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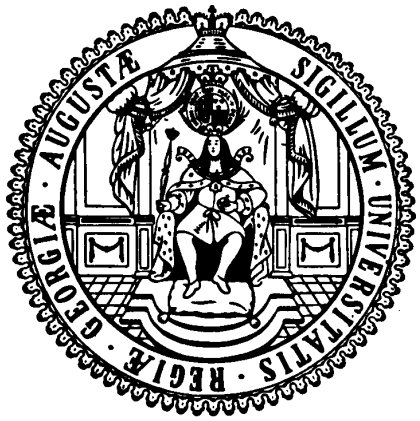

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March 2010

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Summary

The expansion of supermarkets in developing countries may have far-reaching consequences for poverty and rural development. While previous studies have compared farm profits between participants and non-participants in supermarket channels, wider household welfare effects have hardly been analyzed. Moreover, structural differences between the two groups have been ignored. We address these issues by using endogenous switching regression and building on a survey of vegetable farmers in Kenya. Participation in supermarket channels is associated with a 50% gain in average household income, leading to significant poverty reduction. To realize these benefits on a larger scale will require institutional and policy support.

Keywords: supermarkets, household income, sample selection, endogenous switching regression, Kenya, Africa

1. INTRODUCTION

The share of supermarkets in developing country food retailing has increased significantly in the recent past (Neven *et al.*, 2006; Reardon *et al.*, 2003; Mergenthaler *et al.*, 2009). This is affecting food consumers, but it also has far-reaching consequences for agricultural producers, because supermarket procurement channels are more integrated than traditional supply chains and have

higher requirements in terms of product quality and consistency. Especially for perishable products, supermarket procurement often involves contractual arrangements with farmers. From a development policy perspective, it is particularly important to understand how poor rural households are affected. For farmers, participation in supermarket channels might be associated with better market access and rising incomes. However, technical constraints and market imperfections might potentially also lead to smallholder exclusion, which could result in increasing disparities and marginalization.

There is a growing body of literature analyzing such aspects in various developing countries (e.g., Neven and Reardon, 2004; Pingali *et al.*, 2007; Reardon *et al.*, 2009). Different studies have examined determinants of farmer participation in supermarket channels (Hernandez *et al.*, 2007; Moustier *et al.*, 2010; Neven *et al.*, 2009). There are also a few studies that have tried to assess economic effects by comparing enterprise budgets for specific crops that are either supplied to supermarkets or traditional channels (Hernandez *et al.*, 2007; Neven *et al.*, 2009). However, such comparisons cannot establish causality, nor do they take into account broader household welfare effects. We are not aware of research that has looked more comprehensively into the impacts of supermarkets on farm household income and poverty, as we do in this article.

A related strain of literature focuses on modernizing export supply chains for high-value foods and the increasing role of standards in international trade (Bolwig *et al.*, 2009; Maertens and Swinnen, 2009; Minten *et al.*, 2009; Miyata *et al.*, 2009; Warning and Key, 2002; Wollni and Zeller, 2007). Some of these studies also look at income and poverty effects in the small farm sector, mostly building on standard treatment models that account for non-random sample selection. This strain of literature is very relevant for our work, because the conditions in high-value export chains are often similar to those in supermarket channels. However, standard

treatment models assume uniform effects across different groups of observations, while recent evidence suggests that there may be systematic differences between farmers supplying supermarkets and their counterparts in traditional channels (Hernandez *et al.*, 2007; Neven *et al.*, 2009). Welfare measures such as income are therefore likely to differ structurally, especially if participation in supermarket channels is determined by the same factors that affect income. In that case, assuming uniform effects conceals inherent interaction between marketing channel choice and other factors influencing income, potentially leading to spurious results and conclusions.

We address these issues by using an endogenous switching regression model that treats marketing channels as regimes and thus allows for structural differences in income functions between farmers supplying supermarkets and traditional channels. While switching regression models have been used in other impact studies related to agriculture (e.g., Fuglie and Bosch, 1995), they have never been employed in the context of supermarkets or other high-value market developments. The approach also allows us to simulate poverty effects of supermarket channel participation. The empirical research builds on primary household level data from a survey of vegetable farmers in central Kenya. Even though the overall share of supermarkets in vegetable retailing is still relatively small in Kenya, it is increasing rapidly (Neven and Reardon, 2004). Similar trends are also observed in other countries of Africa. Since many African smallholders are involved in horticultural production, there may be important effects for rural welfare and poverty.

The article proceeds as follows. In the next section, we present the analytical framework and estimation procedure. In section 3, we describe the data and undertake some descriptive analyses, while in section 4 we present and discuss the estimation results. Section 5 concludes.

2. ANALYTICAL FRAMEWORK AND ESTIMATION PROCEDURE

Participation in supermarket channels can be viewed as a binary choice decision problem by farm households that try to maximize utility or net returns. Utility is determined by a set of exogenous variables *Z*, which influence the cost of adjusting to a market option with new requirements. Variables in Z also determine the relative returns that a farmer can earn from supermarket and spot market channels. Thus, Z can include farm, household, and contextual variables.

In choosing a market option, farmers therefore compare expected utility of participation in supermarket channels, I_s^*, against expected utility of participating in traditional markets, I_t^*. Supermarket channels are chosen if $I_s^* > I_t^*$. However, I_s^* and I_t^* are latent variables; what is observed is actual participation in supermarket channels, I, with $I = 1$ if $I_s^* > I_t^*$ and $I = 0$ if $I_s^* \leq I_t^*$. Participation in supermarket channels can therefore be represented as follows:

$$I = Z\alpha - v \tag{1}$$

where α is a vector of parameters, and v is an error term with zero mean and variance σ^2. Since farmers are heterogeneous in their characteristics, not all of them will participate in supermarket channels. For those who do, participation is expected to result in higher farm returns that will also affect household income positively. These benefits can, for instance, be due to better and more stable prices, assured markets, and better access to inputs and technologies.

(a) *Modeling income effects*

The income effects of supermarket channel participation can be estimated using the following model:

$$y = f(X; I) \tag{2}$$

where y is household income, X is a vector of farm, household and contextual characteristics, and I is the participation dummy. Thus, the coefficient estimate for I captures the income effect. However, because farmers self-select into the group of participants, this estimate may be biased. Especially when more efficient farmers, whose incomes are higher anyway, are more likely to participate in supermarket channels, the income effect would be overestimated. In order to correct for such bias, Heckman selection or instrumental variable approaches could be used (Wollni and Zeller 2007; Schipmann and Qaim, 2010). 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 marketing channel choice and the other income determinants captured in X. Maertens and Swinnen (2009) have used propensity score matching, which can deal with structural differences, but only to the extent that these differences are based on observables. When there are unobserved factors that simultaneously influence farmers' 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 both self-selection and systematic differences across groups is switching regression (Maddala, 1983). A switching regression model treats market channels as regime shifters; this can be represented as follows:

$$\begin{aligned} y_s &= X\beta_s + u_s \\ y_t &= X\beta_t + u_t \\ I^* &= Z\alpha - v \end{aligned} \tag{3}$$

where y_s and y_t represent household income for supermarket and traditional channel suppliers, respectively, and I^* is a latent variable determining which regime applies. β_s and β_t are sets of parameters to be estimated. While the the variable sets $\boldsymbol{X}$ and $\boldsymbol{Z}$ are allowed to overlap, proper identification requires that at least one variable in Z does not appear in X. Note that in a cross-section sample y_s and y_t are only partially observed: y_s is only observed for the subsample of supermarket suppliers, and y_t for the subsample of farmers supplying traditional channels. So what is totally observed is a single variable y_i defined as follows:

$$y_i = \begin{cases} y_s & \text{if } I^* > 0 \\ y_t & \text{if } I^* \leq 0 \end{cases} \qquad and$$

$$I = \begin{cases} 1 & \text{if } I^* > 0 \\ 0 & \text{if } I^* \leq 0 \end{cases} \tag{4}$$

In equation (3), u_s, u_t, and v are residuals that are only contemporaneously correlated; they are assumed to be jointly normally distributed with a mean vector 0, and covariance matrix as follows:

$$\Sigma = \begin{pmatrix} \sigma_s^2 & \sigma_{st} & \sigma_{sv} \\ \sigma_{st} & \sigma_t^2 & \sigma_{tv} \\ \sigma_{sv} & \sigma_{tv} & \sigma^2 \end{pmatrix} \tag{5}$$

where $var(u_s) = \sigma_s^2$, $var(u_t) = \sigma_t^2$, $var(v) = \sigma^2$, $cov(u_s, u_t) = \sigma_{st}$, $cov(u_s, v) = \sigma_{sv}$, and $cov(u_t, v) = \sigma_{tv}$. The variance of v is set to one, since α is estimable only up to a scale factor (Greene, 2008; Maddala, 1986). In addition, $\sigma_{st} = 0$, since y_s and y_t are never observed together.

The switching model outlined so far accounts for self-selection on observables. When there are unobserved factors that matter, there will be correlation between the error terms of the regime

equations and the selection equation. Estimates of the covariance terms can therefore provide a test for endogeneity. If $\sigma_{sv} = \sigma_{tv} = 0$, there is exogenous switching, but if either σ_{sv} or σ_{tv} is non-zero, then we have a model with endogenous switching (Maddala, 1986). The test is achieved by testing for significance of the computed correlation coefficients $\rho_{sv} = \sigma_{sv}/\sigma_s\sigma_v$ and $\rho_{tv} = \sigma_{tv}/\sigma_t\sigma_v$ (Lokshin and Sajaia, 2004). Using these correlations, the expected values of the truncated error terms can be expressed as follows:

$$E(u_s|I = 1) = E(u_s|v < Z\alpha) = -\sigma_{sv}\frac{\emptyset(Z\alpha/\sigma)}{\phi(Z\alpha/\sigma)} = -\sigma_{sv}\lambda_s \quad (6)$$

$$E(u_t|I = 0) = E(u_t|v \geq Z\alpha) = \sigma_{tv}\frac{\emptyset(Z\alpha/\sigma)}{1-\phi(Z\alpha/\sigma)} = \sigma_{tv}\lambda_t \quad (7)$$

where $\emptyset$ and ϕ are the probability density and cumulative distribution function of the standard normal distribution, respectively. Hence, λ_s and λ_t are the Inverse Mills Ratios (IMR) evaluated at $Z\alpha$ (Greene, 2008).

Besides providing a test for endogeneity, the signs of ρ_{sv} and ρ_{tv} have economic interpretation. If ρ_{sv} and ρ_{tv} have alternate signs, farmers choose supermarket channels based on their comparative advantage (Fuglie and Bosch, 1995; Maddala, 1983). Thus, if $\rho_{sv} < 0$, farmers with above average incomes in supermarket channels have a higher likelihood of participating in these channels. Similarly, if $\rho_{tv} > 0$, farmers with above average incomes in traditional channels have a lower likelihood of participating in supermarket channels. Alternatively, if $\rho_{sv} < 0$ and $\rho_{tv} < 0$, there is evidence of "hierarchical sorting" (Fuglie and Bosch, 1995), implying that supermarket suppliers have above average incomes in both channels but are better off in supermarket channels. Similarly, traditional suppliers have below average incomes in both channels but are better off in traditional channels. Interpretation of the covariance terms also provides proof of model consistency, which requires that $\rho_{sv} < \rho_{tv}$. This condition also implies

that supermarket suppliers earn higher incomes than they would earn if they supplied traditional channels.

(b) *Estimation procedure*

When there is correlation between the error terms in equations (6) and (7), a two-stage method can be used to estimate the model. A first stage probit provides estimates of α , based on which the IMRs can be calculated. The IMRs are then included in estimating the regime equations in (3) in the second stage and the resulting IMR coefficients provide estimates of σ_{sv} and σ_{tv}. However, while this approach produces unbiased results, the parameter estimates are inefficient (Fuglie and Bosch, 1995). A more efficient approach is the full information maximum likelihood (FIML) method for endogenous switching regression, which jointly estimates the selection and regime equations (Greene, 2008; Lokshin and Sajaia, 2004).

Note that the coefficients β_s and β_t in equation (3) measure the marginal effects of independent variables on household income *unconditional* on farmers' actual market choice, i.e. the potential effect of *X* on the respective subsample. If there are variables that appear both in *X* and *Z*, the coefficients can be used, however, to estimate conditional effects as follows:

$$\frac{\partial E(y_s|I=1)}{\partial X_j} = \beta_{sj} - \alpha_j \sigma_{sv} \frac{\emptyset(Z\alpha/\sigma)}{\phi(Z\alpha/\sigma)} \left[Z\alpha/\sigma + \frac{\emptyset(Z\alpha/\sigma)}{\phi(Z\alpha/\sigma)} \right] \quad (8)$$

Equation (8) decomposes the effect of change in X_j into two parts: β_{sj} is the direct effect on the mean of y_s ; the second part is the indirect effect from market choice that appears as a result of correlation between the unobserved component of y_s and *I*.

(c) *Estimating the income effect of supermarket participation*

In order to evaluate the income effect of participation in supermarket channels, we need to estimate the conditional expectation of income that participants would have without participation in supermarket channels (Maddala, 1983). This can be estimated holding other characteristics constant via the following steps. For a farmer with characteristics *X* and *Z*, who participates in supermarket channels, the expected value of y_s is:

$$E(y_s|I = 1) = X\beta_s - \sigma_{sv}\lambda_s \tag{9}$$

where the last term takes into account sample selectivity. For the same farm, the predicted value of y_t (expected value of *y* without participation) is:

$$E(y_t|I = 1) = X\beta_t + \sigma_{tv}\lambda_s \tag{10}$$

The change in income per capita due to participation in supermarket channels can then be calculated as:

$$E(y_s|I = 1) - E(y_t|I = 1) = X(\beta_s - \beta_t) + (\sigma_{tv} - \sigma_{sv})\lambda_s \tag{11}$$

In the impact assessment literature, this is the average treatment effect on the treated. If self-selection is based on comparative advantage, $\sigma_{tv} - \sigma_{sv}$ would be greater than zero, and supplying supermarkets would produce bigger benefits under self-selection than under random assignment (Maddala, 1983).

3. DATA AND DESCRIPTIVE STATISTICS

(a) *Farm survey*

Data for this study was collected in 2008 through a survey of vegetable farmers in Kiambu District, Central Province of Kenya. Kiambu is relatively close to Nairobi, where most of the country's supermarkets can be found. But also before the spread of supermarkets, this district was one of the main vegetable-supplying areas for the capital city. Based on information from the district agricultural office, four of the main vegetable-producing divisions were chosen. In these four divisions, 31 administrative locations were purposively selected, again using statistical information on vegetable production. Within the locations, vegetable farmers were sampled randomly. Since farmers who participate in supermarket channels are still the minority, we oversampled them using complete lists obtained from supermarkets and supermarket traders. In total, our sample comprises 402 farmers – 133 supermarket suppliers and 269 traditional channels suppliers.

Using a structured questionnaire, these farmers were interviewed eliciting information on vegetable production and marketing, other farm and non-farm economic activities, as well as household and contextual characteristics. Both types of farmers produce vegetables in addition to maize, bananas, and other cash crops. The main vegetables produced are leafy types, including exotic ones such as spinach and kale, and indigenous ones such as *amaranthus* and black nightshade, among others.[1] Figure 1 shows the different vegetable marketing channels used by sample farmers. Some supermarket suppliers also sell vegetables in traditional spot markets when they have excess supply. However, for analytical purposes, farmers that supply at least part of their vegetables to supermarkets are classified as supermarket suppliers.

Insert Figure 1 here

Spot markets sales are one-off transactions between farmers and retailers or consumers with neither promise for repeated transactions nor prior agreements on product delivery or price. Depending on the demand and supply situation, prices are subject to wide fluctuation. Farmers who are unable to supply directly to wholesale or retail markets sell their produce to spot market traders who act as intermediaries. Such traders collect vegetables at the farm gate without any prior agreement. In contrast, supermarkets do have agreements with vegetable farmers regarding product price, physical quality and hygiene, and consistency and regularity in supply (Ngugi *et al.*, 2007). Price agreements are made before delivery, and prices are relatively stable. Payments are usually only once a week or every two weeks. All agreements are verbal with no written contract. Some farmers also supply supermarkets through special traders. Based on similar verbal agreements, these traders again maintain regular contacts with farmers, in order to be able to supply supermarkets in a timely and consistent way. Strict supply requirements by supermarkets have led to specialization among traders. Consequently supermarket traders tend to exclusively supply modern retail outlets.[2]

Given the risk of exclusion from emerging modern supply chains, there are various organizations in Kenya trying to link smallholders to supermarket and export channels. One such organization active in Kiambu is the NGO Farm Concern International (FCI). FCI trains farmer groups on production of indigenous vegetables before linking them to various supermarkets in Nairobi (Moore and Raymond, 2006; Ngugi *et al.*, 2007). FCI also promotes collective action and – through training efforts – helps farmers to meet the strict delivery standards imposed by supermarkets. Our sample covers 80 vegetable farmers currently involved in the FCI project. Out of these, more than half were already supplying supermarkets at the time of our survey.

(b) *Descriptive analysis*

Table 1 shows descriptive statistics for the two groups of farmers. There are significant differences with respect to some of the variables. On average, supermarket suppliers own more land and cultivate larger areas of vegetables. They also tend to be somewhat more specialized on vegetable production and have a higher tendency to use advanced irrigation technology such as sprinklers or drip irrigation. There are also significant differences with respect to education levels and participation in off-farm employment. Better educated vegetable growers are more likely to supply supermarkets, as are farmers with off-farm employment.

Insert Table 1 here

In Table 2 we compare vegetable gross margins between farmers in the two market channels. There are significant differences both in revenues and production costs. Revenue differences are due to higher yields obtained by supermarket suppliers and also higher mean prices. In terms of costs, supermarket suppliers spend significantly more on hired labor. Part of the additional labor demand is due to the fact that supermarkets often require farmers to pack or bundle the vegetables into certain units (Neven *et al.*, 2009). Hence, supermarket procurement channels are employment generating in rural areas. On the other hand, farmers supplying supermarkets use slightly less inorganic fertilizer. Instead, they use more farmyard manure, which adds organic matter to the soil and – according to their own statements – entails a quicker regeneration of the leaves after harvest. This is important, because in supermarket channels vegetables have to be supplied on a regular basis.

Insert Table 2 here

The differences in revenues and costs result in significantly higher gross margins for supermarket suppliers. This picture also remains when additionally subtracting the imputed value of household own resources such as family labor and own farmyard manure. Positive gross margin differences occur across the entire distribution, as can be seen in Figure 2. The gross margin cumulative distribution function (CDF) for supermarket suppliers significantly dominates the CDF for spot market suppliers.

Insert Figure 2 here

Yet, gross margins for one particular farm enterprise can only provide a partial picture of household welfare. Therefore, we also look at total household incomes. As can be seen in Figure 3, farm, off-farm, and total incomes expressed in annual per capita terms are notably higher for supermarket suppliers than for households supplying vegetables to traditional channels. These differences cannot be interpreted as causal effects, but they provide a first indication that there may indeed be structural differences in household incomes between supermarket and traditional channel suppliers. Figure 4 shows that income differences are significant across the entire income distribution.

Insert Figure 3 here

Insert Figure 4 here

Superior incomes also translate into lower poverty rates among supermarket suppliers, as can be seen in Figure 5. Poverty incidences were calculated based on 1.25 dollar and 2 dollar a day poverty lines for extreme and moderate poverty, respectively. These poverty lines were converted to local currency equivalents using purchasing power parity (PPP) exchange rates. The PPP exchange rate was 1 dollar to 29.52 Kenyan shillings in 2005 (International Bank for

Reconstruction and Development, 2008). This was updated to current rates using the consumer price index. Compared to the rest of the country, poverty rates in Kiambu are relatively low; in fact, Kiambu is one of the least poor rural districts in Kenya (Ndeng'e *et al.*, 2003).

Insert Figure 5 here

4. ECONOMETRIC ANALYSIS

The descriptive analyses in the previous section revealed significant differences in vegetable gross margins and per capita household incomes between supermarket and traditional channel suppliers. While we went beyond the mere comparison of mean values through looking at the entire income distribution, simple comparisons still do not allow meaningful statements about impacts. To analyze causality we need econometric approaches that link supermarket participation and income outcomes. As outlined in section 2, we apply an endogenous switching regression model to estimate income effects of participation in supermarket channels. The income equations are estimated jointly with the selection equation that explains farmers' participation in supermarket channels. In the following, we first discuss the results on the determinants of participation, before focusing on income and poverty effects.

(a) *Determinants of participation in supermarket channels*

Alongside typical farm and household characteristics we hypothesize that institutional support through FCI influences farmers' access to supermarket channels. Therefore, we include participation in the FCI market linkage program as an additional explanatory variable – defined as a dummy. Yet, participation in that program might potentially be endogenous, which would

lead to a bias in the coefficient estimate. We test for endogeneity of the FCI dummy employing a two-step approach, as suggested by Rivers and Vuong (1988). In the first step, we run a probit regression with the FCI dummy as dependent variable and using membership in a farmer group, which is correlated with FCI but not with supermarket channel participation, as an instrument. In the second step, predicted residuals from this regression are included as additional explanatory variable in the supermarket participation model. The null hypothesis for the test is that these predicted residuals are not significant, which would imply exogeneity of the FCI variable. The test fails to reject this null hypothesis ($p = 0.664$). Therefore, for the actual model of interest we proceed with a normal probit, which is jointly estimated with the income equations using the FIML method, as detailed above. The estimation results are displayed in Table 3.

Insert Table 3 here

Participation in supermarket channels significantly depends on the level of education and age of the farmer. Better educated farmers are more likely to participate in supermarket channels. This is plausible, because education helps farmers to better adjust to the new production and market requirements. In general, better educated farmers tend to be more innovative and therefore more likely to participate in emerging supply chains. Older farmers are also more likely to participate in supermarket channels, which is probably related to longer experience. Yet the negative and significant coefficient for the square term of age indicates that there is an inverse U-shaped relationship, implying that beyond a certain age farmers become less innovative again.

Farmers who are engaged in off-farm employment are more likely to participate in supermarket channels. This could be due to certain capital investments necessary for participation, which are facilitated through off-farm earnings, especially when there are credit constraints. Furthermore,

off-farm income helps to ensure short-term liquidity against the background of lagged supermarket payment schedules. Ownership of land also has a significantly positive, albeit relatively small, effect on the likelihood of supermarket participation. Obviously, larger farmers are at a certain advantage, which may be due to fixed transaction costs in supermarket channels, such as transportation and information search costs. In a similar fashion, ownership of a means of transportation and availability of public transportation in the village increase the likelihood of participation. This is plausible because – unless there are specialized traders – farmers have to deliver their produce themselves to the supermarket locations. These results underscore that infrastructure, which is key for linking farmers to markets in general, is equally important in the context of emerging modern supply chains.

Finally, institutional support by FCI has a positive and significant influence on supermarket participation. FCI negotiates with supermarkets on behalf of farmers. The NGO also facilitates farmer collective marketing approaches and offers training on production techniques and special supermarket requirements. These activities reduce transaction costs and contribute to making smallholder farmers more reliable trading partners for supermarkets. Equally important is the so-called invoice discounting service, that is, FCI anticipates payments to farmers when they present a supermarket delivery receipt; in that case, supermarkets later pay FCI instead of farmers directly. This mechanism enables even relatively poor households with immediate cash needs to participate in supermarket channels, despite the lagged payment schedule. These are important findings from a policy perspective. Where no NGO like FCI is operating, public agencies might potentially take on such roles of institutional support.

(b) *Determinants of household income*

As described in section 2, we explain household income in supermarket and traditional channels with the help of an endogenous switching model, results of which are presented in Table 4. To properly identify the model, two variables in the probit model – namely the FCI dummy and availability of public transportation in the village – are excluded from the income function. It was tested that these variables do not affect household income directly.

The results indicate that there are indeed structural differences across the two market channels. For instance, off-farm employment and ownership of an own means of transportation have a positive and significant influence on per capita household income in both market channels, but the effects are much bigger among supermarket suppliers. This suggests that supermarket suppliers use off-farm income and own vehicles in a more productive way than their colleagues in traditional market channels. Both variables also significantly affect the probability of supermarket participation, which is an indication of joint determination of income status and channel choice.

Insert Table 4 here

Land ownership influences income positively and significantly only for spot market suppliers, which is related to larger quantities of agricultural produce, particularly of cash crops, which are usually associated with larger landholdings. The fact that the impact of land is insignificant in the case of supermarket suppliers suggests that these farmers put greater emphasis on product quality that fetch them higher prices from supermarkets. Somewhat surprising may be that use of advanced irrigation technology is also significant only for traditional channel suppliers. However, as pointed out above, most farmers in supermarket channels use advanced irrigation technology, which is almost a precondition for participation. Hence, the observed variability in

this subsample is lower, entailing larger standard errors. Traditional channel farmers who use advanced irrigation technology benefit because they can supply vegetables also during the off-season when prices are generally higher.

Livestock ownership also has a positive and significant impact on household income of traditional farmers, while the effect is insignificant among supermarket suppliers. This suggests a higher degree of specialization in vegetable production among supermarket suppliers, which is consistent with the descriptive results presented above. Specialization is possible because of more stable and predictable prices in supermarket channels. Moreover, given high seasonal fluctuation in vegetable spot markets, many traditional farmers diversify into dairy activities, because prices of milk remain relatively stable.

The lower part of Table 4 reports estimates for the covariance terms. The terms have the same sign, which indicates "hierarchical sorting". Hence, supermarket suppliers have above average incomes in both channels but are better off in supermarket channels. The fact that the covariance estimate for spot market suppliers is insignificant indicates that, in the absence of supermarket participation, there would be no significant difference in average behavior of the two farmer categories caused by unobserved effects. The model fulfils the necessary condition for consistency, namely that $\rho_{sv} < \rho_{tv}$]. Supermarket suppliers therefore earn higher incomes than they would earn if they supplied traditional channels. We also show the likelihood ratio test for joint independence of the three equations. The test statistic suggests that there is significant dependence between the selection and income equations; this is further evidence of endogeneity, which is accounted for in our specification.

(c) *Income and poverty effects of supermarket channel participation*

Finally, we analyze net income effects of supermarket channel participation as illustrated in equation (11). For clarity, building on the results in Table 4 we compare predicted per capita incomes for the subsample of participating households with and without supermarkets. Results are presented in Table 5, disaggregated for different categories of farmers. Significant positive net income effects can be observed. For the whole subsample of supermarket suppliers, participation produces a gain of 50% in per capita incomes.

Insert Table 5 here

The disaggregated results suggest that supplying supermarkets can also lead to improvements in income distribution. With an average income gain of 68%, small-scale farmers owning less than one acre of land benefit over-proportionally. Likewise, extremely and moderately poor households benefit more than non-poor households.[3] These differences can partly be explained by the fact that small and poor farmers tend to engage mostly in subsistence farming; hence, the option to supply supermarkets at more stable prices provides new incentives to commercialize farm activities, leading to substantial gains in household income. Another disaggregation in Table 5 shows that farmers who supply supermarkets directly gain more than their counterparts who supply through specialized traders. This is plausible: without intermediaries, a bigger share of the price paid by supermarkets accrues to primary producers.

We also use the results to simulate the impact of supermarket participation on the incidence of poverty. For this purpose, the predicted poverty incidence with participation in supermarket channels is compared with the same prediction assuming no participation. Results are shown in the lower part of Table 5. They suggest that supermarket participation reduces the incidence of extreme poverty by 33%, which is quite remarkable. Moderate poverty remains unaffected; while

there are also income gains among the moderately poor, the number of households becoming non-poor is counterbalanced by the number of households that enter the group of moderately poor by escaping extreme poverty. Since the number of poor households in our sample is small, the exact results should certainly be interpreted with caution. Nevertheless, the findings show that supermarket participation can improve household incomes in the small farm sector and contribute to poverty reduction.

5. CONCLUSION

The expansion of supermarkets in developing countries and the establishment of more integrated procurement systems provide new opportunities for farmers to commercialize and participate in modern high-value supply chains. This offers potentials for income increases in rural areas. Yet there is still uncertainty related to the question whether smallholder farmers can benefit, too. While recent studies have analyzed some of the implications in various settings, there is hardly any work that has looked at the impact of supermarkets on household income and poverty. In this article, we have addressed this research gap by analyzing the situation of vegetable farmers in central Kenya. Building on recent farm household survey data, we have developed and used an endogenous switching regression model, which explains household income, taking account of sample selection and structural differences between participants and non-participants in supermarket channels.

The estimation results show that participation in supermarket channels produces significant gains in per capita household income, which are in a magnitude of 50%. Smaller and poorer farms supplying supermarkets even benefit over-proportionally. Simulations based on the estimation

results suggest that poverty rates among supermarket suppliers are 33% lower than they would be were there no supermarkets. This clearly demonstrates the potential of supermarkets and other modern supply chain developments to contribute to poverty reduction and rural development.

However, results from the selection equation of the model also show that there are certain participation constraints for disadvantaged households. Better educated farmers and households with more assets are more likely to be involved in supermarket channels. Moreover, infrastructure and access to transportation are factors that facilitate participation significantly. And, the positive role of off-farm employment suggests that there may be credit constraints. To a large extent, these are the same types of problems that also limit smallholder participation in more traditional markets. They need to be overcome through appropriate rural development policies, in order to fully harness the potentials of emerging modern supply chains for the poor.

Yet there are also more specific policy mechanisms that can help to better link farmers to supermarket channels. In the study region in central Kenya, there is an NGO that promotes collective action, provides training on production techniques and special supermarket requirements, and offers other institutional support. These targeted activities reduce transaction costs and contribute to making smallholder farmers more reliable trading partners for supermarkets. The estimation results confirm that farmers who obtain this NGO support are much more likely to participate in supermarket channels. Hence, such efforts should be scaled up to reach a larger number of farmers and achieve larger geographical coverage. Beyond NGOs, this could potentially constitute a new role for public sector extension services, although this would first require considerable capacity strengthening.

Kenya is only one example in Africa where supermarkets are gradually transforming agricultural supply chains. Therefore, this research has wider policy implications. Understanding both the potentials and risks of emerging value chains is crucial, as developments gradually spread to a wider geographical area. Our results suggest that supermarkets can contribute to income growth and poverty reduction in the small farm sector. Yet to realize this potential on a larger scale will necessitate broader infrastructure development as well as targeted institutional support.

NOTES

1. Recently, African indigenous vegetables have received renewed attention from upper and middle income consumers (Moore and Raymond, 2006; Ngugi et al., 2007).

2. Initially, supermarkets in Kenya purchased fresh vegetables in traditional wholesale markets, which can still be observed today. However, meanwhile supermarkets have diversified their procurement to include contracted farmers and traders, in order to ensure price stability and consistency in quality and supply.

3. When only focusing on the extremely poor, their benefits are even in a magnitude of 88%. However, since the number of both extremely and moderately poor households in our sample is small, we decided to club these two categories here, in order to make the comparison more meaningful and robust.

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Table 1. *General differences between supermarket and spot market suppliers*

	Supermarket (n=133)		Spot market (n=269)	
Variables	**Mean**	**SD**	**Mean**	**SD**
Total area owned *(acres)*	2.692**	5.607	1.870	2.485
Total vegetable area cultivated *(acres)*	1.168***	1.457	0.697	0.992
Share of vegetable area *(%)*	68.8*	31.9	62.8	32.5
Use of advanced irrigation technology *(%)*	87.9***	32.7	71.4	45.3
Age of farmer *(years)*	47	12	49	15
Education of farmer *(years of schooling)*	10.3***	3.14	8.72	4.05
General farming experience *(years)*	16.16**	11.60	17.89	13.33
Off-farm employment of farmer (%)	61***	47	43	50

, **, * Mean values are significantly different from spot market suppliers at 10%, 5%, and 1% level, respectively.*

Table 2. *Gross margin differences between supermarket and spot market suppliers*

	Supermarket (n=133)		Spot market (n=269)	
	Mean	**SD**	**Mean**	**SD**
Gross revenue *(Ksh/acre)*	116,636***	129,370	73,179	60,136
Seed cost *(Ksh/acre)*	2,175	5,428	1,660	3,021
Hired labor cost *(Ksh/acre)*	6,330**	10,019	4,722	7,481
Fertilizer cost *(Ksh/acre)*	4,846*	7,485	5,781	6,379
Purchased manure cost *(Ksh/acre)*	8,666***	14,099	5,712	8,751
Pesticide cost *(Ksh/acre)*	1,104	1,922	1,179	1,835
Other cost *(Ksh/acre)*	1,271**	4,723	623	2,167
Gross margin *(Ksh/acre)*	**92,244*** **	**114,202**	**53,502**	**54,677**
Value of family labor *(Ksh/acre)*	9,775**	21,297	13,951	16,570
Value of own manure *(Ksh/acre)*	2,520	7,253	2,687	7,575
Gross margin less value of own resources *(Ksh/acre)*	**79,950*** **	**112,246**	**36,865**	**54,004**

, **, * Mean values are significantly different from spot market suppliers at 10%, 5%, and 1% level, respectively.*
Note: 1US dollar = 75 Ksh.

Table 3. *Probit model for determinants of participation in supermarket channel*

	Coefficient	**SE**
Gender of operator *(male dummy)*	0.383	0.286
Education of operator *(years)*	0.044*	0.026
Age of operator *(years)*	0.136***	0.045
Age of operator squared *(years)*	-0.002***	4.650^{-04}
Household size *(number of people)*	-0.161***	0.051
Off farm employment *(dummy)*	0.342**	0.159
Total area owned *(acres)*	0.060**	0.028
Use of advanced irrigation technology *(dummy)*	0.155	0.222
Ownership of livestock *(dummy)*	0.010	0.186
Household access to electricity *(dummy)*	0.181	0.208
Own means of transportation *(dummy)*	0.615***	0.229
Availability of public transportation in village *(dummy)*	0.432*	0.242
Proximity to tarmac road *(dummy)*	0.110	0.182
Household access to public piped water *(dummy)*	-0.311*	0.178
Credit accessed in last 12 months *(dummy)*	0.012	0.260
Participation in FCI market linkage program *(dummy)*	0.835***	0.243
Limuru region *(dummy)* [a]	-0.637	0.490
Kikuyu/Westland region *(dummy)* [a]	0.900*	0.459
Githunguri and Lower Lari region *(dummy)* [a]	0.497	0.496
Constant	-5.003***	1.199
Number of observations		*402*

This selection equation is jointly estimated with the income regime equations shown in Table 4.
*, **, *** Significant at the 10%, 5%, and 1% level, respectively.
[a] The reference region is Lari.

Table 4. *Full information maximum likelihood parameter estimates for household income*

	Supermarket suppliers		Spot market suppliers	
	Coefficient	**SE**	**Coefficient**	**SE**
Gender of operator *(male dummy)*	7.935	39.000	11.730	9.551
Education of operator *(years)*	1.430	3.282	1.324	0.884
Age of operator *(years)*	0.900	0.910	-0.143	0.249
Household size *(number of people)*	-6.807	5.691	-1.783	1.762
Off farm employment *(dummy)*	50.990**	20.400	25.380***	6.299
Total area owned *(acres)*	1.176	1.958	7.234***	1.412
Use of advanced irrigation technology *(dummy)*	9.440	29.830	18.000**	7.257
Ownership of livestock *(dummy)*	14.250	25.390	20.550***	6.371
Household access to electricity *(dummy)*	8.532	28.070	16.680**	7.281
Own means of transportation *(dummy)*	87.920***	23.720	34.470***	11.720
Proximity to tarmac road *(dummy)*	-1.202	19.700	5.251	6.467
Household access to public piped water *(dummy)*	-42.540**	21.230	9.426	6.991
Credit accessed in last 12 months *(dummy)*	-62.180**	30.490	-10.620	10.040
Limuru region *(dummy)* [a]	126.000	84.540	11.210	12.330
Kikuyu/Westland region *(dummy)* [a]	-35.230	75.440	5.584	13.110
Githunguri and Lower Lari region *(dummy)* [a]	-62.180	78.900	5.160	13.640
Constant	76.810	102.800	-36.870*	21.520
ln σ_s	4.652***	0.082		
ρ_{sv}	-0.455**	0.215		
ln σ_t			3.853***	0.043
ρ_{tv}			-0.020	0.189
Likelihood ratio test of independent equations χ^2				*2.870**
Number of observations				*402*
Log likelihood				*-2401.445*
F-statistics χ^2				*67.700****

The dependent variable is annual per capita income measured in thousand Ksh. These regime equations are jointly estimated with the selection equation shown in Table 3.

*, **, *** Significant at the 10%, 5%, and 1% level, respectively.

[a] The reference region is Lari.

Table 5. *Simulated impact of participation in supermarket channels on income and poverty*

	No. of obs.	Without supermarket	With supermarket	Net change (%)
		Annual per capita income (1,000 Ksh)		
All supermarket suppliers	133	72.977	109.260	50***
By land holding				
Supermarket suppliers owning < 1 acre of land	62	52.039	87.494	68***
Supermarket suppliers owning 1-2 acres of land	29	70.360	100.543	43***
Supermarket suppliers owning >2 acres of land	42	105.691	147.411	39***
By poverty status				
Extremely and moderately poor	17	49.150	80.703	65**
Non-poor	116	76.469	113.445	49***
By supply category				
Direct suppliers	96	74.090	113.328	53***
Suppliers through traders	37	70.088	98.707	41***
		Poverty incidence (%)		
Extremely poor		3	2	-33
Moderately poor		3	3	0
Non-poor		94	95	1

*, **, *** The net change (difference between predicted income with and without supermarkets) is significant at the 10%, 5%, and 1% level, respectively.

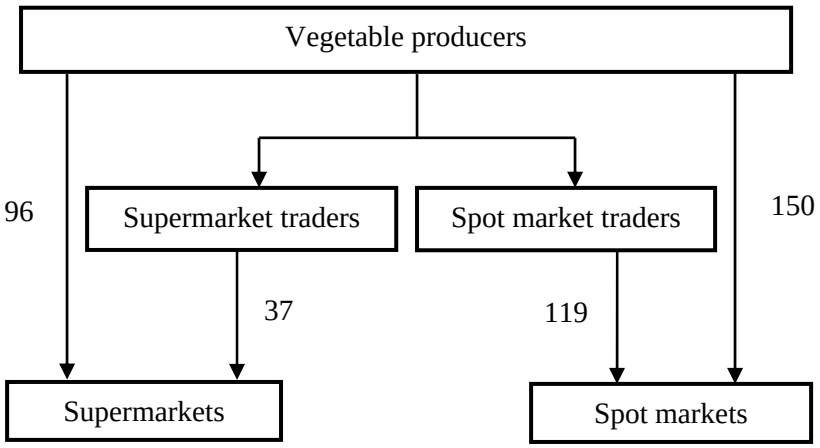

Figure 1. *Vegetable marketing channels among Kenyan sample farmers*

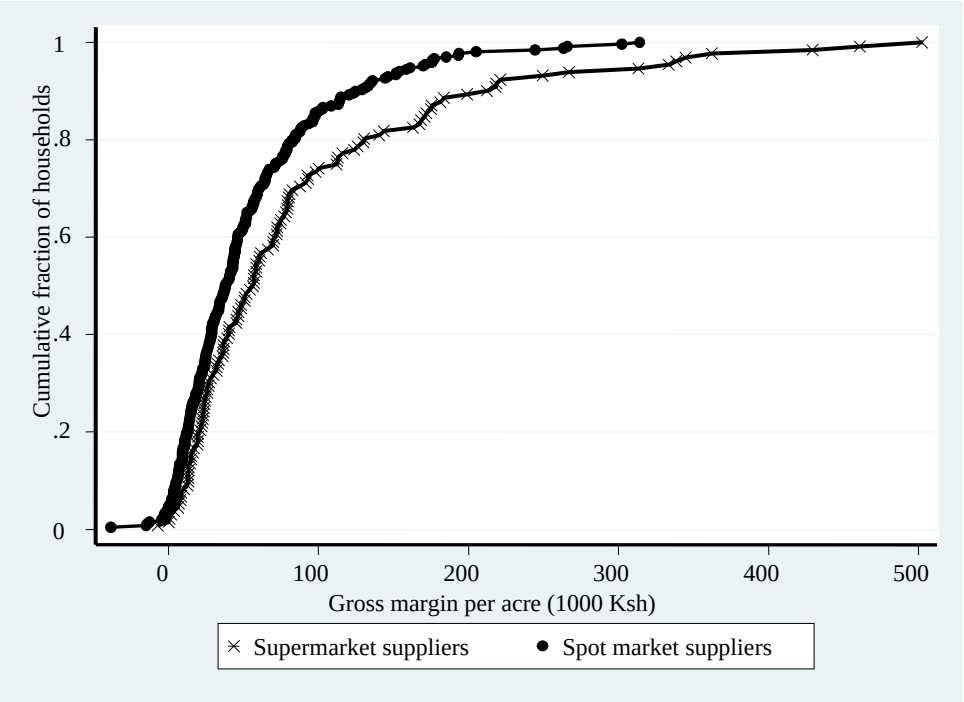

Figure 2. *Cumulative distribution of gross margin by market channel*

Note: The Kolmogorow-Smirnov test statistic of 0.170 indicates that the two distributions are statistically different (p=0.009).

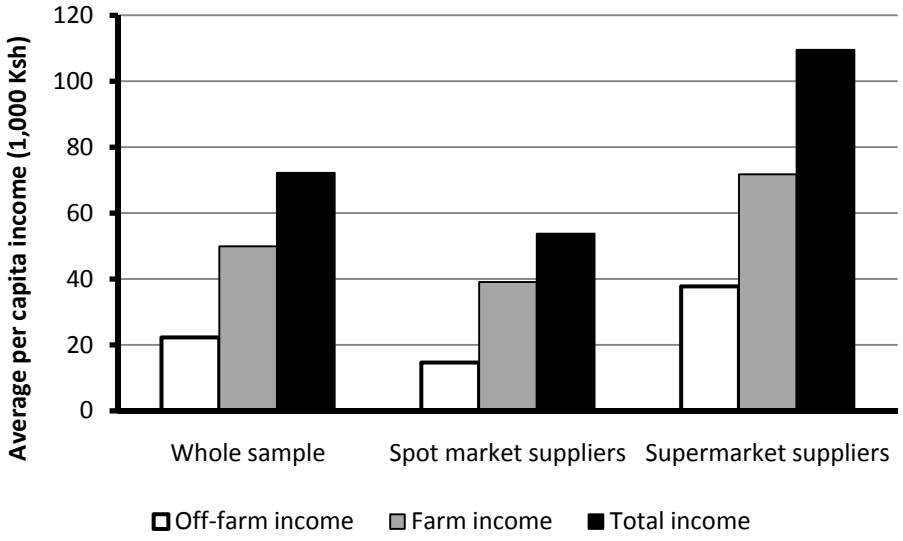

Figure 3. *Average annual per capita income by market channel*

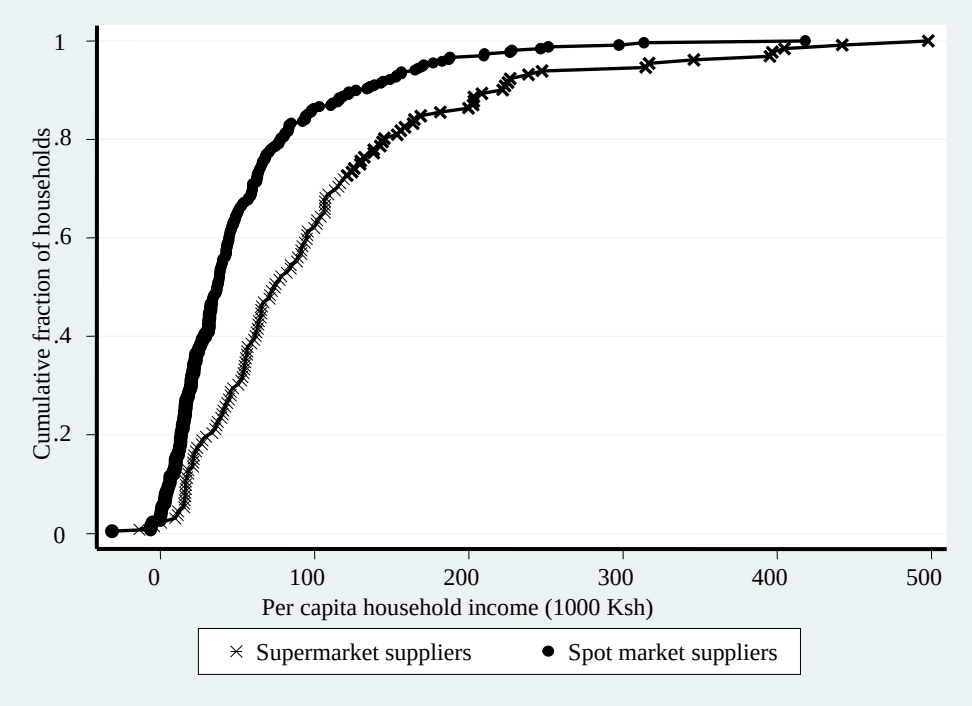

Figure 4. *Cumulative distribution of annual per capita household income by market channel*

Note: The Kolmogorow-Smirnov test statistic of 0.361 indicates that the two distributions are statistically different (p=0.000).

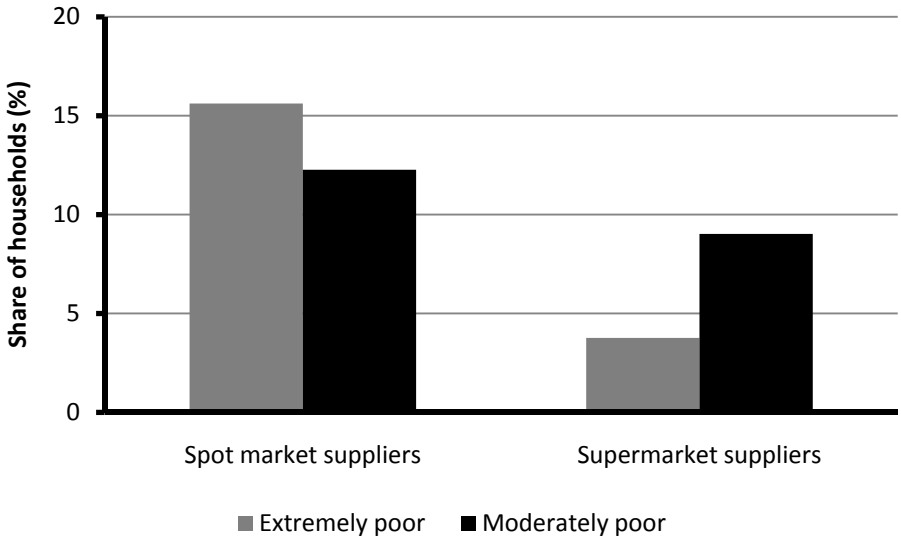

Figure 5. *Incidence of poverty by market channel*