than vegetable production at the same time. In contrast, the livestock assets index exhibits a negative relationship with the extent of commercialisation through the domestic market channel both in the pooled OLS and when we control for unobserved heterogeneity. The ownership of oxen, on the other hand, is positively related to the extent of commercialisation through the domestic market channel, possibly due to its supportive role as a draft animal. Similarly to the export market pathway, measures of non-farm income, i.e.non-farm employment and business ownership, are negatively and statistically significantly related to the extent of commercialisation through the domestic market pathway but only when the unobserved heterogeneity across households is not controlled for. Alternative income-generating activities are a likely explanation for these findings.

Table 4: Determinants of vegetable commercialisation through the domestic market

	ln (Horticultural Commercialization Index, HCI)				*Selection equation (domestic=1)*	
	Household FE		Pooled OLS		2005	2010
	(1)		(2)		(3)	(4)
Household head gender	-0.39	(0.49)	0.04	(0.22)	0.08 (0.35)	-0.16 (0.33)
Household head age	-0.02	(0.01)	-0.01	(0.01)	0.01 (0.01)	-0.02* (0.01)
Head education	0.04	(0.04)	0.001	(0.02)	-0.02 (0.03)	0.01 (0.03)
Household size	0.19	(0.17)	0.04	(0.11)	-0.07 (0.16)	0.09 (0.16)
Household size squared	-0.01	(0.01)	-0.005	(0.01)	0.01 (0.01)	-0.002 (0.01)
Total land owned	0.02	(0.05)	-0.02	(0.03)	-0.01 (0.03)	0.05 (0.04)
Land cultivated	-0.04	(0.08)	0.02	(0.05)	0.07 (0.07)	-0.07 (0.06)
Fertile land	-0.19	(0.23)	0.24*	(0.15)	-0.35 (0.23)	-0.07 (0.19)
Oxen ownership	1.67**	(0.76)	0.64	(0.50)	0.34 (0.71)	-1.65*** (0.64)
Agricultural assets	0.01	(0.29)	0.11	(0.19)	0.45* (0.29)	0.24 (0.25)
Livestock	-2.06**	(0.99)	-1.55**	(0.61)	-0.53 (0.94)	2.26** (1.15)
Off-farm work	0.02	(0.22)	-0.47***	(0.14)	0.14 (0.20)	0.01 (0.25)
Remittances	-0.08	(0.22)	-0.27	(0.15)	0.14 (0.26)	0.17 (0.19)
Business	-0.16	(0.21)	-0.31**	(0.14)	0.12 (0.26)	0.02 (0.19)
Maize price	1.16	(0.82)	0.12	(0.62)	0.69 (1.27)	-0.34 (0.82)
Maize area	-0.004	(0.01)	-0.01*	(0.004)	0.001 (0.01)	-0.01** (0.01)
Annual rainfall	-0.002	(0.002)	0.001	(0.001)	0.01* (0.00)	0.01*** (0.00)
CoV	0.08***	(0.02)	0.03***	(0.01)	0.01 (0.03)	0.01 (0.03)
Credit	0.12	(0.21)	0.01	(0.16)	-0.73*** (0.22)	-0.19 (0.19)
Distance to nearest market town	-0.02	(0.02)	-0.002	(0.01)	0.06** (0.03)	0.07** (0.04)
Road type	0.17	(0.21)	0.35**	(0.15)	-0.13 (0.21)	0.06 (0.21)
Transport facility	0.25	(0.25)	-0.02	(0.14)	-0.03 (0.22)	-0.09 (0.20)
Extension contact					0.02 (0.25)	-0.04 (0.18)
Own TV					0.21 (0.21)	-0.11 (0.20)
Own Radio					0.18 (0.39)	0.77* (0.41)
Own phone					-0.01 (0.21)	-0.46 (0.41)
Potatoes price					3.39 (3.34)	-0.65 (3.16)
Cabbage price					-9.58** (4.13)	2.10*** (0.80)
2010-dummy	-0.41	(0.35)	-0.14	(0.28)		
IMR ($\hat{\lambda}$)	-0.40	(0.44)	-0.41	(0.40)		
IMR*2010-dummy			0.50	(0.45)		
Constant	1.29	(2.54)	0.699	(1.57)	-5.72 (4.51)	-4.79* (2.59)
District FE	No		Yes		Yes	Yes
Number of observations	431		431		309	309
R-squared; Pseudo R-squared	0.181		0.2847		0.2251	0.2332
F(24,74); F(29, 315)	1.35*		5.5***			
LR Chi-squared					79.09***	93.25***
Log likelihood					-136	-153

Note: Significance at 0.01(***), 0.05(**),and 0.1(*) probability levels. Standard errors are given in parentheses. *HCI* is the ratio of income obtained from vegetable sales to total household income in a given year. The inverse Mills ratios generated as part of the models displayed in columns (3) and (4) are used to estimate both the fixed effects and the pooled OLS models.

Regarding the weather indicators, annual rainfall during the previous growing season is related to the decision to supply vegetables to the domestic market in a positive and statistically significant way. The weather risk proxy (*CoV*), however, exhibits an unexpected positive and statistically significant coefficient for the extent of commercialisation, which

may be related to the production patterns of domestically marketed vegetables. Unlike vegetables supplied to the international market, which are being produced throughout the year and thus likely to be affected by the annual variation of rainfall, the planting season for locally consumed vegetables is during the rainy season, which may make them less affected by the annual variability of rainfall.

5.3 Commercialisation through the domestic and export markets jointly

The estimates for the determinants of the decision for and the extent of commercialisation jointly through both the domestic and the export market channels are provided in Table 5. The table is organised identically to the previous two to with the exception that the dependent variable for the selection models given in columns (3) and (4) is a dummy defined as 1 if a household produced vegetables for both the export and domestic markets, and that the response variable in columns (1) and (2) is the extent of this commercialisation. Similarly to the results for the domestic market, the inverse Mills ratios are statistically insignificant so there is no evidence of selection being a critical issue here.

Proportional transaction costs do not appear to influence the extent of commercialisation through both markets, except for the distance to the nearest market, which is positively and statistically significantly related to the decision to participate in both markets in 2010. Similarly to the domestic and export market pathways separately, most of the fixed transaction cost indicators are statistically insignificant, except for the price of cabbage, French beans, and snow peas, which are related to the decision to participate in both markets in 2010 in a positive way. In contrast to 2010, the price of cabbage exhibits a negative and statistically significant influence on the decision to commercialise jointly through both markets in 2005.

Table 5: Determinants of vegetable commercialisation through both the export and domestic markets

	ln (Horticultural Commercialization Index, HCI)				*Selection equation (both markets=1)*			
	Household FE		Pooled OLS		2005		2010	
	(1)		(2)		(3)		(4)	
Household head gender	1.12**	(0.48)	0.20	(0.19)	-0.15	(0.30)	0.27	(0.37)
Household head age	-0.004	(0.02)	-0.003	(0.005)	-0.01*	(0.01)	-0.01	(0.01)
Head education	-0.09*	(0.06)	0.004	(0.02)	-0.02	(0.03)	0.003	(0.03)
Household size	-0.47**	(0.20)	-0.12	(0.10)	0.05	(0.15)	0.03	(0.18)
Household size squared	0.03**	(0.01)	0.01	(0.01)	-0.003	(0.01)	0.004	(0.01)
Total land owned	-0.06	(0.11)	-0.02	(0.03)	-0.05	(0.04)	-0.01	(0.06)
Land cultivated	0.05	(0.18)	0.05	(0.05)	0.08	(0.08)	0.05	(0.07)
Fertile land	-0.65**	(0.29)	0.001	(0.14)	-0.67***	(0.21)	-0.31	(0.22)
Oxen ownership	1.95**	(0.88)	0.93**	(0.38)	0.12	(0.65)	-0.83	(0.65)
Agricultural assets	0.82***	(0.32)	0.11	(0.17)	0.47*	(0.25)	0.16	(0.29)
Livestock	-1.50	(1.49)	-2.56***	(0.55)	0.24	(0.84)	1.12	(0.94)
Off-farm work	0.45*	(0.25)	-0.24**	(0.12)	-0.26	(0.18)	-0.61**	(0.27)
Remittances	0.29	(0.30)	0.04	(0.14)	0.05	(0.23)	-0.17	(0.21)
Business	0.05	(0.22)	-0.49***	(0.13)	-0.06	(0.23)	-0.29	(0.20)
Maize price	1.71	(1.62)	-0.15	(0.48)	-0.46	(0.96)	1.60*	(0.95)
Maize area	-0.01	(0.01)	-0.003	(0.003)	-0.01*	(0.005)	-0.01	(0.01)
Annual rainfall	-0.001	(0.003)	0.0004	(0.001)	0.002	(0.003)	0.002	(0.002)
CoV	-0.04*	(0.02)	0.01	(0.01)	-0.04	(0.03)	0.01	(0.03)
Credit	0.59	(0.45)	-0.06	(0.15)	-0.34	(0.21)	0.69***	(0.22)
Distance to nearest market town	-0.02	(0.02)	0.01	(0.01)	0.03	(0.02)	0.07***	(0.02)
Road type	0.41	(0.47)	0.13	(0.13)	-0.07	(0.19)	0.20	(0.26)
Transport facility	-0.12	(0.41)	0.07	(0.11)	-0.16	(0.19)	0.02	(0.22)
Extension contact					0.02	(0.22)	0.12	(0.20)
Own TV					-0.04	(0.19)	-0.19	(0.22)
Own Radio					0.14	(0.34)	-0.27	(0.42)
Own phone					-0.14	(0.20)	-0.28	(0.58)
Potatoes price					4.20	(3.77)	-2.82	(3.55)
Cabbage price					-11.03***	(4.21)	3.34**	(1.65)
French beans price					-0.49	(0.69)	11.84***	(4.79)
Snow peas price					0.30	(1.98)	21.58***	(8.48)
2010-dummy	-0.36	(0.77)	-0.33	(0.40)				
IMR ($\hat{\lambda}$)	-0.70	(0.45)	-0.26	(0.26)				
IMR*2010-dummy			0.32	(0.36)				
Constant	7.43*	(3.89)	4.02***	(1.40)	2.93	(4.17)	-25.24	(8.89)
District FE	No		Yes		Yes		Yes	
Number of observations	223		223		309		309	
R-squared/ Pseudo R-squared	0.60		0.37		0.17		0.24	
F(24,178)/F (29, 193)	11.19***		3.9***					
LR Chi-squared					74.1***		80.1***	
Log likelihood					-177.1		-126.4	

Note: Significance at 0.01(***), 0.05(**),and 0.1(*) probability levels. Standard errors are given in parentheses. *HCI* is the ration of income obtained from vegetable sales to total household income in a given year. The inverse Mills ratios generated as part of the models displayed in columns (3) and (4) are used to estimate both the fixed effects and the pooled OLS models.

Similarly to the selection equation for the export market, the age of the household head exhibits has a negative relationship with the decision to commercialise through both markets in 2005. In the same way as the export market, household size and education of the household head exhibit negative and statistically significant relationships with the extent of commercialisation through both the domestic and export markets in column (1). The agricultural asset index is positively and statistically significantly associated with the decision to commercialise through both market channels simultaneously in 2005, while diversification of income through livestock ownership negatively affects the extent of commercialisation. The share of the cultivated area allocated to maize is negatively and statistically significantly associated with the decision to commercialise through both markets in 2005 only. Also similar to the results for pure export commercialisation, the price of maize yields a statistically significant and positive coefficient for the decision to commercialise in 2010.

The institutional indicators, i.e. membership in a PMO and GlobalGap compliance, which are not included in the model due to the possibility of endogeneity, are likely to be positively related to the extent of commercialisation through both markets jointly as discussed above. Spill-over effects from GlobalGap training to the production of domestic market vegetables are likely but more research needed to add substance to this speculative explanation. PMOs are associated with the production of export crops, but the modern domestic market channels also dictate the need for collective action in the form of producer groups to reduce the transaction costs of trading with several scattered smallholders. However, such initiatives are still limited and mainly concentrated in regions near urban areas (RAO and QAIM, 2011), which is supported by the fact that no farmer groups engaged in the production of locally consumed vegetables were observed in the study area during data collection.

6. Conclusions

The aim of this study was to describe the market pathways for the commercialisation of smallholder vegetable farming in Kenya and to empirically analyse the factors that influence the decisions of households regarding the commercialisation of vegetables through different market channels. Overall, the number of smallholders participating in the production of vegetables for commercial purposes has been decreasing. For instance, a fifth of those who participated in the trading of vegetables in 2005 had exited by 2010 and the decline was

greater among producers for the export than for the domestic market. Some of the responsible factors mentioned by the farmers themselves are weather risks, low productivity, high inputs costs, and unstable international market prices for vegetables. The standards imposed by international markets also present a challenge to resource-constrained small-scale producers.

We find that the age of the household head and household size are negatively related to vegetable commercialisation, which may be related to risk aversion or less flexibility to adopt new techniques among farmers who are older or have a large number of dependants. Furthermore, competition for land and labour limits commercialisation as indicated by the negative relationship between area allocated to maize production and off-farm activities, and the decisions to commercialise vegetable production, respectively. Credit and high export vegetable prices show positive relationships with export market participation, while the extent of commercialisation is positively associated with remittances and the size of cultivated land. The decision to participate in the domestic market, on the other hand, is positively associated with livestock ownership, annual rainfall, longer distances to the nearest market town, and ownership of a radio. However, due to the limited supply of labour, a negative relationship exists between livestock ownership and the extent of commercialisation through the domestic market. Commercialisation through both the domestic and export markets jointly is found to be positively associated with credit, longer distances to the nearest market town, and high vegetable prices.

We include measures of precipitation to incorporate weather risks. The findings reveal that more respondents commercialise through the domestic vegetable market channel after higher than average annual rainfall. Weather risk, as measured by the variability in rainfall, is negatively related to the choice and extent of commercialisation through the export market and positive for the extent of commercialisation through the domestic market channel, which is possibly due to the different planting systems.

A number of policy recommendations may be derived from our findings. Driven by high population growth and rural-urban migration, domestic market vegetables and other locally consumed farm produce, e.g. milk and maize, present market potential for small producers. Taking advantage of this opportunity, however, requires physical infrastructure and some

form of institutional support. The initiative of the government to provide subsidised fertiliser to small farmers established in 2011, for instance, is a start in this direction. Furthermore, there is need to explore strategies to adapt to unfavourable weather conditions and, in order to maintain their position in the export market, small producers require up-to-date information services to stay on top of evolving market requirements. Additional training of extension personnel and the institution of sustainable farmer groups to facilitate compliance with private market requirements such as GlobalGap standards and equivalent local guidelines such as KenyaGap may also encourage market participation of small horticultural producers.

Further research is recommended on the effects of national and global food price volatility on the commercialisation of vegetables. Similarly, an explicit investigation of the role of producer and marketing organizations and GlobalGap standards for the extent of commercialisation is beyond the scope of this study but worth further attention.

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