The Effects of Market Participation on Farm Households' Food Security in Cambodia: An endogenous switching approach

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Abstract

This paper evaluates the effects of market participation on farm households' food security in rural Cambodia in terms of household dietary diversity score. The evaluation is carried out with an endogenous switching model built on data from the Cambodia Socio-Economic Survey conducted in 2009. This model accounts for selection bias arising from unobserved factors that potentially affect both the participation and food security. The model also controls for structural differences between participants and nonparticipants in markets in terms of food security functions. The results reveal that by participating in markets, farm households enjoy higher household dietary diversity score, thus confirming the hypothesis that participation in markets exerts positive effects on farm households' food security.

Keywords: market participation, farm households, food security, endogenous, rural Cambodia

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Introduction

Cambodia is an agrarian country, with approximately 80 per cent of the population living in rural areas (National Institute of Statistics [NIS], 2011). The agriculture employs over 70 per cent of the labor force (Asian Development Bank [ADB], 2013), making the sector the most important in the economy. The majority of farmers, especially smallholder farmers, make their living by farming, either for subsistence or small-scale commercial purpose, conditionally on rain-fed water. Paddy fields are dominant, accounting for about 2.63 million hectares during 2007-2011 (up to 90% of the cultivated land); and the yields increased from 4 million tons in 2000 to 6 million tons in 2007 (Ministry of Agriculture Forestry and Fisheries [MAFF], 2011; MAFF & Ministry of Water Resources and Meteorology [MWRM], 2010).

Although the economic growth contributed significantly to poverty reduction from 50 per cent in 2004 to 20 per cent in 2011 (ADB, 2013), the rural poverty rate remains high; and income disparity has remarkably widened between rural and urban populations. The vulnerability and the risk of getting back to the poverty trap are still relatively high (World Bank [WB], 2015). This demonstrates that rural households have not been much better off, more likely still facing food security issues. The nationwide undernourishment prevalence declined from 37 per cent in 2004 to 33 per cent in 2009; nevertheless, rural undernourishment prevalence slightly increased (NIS, 2011), raising concern over food security issues among rural farm households and the poorest population. This result demonstrates that rural poverty alleviation cannot be achieved without an improvement in rural household food security. Given Cambodia has a high potential for agriculture, promoting market-oriented agriculture would make a tremendous contribution to improving rural farm households' welfare in terms of food security.

One of the most likely pathways towards improving the farm households' livelihoods in developing countries is to integrate them into markets (Olwande, Smale, Mathenge, Place, & Mithöfer, 2015). According to Barrett (2008), the importance of market entrance to farm household earnings and welfare can be shown based on productivity improvement and comparative advantage arguments. That is, once entering markets, farmers can not only reach economies of scales and use technologies that improve productivity but also can produce goods they are adept at producing and exchange the surplus for other goods they are not. The farm households' participation in markets as sellers might be, however, affected by sale volume and price instability, technical inability and market imperfections (Roa & Qaim, 2011). Moreover, such factors as inappropriate agricultural policies, limited knowledge, inadequate irrigation and poor urban-rural road connectivity, and natural calamities like drought, excessive rainfall and flood may constrain market-oriented farming.

A myriad of studies have paid more attention to such aspects by analysing factors determining farmers' participation in markets in various developing countries (see, for example, Goetz, 1992; Key, Sadoulet, & de Janvry, 2000; Heltberg & Tarp, 2002; Bellemare & Barrett, 2006; Olwande et al., 2015; Burke, Myers, & Jayne, 2015). Some studies have also tried to evaluate effects of supplying agricultural products to either supermarkets or traditional markets on farm household income (see, for example, Hernandez, Reardon, & Berdegue, 2007; Neven, Odera, Reardon, & Wang, 2009). They evaluated the effects by comparing gross margins generated from selling produce in supermarkets with those generated from selling in traditional markets. However, the comparison cannot spell out net effects of product supply due to unobserved factors that potentially affect the outcomes. Asfaw, Lipper, Dalton, & Audi (2012) assessed the impacts of market participation as sellers on farm households' welfare by using a propensity score matching approach. Still, the approach cannot control for unobserved

characteristics that can influence both the treatment and outcome, then potentially yielding biased and inconsistent estimates of the outcome. To address this econometric challenge, some use standard treatment models that control for non-random sample selection. However, the models assume that the impacts are uniform across different subsamples, while recent studies show that market participants may inherently differ from nonparticipants (Hernandez et al., 2007; Neven et al., 2009). This demonstrates that household expenditures are very likely to systematically differ, especially if factors determining decisions of whether to participate or not participate in markets affect equally the expenditures. In this case, the uniform effects assumption can hide an inherent interaction between the decisions concerning market participation and factors affecting the expenditures, more likely bringing about unreliable outcomes (Roa & Qaim, 2011).

The attempt of the current paper is to quantify the effects of market participation on farm households' food security in terms of household dietary diversity score [HDDS] in Cambodia by applying an endogenous switching model to data from the Cambodia Socio-economic Survey [CSES] conducted in 2009. The model treats the market participation as a seller and self-sufficiency as regimes to address potential endogeneity arising from endogenous selection bias of the decisions regarding market entrance and the inherent differences between market participants and nonparticipants. Then, adopting the model, the effects can be evaluated by accounting for both observed and unobserved factors that determine both the decisions concerning regimes and households' food security. Furthermore, it controls for potential systematic differences between the participants and nonparticipants in terms of food security functions. In spite of a relatively large number of studies on welfare effects of agricultural commercialisation on farm households, as presented in the following section, most of them have evaluated the effects based on productivity and income. The analysis of the effects on household food security is rare. This study tries to bridge this gap and address the endogeneity issue using cross-sectional data.

The remainder of the paper proceeds as follows. Section 2 reviews related literature, while Section 3 describes analytical framework and empirical approach used for the analysis. In Section 4, the data used in the analysis and variables are described, while the estimated results and discussion are presented in Section 5. Section 6 concludes the study.

Literature Review

The role of market participation in increasing productivity and household income is discussed by a number of studies (see, for example, Hernandez et al., 2007; Rao & Qaim, 2011; Rao, Brümmer, & Qaim, 2012; Barrett et al., 2012; Bellemare, 2012; Maertens, Minten, & Swinnen, 2012; Asfaw et al., 2012; Michelson, 2013; Muriithi & Matz, 2015; Chege, Andersson, & Qaim, 2015). Their findings show that participating in markets can allow farmers to improve farm productivity and enhance household earnings. For example, Hernandez et al. (2007) provided evidence that participation of tomato farmers in supermarkets has positive association with the yields in Guatemala; and Rao & Qaim (2011) found the positive correlation between supply of vegetables to supermarkets and farm household income in Kenya. In addition to these findings in the case of Kenya, Rao et al. (2012) found that entrance into supermarket channels improves farm productivity in terms of technical efficiency and scale efficiency.

Michelson (2013) analysed the role of geographical location of supermarket supply chain during 2000-2008 in Nicaragua by using the panel data. The author employed a difference-in-differences method comparing growth of suppliers' and non-suppliers' assets overtime to

evaluate the impacts of market entry on smallholder well-being. The findings demonstrate that supplying to supermarkets augments the holdings of productive assets. Moreover, farm households with advantageous geographical location and access to water are very likely to enter markets. Muriithi & Matz (2015) examined the effects of smallholders' commercialisation of horticulture on household welfare based on household income and wealth by using panel data on household survey from Kenya. By using an OLS regression and controlling for unobserved heterogeneity across households, the authors found that vegetable commercialisation has significantly positive impacts on household well-being. However, the effects depend on market channels, with export channel producing a positive effect on income but not on wealth and with domestic channel producing a mixed effect on wealth and income. Chege et al. (2015) investigated the nutrition effects of supermarkets on farm households by estimating simultaneous equation models with data from a survey in Kenya. The estimated results show that entry into supermarkets is positively associated with consumption of vitamin A, calorie, iron and zinc. Moreover, farm households supplying produce to supermarkets enjoy significantly higher incomes. Bellemare (2012) analised the effects of contract farming on household welfare proxied by household income by using cross-sectional data and addressing self-selection issue with an instrumental variable approach. The author found that the contract stimulates household income and reduces vulnerability of household earnings.

Roa & Qaim (2011) studied the effects of supermarket participation on farm household income and poverty by applying an endogenous switching regression method to cross-sectional data from the vegetable farmer survey in Kenya. The estimated results suggest that entrance into supermarkets increase household incomes and contribute to poverty alleviation. Asfaw et al. (2012) investigated factors affecting input and output market participation and evaluated the effects of market participation on crop diversity and farm household well-being in Kenya by using propensity score matching method with cross-sectional data. The results show that input market entrance is affected by access to off-farm income, transportation ownership and farm size, while the output market entry is determined by farm size, household characteristics and ownership of radio. The participation in output market is found to increase food security, while the significant effects of input market entry on household well-being is not found. Yet, this approach cannot control for unobserved characteristics, such as entrepreneurial skills and motivation, that potentially influence both the treatment and outcome, and then more likely to yield biased and inconsistent estimates of the welfare effects.

There are few empirical studies that evaluate the impacts of agricultural commercialisation on household food security, in particular, by addressing endogeneity arising from endogenous selection bias of decisions regarding market entry and inherent differences between participants and nonparticipants using cross-sectional data. To evaluate the potential for farming to enhance rural well-being and reduce poverty in rural Cambodia, one needs an unbiased and consistent estimation of the socio-economic effects of farmers' market entrance. This paper makes attempt to reduce the bias and inconsistent estimation by accounting for unobserved characteristics across farm households and the systematic differences between the participants and nonparticipants in markets.

While agricultural commercialisation has been perceived as a contributor to poverty reduction in developing countries, the market environment may raise concern over small-scale farmers' ability to compete in growingly-integrated markets. For example, when developing countries are increasingly integrated into international trade, the farmers, especially smallholder, are increasingly constrained by non-tariff barriers such as produce quality and safety standards

(Dolan & Humphrey, 2000; Jaffee, 2003; Henson & Reardon, 2005; Jaffee et al., 2005; Okello & Swinton, 2007). This encourages exporters to move away from small-scale contract farming to either large-scale farmers or developing their own agro-businesses by diversifying into large-scale production (Graffham, Karehu, & McGregor, 2007; Okello, Narrod, & Roy, 2007; Maertens & Swinnen, 2009; Adekunle et al., 2012; Maertens et al., 2012). This can produce negative effects on smallholder farmers. Moreover, small-scale farmers may gain less from supplying produce to domestic supermarkets because they find it hard to meet the standard requirements and face high transportation costs (Neven & Reardon, 2004; Maertens & Swinnen, 2009; Neven et al., 2009). Then, they may get stuck in subsistence farming or supply their produce to traditional markets which, however, offer lower returns than do supermarkets (Muendo & Tschirley, 2004).

In addition to the standard requirements, Barrett et al. (2012) documented that limited access to productive assets and unfavorable geographical location place constraints on contract farming of small-scale farmers in five countries from Asia, Africa and Central America. Moreover, Barrett (2008) asserted that, to alleviate poverty in eastern and southern Africa, rural markets need to work more cost-efficiently in order that cereal farmers have easier access to modern technologies and productive inputs. Also, the deficiency in physical infrastructure (road, irrigation, information technology, etc.), high production costs and transaction costs, limited access to credit and production technologies like fertilizer, irrigation equipment and so forth impose constraints on market participation of farmers (Jaffee, 2003; Adekunle et al., 2012).

Analytical Framework and Empirical Approach

This section discusses the analytical framework and empirical procedure for addressing the questions on factors determining farm households' decisions concerning the participation in markets and for evaluating its impacts of on farm households' food security in terms of HDDS.

(a) Market Participation

In a standard agricultural household model, a farm household maximises utility as a function of consumption goods self-produced on the farm or bought from markets subject to household income constraints. Under the assumption that markets are perfect, prices are exogenously determined, and then household decisions on production and consumption are separable in household behavior of maximising profit. However, the markets are imperfect in the reality. In imperfect markets, according to the non-separable model the decision prices are endogenously affected by market prices and factors influencing transaction costs in the markets. These decision prices are household-specific prices and heterogeneous across farm households and cannot be observed (Owande et al., 2015). Due to the heterogeneity of farm households, the empirical model of market participation in this study is built on the non-separable model.

In the non-separable model, a farm household decides to produce crops for home consumption or sale in markets. According to Barrett (2008), household decisions whether or not to enter markets as a seller get made based on the decision prices determined by household-specific and location-specific transaction costs. Then, the decision prices depend on public goods and services, household location characteristics, and household characteristics affecting information search costs such as family head's education level and information asset ownership. According to the theoretical model of market participation decision developed by Barrett (2008), a household is considered entering markets as a seller if making a positive crop sale volume generally defined as total outputs less own consumption (M^{sc}). Similar to Owande et al. (2015),

the regression equation that defines a market participation model can be therefore written as follows:

$$I^* = \alpha Z + v \quad (1)$$
$$I = \begin{cases} 1, \text{if } M^{sc} > 0 \\ 0, \text{if } M^{sc} \leq 0 \end{cases}$$

where I^* is the probability that a farm household enters markets (also known as the latent variable). M^{sc} is the vector of crop quantity sold by the household. I is equal to 1 for a farm household that generates positive crop quantity sold ($M^{sc} > 0$) and 0 for a farm household that makes no sale ($M^{sc} \leq 0$). α is the vector of parameters to be estimated, and v is error term under the assumption that $v \sim N(0,1)$. Z includes household characteristics that can capture transaction costs, farm characteristics, village public transportation conditions, agro-ecological risks, and land ownership documents as a proxy for legal land rights.

(b) Modelling Food Security Effects

According to the standard agricultural household model, a farm household allocates consumption expenditure by maximising the utility subject to income constraints. Household income is normally determined by agricultural returns that depend on farm productivity and capacity to generate marketable surplus which is the main condition for market participation. Then, market entrance would determine the household expenditure on necessary goods. The study hypothesises that participation in markets exerts positive effects on household food security in terms of HDDS through augmenting household food consumption because it makes the production more efficient and increases household earnings. To assess the effects of market entry on household food security, a commonly used model in literature on effect evaluation is specified as follows:

$$Y = \beta X + \gamma I^* + \varepsilon \quad (2)$$

where Y is the household's HDDS per capita, X is a vector of household and farm characteristics and other factors expected to affect the consumption. I^* is a dummy for market participation, and then γ is the coefficient capturing the effect of market participation on the consumption. However, this coefficient may be inconsistent and biased due to a self-selection of farm households into the market participant group. If, for example, more productive farmers who are wealthier and more motivated, and/or have great entrepreneurial skill are very likely to enter markets, the impacts on the consumption would be overestimated. One can use a Heckman selection approach to control for such selection bias. Still, this approach cannot control for the potential systematic differences between the groups due to the assumption that the consumption functions would be different between participants and nonparticipants by only a constant term (Rao & Qaim, 2011). Asfaw et al. (2012) adopted the propensity score matching approach that can account for the systematic differences based on observed characteristics. The approach may still yield biased and inconsistent estimates due to unobserved factors, such as entrepreneurial skill, motivation and wealth that potentially affect both the marketing decisions and the consumption.

The endogenous switching regression model is adopted to address the above mentioned econometric challenges. The model treats the crop market participation and self-sufficiency as regimes and is specified as follows:

$$I^* = \alpha Z + v \quad (3)$$

$$y_1 = \beta_1 X_1 + u_1 \quad \text{if } I = 1 \quad (4)$$

$$y_0 = \beta_0 X_0 + u_0 \quad \text{if } I = 0 \quad (5)$$

where y_1 and y_0 represent HDDS for market participants and nonparticipants, respectively; I is a latent variable as defined in Equation (1); and α, β_1 and β_0 are vectors of parameters to be estimated. Although Z and X can overlap, at least one variable in Z is required not to be included in X to properly indentify the outcome equations. v, u_1 and u_0 are error terms assumed to be jointly normally-distributed with zero mean vector and the following covariance matrix:

$$cov(v, u_1, u_0) = \begin{bmatrix} \sigma_{u_1}^2 & \sigma_{u_1 u_0} & \sigma_{u_1 v} \\ \sigma_{u_1 u_0} & \sigma_{u_0}^2 & \sigma_{u_0 v} \\ \sigma_{u_1 v} & \sigma_{u_0 v} & \sigma_v^2 \end{bmatrix} \quad (6)$$

where $var(v) = \sigma_v^2$, $var(u_0) = \sigma_{u_0}^2$, $var(u_1) = \sigma_{u_1}^2$, $cov(u_1, u_0) = \sigma_{u_1 u_0}$, $cov(u_1, v) = \sigma_{u_1 v}$, and $cov(u_0, v) = \sigma_{u_0 v}$. The variance σ_v^2 is assumed to be 1, as α can be only estimated up to a scale factor (Maddala, 1986; Rao & Qaim, 2011). In addition, the covariance $\sigma_{u_1 u_0}$ is equal to zero because y_1 and y_0 are not observed together. Note that in a cross-sectional sample, y_1 and y_0 are only partially observed, with the former being only observed for the subsample of market participants and the latter being only observed for the subsample of nonparticipants (Seng, 2015).

When there are unobserved effects, the error term v of selection equation is correlated with the error terms u_1 and u_0 of outcome equations. That is, the expected values of u_1 and u_0 would be non-zero conditional upon market regime selection. Therefore, the endogeneity can be tested with estimates of the covariance terms. If $\sigma_{u_1 v} = \sigma_{u_0 v} = 0$, one has a model with an exogenous switching; but one has a model with an endogenous switching if either $\sigma_{u_1 v}$ or $\sigma_{u_0 v}$ is non-zero (Maddala, 1986). In this case, one needs to test for significant coefficients of the correlation between u_1 and v ($\rho_{u_1 v} = \sigma_{u_1 v} / \sigma_{u_1} \sigma_v$) and between u_0 and v ($\rho_{u_0 v} = \sigma_{u_0 v} / \sigma_{u_0} \sigma_v$) (Lokshin & Sajaia, 2004). Using these correlations, the expected values of error terms u_1 and u_0 conditional on market regime selection can be derived as follows:

$$E(u_1 | I = 1, X_1) = E(u_1 | v > -\alpha Z) = \sigma_{u_1 v} \frac{\phi(Z\alpha)}{\Phi(Z\alpha)} = \sigma_{u_1 v} \lambda_1 \quad (7)$$

$$E(u_0 | I = 0, X_0) = E(u_0 | v \leq -\alpha Z) = \sigma_{u_0 v} \frac{-\phi(Z\alpha)}{1 - \Phi(Z\alpha)} = \sigma_{u_0 v} \lambda_0 \quad (8)$$

where ϕ is the probability density function; and Φ is the cumulative distribution function of standard normal distribution. λ_1 and λ_0 are the Inverse Mills Ratios [IMR] predicted at $Z\alpha$ for participants and nonparticipants, respectively (Greene, 2008).

In addition to the endogeneity test, $\rho_{u_1 v}$ and $\rho_{u_0 v}$ provide economic interpretation, depending on their signs. If the coefficients have opposite signs, farmers decide whether or not to participate in markets based on a comparative advantage (Maddala, 1983; Fuglie & Bosch, 1995). That is, participants enjoy above-average HDDS once participating in markets, whereas nonparticipants enjoy above-average HDDS when not participating. Alternately, if $\rho_{u_1 v}$ and $\rho_{u_0 v}$ have the same signs, it demonstrates "hierarchical sorting" (Fuglie & Bosch, 1995), suggesting that the participants' HDDS is above the average level whether or not they

enter markets but get better off participating than not participating. Similarly, the nonparticipants' HDDS is below the average level in either case but get better off choosing self-sufficiency. Furthermore, the coefficient $\rho_{u_1 v}$ and $\rho_{u_0 v}$ can give evidence for model consistency under a condition $\rho_{u_1 v} < \rho_{u_0 v}$ (Trost, 1981). The condition implies that the participants enjoy higher consumption level than they would if they did not participate in markets.

(c) Estimation Approach

When either $\sigma_{u_1 v}$ or $\sigma_{u_0 v}$ takes non-zero value, one can estimate the model by using a two-stage procedure. In the first stage, a probit model of decisions on market regimes is estimated, providing the estimates of α, on which λ_1 and λ_0 can be predicted according to Equations (7) and (8). Then, the outcome equations are estimated by including the predicted IMRs as regressors, and then the coefficients of IMRs yield the estimates of $\sigma_{u_1 v}$ and $\sigma_{u_0 v}$ in the second stage,. However, due to the estimation of the IMRs, the residuals u_1 and u_0 cannot be employed to compute the standard errors of estimates in the second stage (Maddala, 1983; Fuglie & Bosch, 1995). Simultaneously estimating the selection and outcome equations with the full information maximum likelihood [FIML] procedure is more efficient for the endogenous switching regression (Lokshin & Sajaia, 2004; Greene, 2008; Clougherty & Duso, 2015). It should be noted that the coefficients β_1 and β_0 in Equations (4) and (5) measure the marginal effects of explanatory variables on household food consumption unconditional on households' actual market regime choice (Rao & Qaim, 2011).

To properly identify the model, it is necessary to use variables directly influencing the decisions on market entrance but not the outcomes as selection instruments. Following Rao & Qaim (2011), the study uses a dummy for availability of public transportation in the village as the identification restriction. The study also hypothesises that the availability of public transportation in the village would increase the likelihood of participating in markets. The hypothesis is built on the fact that the public transportation availability can, unless there are specialised traders, facilitate crop supply chains between farmers and markets (Rao & Qaim, 2011). So too can it contribute to reducing transaction costs, thus inclining farmers to produce market-oriented crops, according to Key, Sadoulet & de Janvery (2000) and Barrett (2008). Following Di Falco, Veronesi, & Yesuf (2011), a simple falsification test is conducted to establish the admissibility of the instruments: if a selection instrument is valid, it will determine the participation decision but not HDDS amongst nonparticipants. Table A2 in the appendix suggests that the dummy for availability of public transportation can be considered as a valid identification instrument as it is statistically significant driver of the decisions whether or not to enter markets but not of the nonparticipants' HDDS.

(d) Estimation of Food Security Effects of Market Participation

The particular interest in the study is to evaluate the welfare effects of market participation on farm households. In doing so, one needs to compare participants' conditional expected HDDS derived from the endogenous switching regression model with the counterfactual case that the same participants have chosen not to participate in markets. The conditional expected HDDS by a farm household that has characteristics X and Z and participates in markets is derived as follows (Maddala, 1983):

$$E(y_1 | I = 1) = \beta_1 X_1 + \sigma_{u_1 v} \lambda_1 \quad (9)$$

where $\sigma_{u_1 v}\lambda_1$ accounts for sample selection resulted from the fact that a farm household participating in markets differs from others with characteristics *X* and *Z* because of unobserved characteristics (Fuglie & Bosch, 1995). The conditional expected HDDS that the same farm household would enjoy without participation in markets is derived as follows (Maddala, 1983):

$$E(y_0|I = 1) = \beta_0 X_1 + \sigma_{u_0 v}\lambda_1 \quad (10)$$

The household food security gain, which is defined as the change in HDDS due to market participation, can then be computed as follows (Maddala, 1983; Fuglie & Bosch, 1995):

$$E(y_1|I = 1) - E(y_0|I = 1) = (\beta_1 - \beta_0)X_1 + (\sigma_{u_1 v} - \sigma_{u_0 v})\lambda_1 \quad (11)$$

This food security gain from market participation is, in literature on the impact assessment, called the average treatment effect on the treated (ATT), which accounts for all factors potentially causing the differences in HDDS. The treatment effect on the treated is resulted from the differences in the coefficients in Equations (9) and (10) ($\beta_1 - \beta_0$ and $\sigma_{u_1 v} - \sigma_{u_0 v}$). If a farm household self-selects to enter markets or not based on comparative advantage, $\sigma_{u_1 v} - \sigma_{u_0 v}$ would be positive, and then participation in markets would yield higher returns under self-selection (Maddala, 1983; Rao & Qaim, 2011). In this case, a simple comparison between average consumption in participant group $E(y_1|I = 1)$ and that in nonparticipant group $E(y_0|I = 0)$ would result in a bias of treatment effect that is accounted for in Equation (11).

Data and Variables

(a) Data

The data from the 2009 CSES conducted by the National Institute of Statistics [NIS] are used to provide the empirical analysis. The survey was sampled based on the preliminary data from the General Population Census [GPC] carried out in 2008, with three-stage cluster procedure. Villages and enumeration areas were selected in the first and second stage, respectively; and households were selected in the last. 12,000 households within 24 provinces (all provinces in Cambodia) were selected as the sample, which is the largest sample size amongst the CSESs. However, 29 households were dropped due to their absence in the time of the enumerators' visit, and then the remaining households were 11,971.

Although the NIS has conducted the CSESs annually since 2007, the 2009 dataset represents the nationwide sample of the household survey. Because it has the largest sample size, the 2009 dataset is employed for the analysis in lieu of an updated dataset. Furthermore, because the study is interested in Cambodian farmers, Phnom Penh city (the capital of Cambodia) and other provincial capital cities are excluded from the observations such that the focus is only on rural farmers in Cambodia. After excluding the capital and the provincial capital cities and deleting some missing observations, the final sample count is 5762 households.

(b) Variables and Descriptive Analysis

Dependent variables include a binary variable for market participation and HDDS capturing the household food security. As indicated earlier, a household is considered to participate in markets as a seller if making positive market surplus (M^{sc}). That is, $M_i = 1$ if the household participating in markets ($M^{sc} > 0$), and $M_i = 0$ if the household does not participate in markets ($M^{sc} \leq 0$).

M^{sc} is defined as the total value of post-harvest crops at selling prices plus the value of crops in the beginning inventory less values of postharvest crops loss, payment as crop quantity (values are evaluated at sale prices), value of crops in 2009 inventory and own consumption. The aggregate values evaluated at village prices are used to compute the market surplus. This aims at using all information in the data such as the information on farmers who sell other crops than rice or maize, which are more likely important to farm household well-being. Using the aggregated quantities with multiple crops is impractical. However, the drawback of this aggregation is that it may conceal differences in the mechanisms of causality related to decisions on individual crops due to different views of farmers about different crops. Yet, because Cambodia's agriculture is characterised by mono-cropping with predominant paddy, aggregating crops is basically the aggregation of paddy crops in wet and dry seasons (Azam, Imai, and Gaiha 2012). Hence, it is unlikely that the aggregation would create serious problem for this study.

According to Swindale & Bilinsky (2006) and FAO (2011), HDDS can be used to as a proxy for the household food security. It measures a household's economic ability to consume a variety of foods. Earlier studies indicate that an increase in dietary diversity is associated with socio-economic status and household food security - household energy availability (see, for example, Hatloy et al., 2000; Hoddinot & Yohannes, 2002; Swindale & Bilinsky, 2006; FAO, 2011). Following Swindale & Bilinsky (2006) and FAO (2011), the HDDS in this paper is built on the availability of data from the 2009 CSES and shown in Table A1 in the appendix. There are 15 food groups that are the most important for human energy; then the total score is 15 points.

The explanatory variables consist of household characteristics that can capture transaction costs, farm characteristics and agro-ecological risks. Household characteristics include household head age, education level, household size, and dummies for household off-farm activities. The age represents farming experiences of the family head, and then it can improve productivity that can allow farmer to generate large market surplus (M^{sc}). The education level is an indicator for human capital, and then high education level would improve farming productivity (Alene & Manyong, 2007). Moreover, better-educated head would have easier access to high level of information and be able to have better networks in community (Key et al., 2000; Azam et al., 2012). Besides generating supplementary incomes, engaging in off-farm activities such as non-agricultural paid jobs and other activities for their own accounts can allow the farmers to get more access to social networks and information. Hence, off-farm activities would influence the likelihood of participating in markets and per capita household consumption.

Farm characteristics include landholding in hectares, a dummy for availability of irrigation infrastructure in the village, and a dummy for land ownership documents. The land area owned is used instead of cultivated land area because the latter has more potential for endigeneity. The land area owned is expected to influence the market participation and the household consumption. The availability of irrigation infrastructure in the village is very important for Cambodian farmers; it can allow farmers to improve farming productivity, one of the main factors contributing to huge market surplus generation. Holding a legal document to certify the land ownership can secure farm households' land rights, providing incentives for them to make investment in agricultural technologies, a main factor in the improvement of the productivity (Pingali & Rosegrant, 1995). So too, it can allow farmers to have easier access to credit for such an investment according to De Soto (2000, p.86). Then, such a document would affect farmers' participation in markets. These farm characteristics would affect the market participation and the household food security. Land area in hectares damaged by excessive rainfall and/or flood and a dummy for yield damage caused by drought, rot, eaten by birds/other insets and rodents are used

to capture agro-ecological risks. These factors would have effects on the market participation and the consumption because they affect crop yields. As mentioned in Section 3, the dummy for availability of public transportation in the village is additionally used as the identification instrument in the model. All variables are summarised in Table 1.

Table 1. Definition and general descriptive statistics of variables

Variables	Definition	Mean	SD
Dependent			
- HDDS	Household dietary diversity score per household member	2.010	1.065
- Market Participation	=1 if the farm household makes positive sale of paddy crops ($M^{sc} > 0$)	0.662	0.473
Independent			
- Household head's age	Natural log of household head age	3.740	0.312
- Head's education level	Natural log of head schooling years	1.589	0.534
- Household size	The farm household's total family members	4.936	1.785
- Salary-paid employment	=1 if any family member engages in salary-paid employment	0.202	0.402
- Self-employment	=1 if the farm household engages in off-farm activities for own account	0.780	0.414
- Landholding per worker	Natural log of land area in ha owned by farm household per working-age household member	-1.207	1.102
- Availability of irrigation	=1 if the farm household live in the village where there is irrigation infrastructure	0.158	0.365
- Land ownership documents	1 if the farm household holds any legal document to certify the land ownership	0.513	0.500
- Land area damage	Land area in ha damaged by excessive rainfall and/or flood	0.063	0.633
- Yield damage	=1 if yield damage caused by drought, rot, eaten by birds/other insets and rodents	0.748	0.434
- Availability of public transportation	=1 if the farm household lives in the village where there is public transportation	0.552	0.497

Table 1 presents the definition and the mean values of the variables employed in the analysis. The table shows that on average approximatley 66 per cent of the observed farm households made positive sale, meaning that 60 per cent of them participated in markets as sellers. On average, approximately 16 per cent of the farmers were able to have access to irrigation infrastructure available in the village. Approximately 52 per cent has held legal document to certify their land ownership, suggesting that their lands are more secure than the lands owned by other 48 per cent farmers. Moreover, approximately 54 per cent of the farmers live in the village where there is public transportation such as car taxi and/or motorbike taxi.

Table 2 describes general differences between the participant and nonparticipants in terms of each variable. The summary statistics reported in Table 2 indicate some remarkable differences between the participants and the nonparticipants, which are confirmed by simple statistical tests of difference in means. With an average HDDS of approximately 2 per capita, farm households who participated in markets could enjoy significantly higher HDDS than those who did not, with an average of approximately 1.89 per capita. This does not necessarily suggest that participation in markets can significantly improve household food security of rural farmers due to the selection bias issue. The participants owned average land areas of 0.80 ha per working-age family member, significantly higher than average areas owned by the nonparticipants. In addition, approximately 18 per cent of the participants could have access to irrigation because of the availability of irrigation infrastructure in the village, while only 9.8 per cent of the

nonparticipants were able to do. Due to the limited access to irrigation, farmers tend to face deficiency of water for their farming, especially in the dry season. This indicates that the irrigation infrastructure, one of the main factors contributing to farming productivity enhancement, would be very likely a main determinant of rural farmers' commercialisation.

Table 2. Differences between market participants and nonparticipants

	Market Participants		Nonparticipants		Difference in Means
Variables	Mean	Std. Dev.	Mean	Std. Dev.	
HDDS	2.134	1.243	1.982	1.218	0.152***
Household head's age	45.684	13.942	45.147	14.193	0.537*
Head's education level	5.700	2.693	5.444	2.682	0.256***
Household size	4.836	1.852	4.886	1.870	-0.050
Salary-paid employment	0.198	0.398	0.209	0.407	-0.012
Self-employment	0.747	0.435	0.753	0.431	-0.006
Remittance	0.209	0.407	0.185	0.388	0.024**
Landholding per worker	0.801	3.048	0.366	0.529	0.435***
Availability of irrigation	0.181	0.385	0.098	0.297	0.083***
Land ownership documents	0.520	0.500	0.473	0.499	0.048***
Land area damage	0.123	1.102	0.085	0.705	0.038*
Yield damage	0.712	0.453	0.736	0.441	0.024**
Availability of public transport	0.650	0.477	0.381	0.486	0.270***

* denotes statistically significant difference at 10 per cent level.
** denotes statistically significant difference at 5 per cent level.
*** denotes statistically significant difference at 1 per cent level.

Approximately 65 per cent percent of the participants could have access to public transportation services, because of the availability of public transportation in the village where they live, while only 38 per cent of the nonparticipants could. This demonstrates that transportation means to facilitate the supply chains between farmers and market would be one of the main factors contributing to promoting commercialisation of rural agriculture. In relation with off-farm activities, although there are no significant differences between the participants and nonparticipants, the percentage of nonparticipants engaging in the activities is higher than that of participants. This can somehow indicate that those who produce crops for self-sufficiency lead their lives by relying on other off-farm activities.

Econometric Analysis Results

The descriptive analysis indicates significant differences in HDDS between the market participant households and nonparticipants. However, to properly evaluate the effects of market entrance on farm households' food security, as outlined in Section 3, an endogenous switching regression model is used to estimate the effects on HDDS per capita. The HDDS equations are jointly estimated with the selection equation explaining farm households' market participation.

(a) Determinants of Market Participation

Table 3 reports estimated results of likelihood of market participation. The first column presents the independently estimated results of a normal probit, while the second column presents the

results of the probit model jointly estimated with the HDDS equations by using the FIML procedure. The likelihood of participating in markets is significantly dependent on farm household head's education level. Farm households with better-educated head are very likely to produce crops for market participation. The result is consistent with the above descriptive statistic analysis and the findings by previous studies on determinants of market participation (see, for example, Key et al., 2000; Neven et al., 2009; Rao & Qaim, 2011; Azam et al., 2012). Generally, better-educated farmers are more innovative and entrepreneurial and, then, more likely to participate in market supply chains. This is plausible, because education can help farm households to better adapt to new production technologies and market requirements. Moreover, better-educated farmers would have easier access to high level of information and be able to have better networks in community (Key et al., 2000; Azam et al., 2012), then facilitating the entrance to markets.

Table 3. Determinants of market participation

Variables	Independently Estimated Probit[a]			Jointly Estimated Probit[b]		
	Coef.	Std. Err.	*P*-value	Coef.	Std. Err.	*P*-value
Household head's age	0.439	1.221	0.719	1.162	1.133	0.305
Head's age squared	-0.044	0.164	0.787	-0.131	0.152	0.390
Head's education level	0.115***	0.033	0.000	0.067**	0.031	0.027
Household size	-0.034***	0.011	0.001	-0.113***	0.011	0.000
Salary-paid employment	0.030	0.044	0.493	0.049	0.041	0.240
Self-employment	-0.116***	0.041	0.005	-0.118***	0.038	0.002
Remittance	0.142***	0.045	0.002	0.152***	0.042	0.000
Landholding per worker	0.196***	0.020	0.000	0.214***	0.016	0.000
Availability of irrigation	0.471***	0.051	0.000	0.374***	0.046	0.000
Land ownership documents	0.100***	0.035	0.005	0.085**	0.033	0.010
Land area damage	-0.032	0.021	0.133	-0.021	0.019	0.282
Yield damage	-0.174***	0.040	0.000	-0.116***	0.037	0.002
Availability of public transport	0.489***	0.046	0.000	0.249***	0.031	0.000
Constant	-0.729	2.253	0.746	-1.683	2.090	0.421
Observation	5762			5762		
Prob. > Chi-squared			0.000			0.000
Pseudo R^2	0.093					

[a] Probit model is estimated independently from the consumption regime equations. [b] Probit model is jointly estimated with the consumption regime equations by using the FIML method reported in Table 4.
*** denotes statistic test significance at 1 per cent level.

Household size has a significantly negative correlation with the market participation, suggesting that farm households with larger family size are more likely discouraged from entering markets. In general, the agricultural production in developing countries tends to exhibit decreasing returns to scale due to poor agricultural technologies. As defined in Section 3, farm households participate in markets as sellers if their crop quantity produced is larger than their own consumption of those crops. However, the larger the household size, the higher the consumption level. Then, the larger family size is likely to reduce the market surplus available for sale in markets, more possibly due to decreasing returns to scale.

By distinguishing between off-farm employment for salary and own account, the self-employment has a significant and negative correlation with the likelihood of entering markets. This result shows that farm households partaking in self-employment are likely to be

discouraged from participating in markets. This could be because returns on off-farm activities for own account are higher than returns on farming, inducing them to focus on such activities more than farming that is probably for self-sufficiency only. Other possible reason is that engaging in such off-farm activities, farm households may face a shortage of their own labor available for farming. However, one should recognise a potential causation that runs in opposite direction; that is, participation in markets is also likely to discourage farm households from engaging in own-account employment because the latter is potentially endogenous.

Landholding per working-age family member is positively and significantly correlated with the likelihood of market participation. This result is consistent with the above descriptive statistic analysis and the existing literature (see, for example, Rao & Qaim, 2011; Asfaw et al., 2012; Azam et al., 2012), suggesting a positive effect of farm size on market participation. Larger farms are more likely to produce large market surplus in comparison with smaller farms, indicating the crucial role of land possession in promoting market participation amongst rural famers in Cambodia. Landholdings can facilitate farmers' access to credit that has main role in promoting investments in agricultural technologies and, in turn, generate huge market surplus. In addition, land ownership documents have significant and positive relationship with the market participation, indicating that land security is very likely to stimulate the agricultural commercialisation. The land ownership documents can secure land rights and also help improve the access to credit and provide incentives for farmers to make investments (Pingali & Rosegrant, 1995; De Soto, 2000).

In a similar fashion, availability of irrigation infrastructure and public transportation in the village is very likely to increase the likelihood of entering markets. The result demonstrates the key role of irrigation infrastructure development in promoting the agricultural commercialisation in rural localities. Also, transportation infrastructure, such as road and bridge, to connect farmers to markets is crucial in integrating farmers into markets. Yield damage capturing the ecological condition decreases the probability of market participation, because the damage reduces market surplus.

(b) Determinants of Farm Household Food Security

As outlined in Section 3, the participants' and nonparticipants' household food security is explained based on HDDS with the endogenous switching model. The estimates for the HDDS equations of the model are reported in Table 4. The significance of the ρ covariance coefficients indicating a self-selection and the likelihood ratio test for joint independence of the three equations (Lokshin & Sajaia, 2004) are presented at the bottom of the table. The likelihood ratio test result suggests that the three equations are jointly dependent, providing evidence of endogeneity that needs to be controlled in the model specification of food security equations. The model also shows that $\rho_{u_1 v}$ and $\rho_{u_0 v}$ have alternative signs, with the former being statistically significant and positive but the latter being statistically nonsignificant and negative, suggesting that farm households decide whether to participate in markets based on the comparative advantage. The significance of $\rho_{u_1 v}$ indicates that self-selection would matter if not accounted for. Farm households with HDDS below the average level have lower than expected chances of entering markets. The nonsignificance of $\rho_{u_0 v}$ for the nonparticipants indicates that, without participation in market, there would be no significant difference in average behavior of the two farm household groups which arises from unobserved effects. Therefore, the participants enjoy better household food security than they would if they did not participate in markets.

Furthermore, the positive value of $\sigma_{u_1 v} - \sigma_{u_0 v}$ term demonstrates that participation in markets produces bigger food security gains under self-selection than under random assignment. These results confirm that the endogenous switching model is an appropriate model for controlling for self-selection and inherent differences between the market participants and the nonparticipants.

Table 4. Determinants of household food security

Variables	Participants (n = 3464)			Nonparticipants (n = 2298)		
	Coef.	Std. Err.	P-value	Coef.	Std. Err.	P-value
Household head's age	-0.522	1.153	0.651	2.514**	1.149	0.029
Head's age squared	0.096	0.155	0.535	-0.318**	0.154	0.039
Head's education	0.103***	0.031	0.001	0.035	0.033	0.285
Household size	-0.409***	0.010	0.000	-0.416***	0.018	0.000
Salary-paid employment	0.095**	0.042	0.022	0.149***	0.043	0.001
Self-employment	-0.180***	0.038	0.000	-0.053	0.044	0.232
Remittance	0.219***	0.042	0.000	0.101**	0.051	0.047
Landholding per worker	0.125***	0.015	0.000	-0.110**	0.045	0.014
Availability of irrigation	0.304***	0.043	0.000	-0.079	0.079	0.318
Land ownership documents	0.073**	0.033	0.027	0.022	0.036	0.539
Land area damage	-0.031*	0.018	0.091	0.058	0.029	0.500
Yield damage	-0.112***	0.036	0.002	-0.022	0.043	0.611
Constant	4.118*	2.127	0.053	-1.168	2.105	0.579
ln $\sigma_{u_1 v}$	0.089***	0.015	0.000			
$\rho_{u_1 v}$	1.864***	0.052	0.000			
ln $\sigma_{u_0 v}$				-0.223***	0.018	0.000
$\rho_{u_0 v}$				-0.055	0.297	0.854
LR test of indep. eqns.						0.000
Log likelihood						-1017.103

Notes: Dependent variable is HDDS. These outcome equations are jointly estimated with the selection equation reported in Table 3 by using the FIML.

* denotes statistic test significance at 10 per cent level.

** denotes statistic test significance at 5 per cent level.

*** denotes statistic test significance at 1 per cent level.

The estimated results also demonstrate that there are systematic differences across the two regimes. For example, household head's education level has significant and positive correlation with HDDS only for the participants, with higher coefficient than that for the nonparticipants. This suggests that the effects of education are great amongst the participants, because better-educated participants may be more productive in farming than their counterparts in the nonparticipant group. The results confirm the important role of education and/or technical training in contributing to the improvement of household food security in rural Cambodia. Of not, because the coefficient presented in Table 4 represents unconditional effects, the differences are not due to participation in markets. Moreover, the results show that the education jointly determines the likelihood of participating in markets and household food security.

The coefficient of household size is significantly negative for both the market participants and nonparticipants. That is, household size has significantly negative correlation with HDDS for both regimes, suggesting that larger household size reduces the household food security. Yet, the effects are likely to be greater amongst the nonparticipants. Off-farm salary-paid employment has positive and significant correlation with HDDS for both the participants and the

nonparticipants. This result indicates the positive effects of salaried employment on the household food security in the rural communities, but the effects are greater amongst the nonparticipants, revealing that the nonparticipants rely more heavily on income from the salary-paid employment than do the participants for their livelihoods and household food security. Furthermore, the result demonstrates that the agriculture *per se* may fail to lift farm households, in particular smallholder and poor as well as vulnerable farm households, out of the poverty trap in rural Cambodia (Seng, 2015). However, the coefficient of off-farm self-employment is significantly negative for the market participants, suggesting that farm households engaging on self-employment are likely to enjoy lower household food security. This result is similar to the findings by Olugbire et al. (2011). The self-employment may generate negative profits due to high costs of and/or inefficiency of self-employment, thus reducing the expenditure on household food consumption.

As expected, the coefficient of remittance is significantly positive for both the market participants and nonparticipants. This result shows that farm households receiving remittances are very likely to enjoy better household food security, suggesting the important role of remittances in reducing rural poverty. Furthermore, the coefficient of landholding is significantly positive for the participants but negative for the nonparticipants, showing that land area has positive influences on the household food security. The significantly negative effects of land area for the nonparticipants can explain the fact that the nonparticipants use their own land in a less productive way than do the participants. Furthermore, the participants put a greater emphasis on generating large market surplus which is usually associated with larger landholdings, while the nonparticipants produce only for self-sufficiency normally associated with smaller landholdings.

Land ownership documents are positively and significantly associated only with the household food security of the participants. According to the report on Cambodia Socio-economic Survey conducted in 2009, Cambodian farmers mostly borrow either from formal or informal lenders for consumption expenditure. This can suggest that the participants use such a document to facilitate the access to credit mostly for consumption expenditure. The nonsignificance effect of land ownership documents for the nonparticipants can somehow show that they may not need credit; or even though they need, the document is not important because they produce crops not for commercial purpose. Agro-ecological factor captured by the cultivated land damage in hectares and yield damage dummy is more likely to affect negatively only the household food security of the participants. It is plausible, because the participants rely heavily on their crops produced to be sold in markets, and thus the effects of unfavorable agro-ecological condition on their yields wreak havoc on their living standards and household food security. Cambodia tends to face the prolonged periods of flooding and droughts, which destroy infrastructure, crops and livestock and contaminate sources of water, causing substantial damage and food deficiency. However, according to the estimated results, it seems that the effects are not matter for the nonparticipants because their production is subsistence-oriented.

(c) Welfare Effects of Market Participation

To evaluate the effects of market participation on household food security, the conditional expected HDDS by the participant households $E(y_1|I = 1)$ are compared with what they would have enjoyed without participating in markets $E(y_0|I = 1)$. The difference in HDDS conditional on market participation is computed following Equation (11) and reported in Table 5. It is also possible to compute the counterfactual hypothetical effects for the nonparticipants. Yet, due to

the absence of a selection effect for the nonparticipants; that is, the nonparticipants are not different from random farm households, the effects are not taken into account.

Table 5. Effects of market participation on household food security

	Obs.	$E(y_1 \mid I = 1)$	$E(y_0 \mid I = 1)$	ATT	% Change
Whole sample	5762	2.160	1.964	0.196***	10.00
		(0.654)	(0.734)		
By landholding					
Households owning land ≤ 1 ha	3115	2.355	2.095	0.260***	12.42
		(0.608)	(0.698)		
Households owning land > 1 ha	2647	2.001	1.918	0.345***	20.75
		(0.648)	(0.728)		

Notes: Standard deviations are given in parentheses.
*** denotes statistic test significance at 1 per cent level.

For the whole sample, the expected HDDS by the participant households $E(y_1 \mid I = 1)$ is approximately 2.16, while the expected HDDS that the same participant households would have enjoyed if they did not participate $E(y_0 \mid I = 1)$ is approximately 1.96. Therefore, when participating in markets, on average, farm households can make HDDS gains of approximately 0.20 per household member. The disaggregated results indicate that farm households possessing more than one hectare of land can make HDDS gains of approximately 0.35 per household member or increase HDDS by approximately 21 per cent when participating in markets, while those owning land of one hectare or less can increase HDDS by approximately 12.41 per cent. The results indicate that large-scale farmers can benefit more than do small-scale farmers in terms of household food security from supplying crops to markets. These results are consistent with the earlier results of descriptive analysis presented in Table 3 and the findings by the World Bank in 2015, which show that market participation is associated with large farm area. The benefit gap can partly explain the fact that the large-scale farmers may produce crops more efficiently and are very likely to be more motivated to enter markets than the small-scale farmers, thus putting a greater emphasis on what the markets need, such as types of crops and quality standard, on the one hand. On the other hand, small-scale farmers usually find it harder to maximise the benefits from markets due to such non-tariff barrier constraints as product standard requirements in both international and domestic markets (Henson & Reardon, 2005; Jaffee et al., 2005; Okello & Swinton, 2007; Neven & Reardon, 2004; Maertens & Swinnen, 2009; Neven et al., 2009).

Due to the potential endogeneity of some explanatory variables in the estimated models and the difficulty to identify proper instruments for all of them, a sensitivity analysis is conducted to check the robustness of the estimated results. Those potentially endogenous variables include the off-farm self-employment, salary-paid employment, remittance and land ownership documents. The FIML models are re-estimated by excluding these variables one by one, and then the alternative results are used to recalculate the effects of market participation on household food security. In the estimation, the availability of public transportation in the village is still used as the identification instrument and remains valid based on the simple falsification test proposed by Di Falco et al. (2011). The estimated results of the ATT analysis are reported in Table A3 in the appendix. There are slight variations in numerical outcomes, with the percentage change in HDDS decreasing from approximately 10 per cent to 8 per cent after the exclusion, suggesting

that the estimated effects of market participation on household food security are also very robust in general.

Conclusion

This paper assesses the effects of market participation on rural farm households' food security in term of HDDS by using data from the CSES conducted in 2009. The evaluation was carried out with the endogenous switching model, which explains household food security and accounts for selection bias and systematic differences between participants and nonparticipants in markets in terms of HDDS functions. The results confirm that the decisions regarding market participation and household food security are affected by unobserved characteristics of farm households. There is also the presence of structural differences between the participants and nonparticipants; for example, landholding has positive effects on the market participants' household food security but negative impacts on the nonparticipants' household food security.

By accounting for the self-selection bias and systematic differences between the market participants and nonparticipants, the HDDS gains from participation in market are positive, albeit small. Therefore, in general, the farm households are more likely to improve household food security with the HDDS gains from participating in markets. This result is consistent with the literature on the role of market participation in promoting farm household welfare and poverty reduction. Nonetheless, large-scale farmers are very likely to make greater household food security improvement than small-scale farmers when participating in markets. Increased and stable earnings of farm households, especially rural households, can increase and stabilise their food consumption, thus ensuring better household food security.

Disadvantaged farmers, mostly small-scale farmers, tend to face constraints on offering produce to markets. The analysis suggested that better-educated farmers and those having more access to irrigation infrastructure available in the village are very likely to supply produce to markets. In addition, access to public transportation and infrastructure are also main factors facilitating market participation. In Cambodia, there are some nongovernmental organisations [NGO], amongst them Centre d' Etude et de Développement Agricole Cambodgien [CEDAC] is more active, providing training on production techniques and agricultural market information. These activities make a tremendous contribution to reducing transaction costs and making farmers, small-scale farmers in particular, more market-oriented and reliable suppliers to markets. Farmers joining such a NGO programme are much more likely to participate in markets, especially in supermarket channels (Rao & Qaim, 2011). However, in the current study, this factor is not included in the analysis due to the unavailability of data.

At policy level special attention should be paid to irrigation infrastructure development, education, in particular in agricultural field, and training programmes that help improve farming productivity and facilitate market participation. The training programmes are mostly provided by nongovernmental agents, but sometimes need financial support from the government. Thus, a sub-budget of the government's agricultural budget should be prioritised for such a programme. Moreover, linking rural farmers to high-value markets in some cases requires also public-private partnerships. For example, the government can intervene in facilitating farmers-to-markets linkage by developing adequate physical infrastructure to support market connectivity and extension services provided by private agents. Such a policy has been successfully implemented in Uganda, Kenya and India (Narrod et al., 2009; Rao & Qaim, 2011).

Finally, the fact that small-scale farmers benefit less from participating in markets than do large-scale farmers in terms of household food security improvement is worth being taken in

consideration in future studies of market entrance and farm household food security, livelihoods and poverty reduction in the rural communities of Cambodia.

References

ADB. (2013). *Cambodia diversifying beyond garment and tourism, country diagnostic study*. Manila, Philippines: Economic Research Department, Asian Development Bank.

Adekunle, A. A., Ellis-Jones, J., Ajibefun, I., Nyikal, R. A., Bangali, S., Fatunbi, O., & Ange, A. (2012). Agricultural innovation in sub-Saharan Africa: Experiences from multiple-stakeholder approaches. Forum for Agricultural Research in Africa (FARA). Accra, Ghana.

Alene, A. D. & Manyong, V. M. (2007). The effects of education on agricultural productivity under traditional and improved technology in northern Nigeria: an endogenous switching regression analysis. *Empirical Economics, 32(1),* 141–159. DOI 10.1007/s00181-006-0076-3

Asfaw, S., Lipper, L., Dalton, T. J., & Audi, P. (2012). Market participation, on-farm crop diversity and household welfare: micro-evidence from Kenya. *Environment and Development Economics, 17(5),* 579 – 601. doi: 10.1017/S1355770X12000277

Azam, M.S., Imai, K.S., & Gaiha, R. (2012). Agricultural supply response and smallholders market participation – the case of Cambodia. Discussion Paper DP2012-09, Kobe, Japan: Research Institute for Economics and Business Administration, Kobe University.

Barrett, C. B. (2008). Smallholder market participation: concepts and evidence from Eastern and Southern Africa. *Food Policy, 33(2008),* 299–317. doi:10.1016/j.foodpol.2007.10.005

Barrett, C. B., Bachke, M.E., Bellemare, M.F., Michelson, H.C., & Narayanan, S. (2012). Smallholder participation in contract farming: comparative evidence from five countries. *World Development, 40(4),* 715 – 730. doi:10.1016/j.worlddev.2011.09.006

Bellemare, M. F. & Barrett, C. B. (2006). An ordered Tobit model of market participation: evidence from Kenya and Ethiopia. *American Journal of Agricultural Economics, 88(2)*, 324–337. doi: 10.1111/j.1467-8276.2006.00861.x

Bellemare, M. F. (2012). As you sow, so shall you reap: the welfare impacts of contract farming. *World Development,* 40(7), 1418-1434. doi:10.1016/j.worlddev.2011.12.008

Burke, W. J, Myers, R. J, & Jayne, T. S. (2015). A triple-hurdle model of production and market participation in Kenya's dairy market. *American Journal of Agricultural Economics,* 1–20; doi: 10.1093/ajae/aav009

Chege, C. G. K, Andersson, C. I. M, & Qaim, M. (2015). Impacts of supermarkets on farm household nutrition in Kenya. *World Development ,72,* 394–407. doi:10.1016/j.worlddev.2015.03.016

Clougherty, J. & Duso, T. (2015). Correcting for self-selection based endogeneity in management research: a review and empirical demonstration. Discussion Paper 1465, Berlin: Deutsches Institut für Wirtschaftsforschung.

De Soto, H. (2000). *The Mystery of Capital: Why Capitalism Triumphs in the West and Fails Everywhere Else*. New York: Basic Books.

Di Falco, S., Veronesi, M. & Yesuf, M. (2011). Does adaptation to climate change provide food security? A micro-perspective from Ethiopia. *American Journal of Agricultural Economics, 93(3),* 829–846. doi: 10.1093/ajae/aar006

Dolan, C. & Humphrey, J. (2000). Governance and trade in fresh vegetables: the impact of UK supermarkets on the African horticulture industry. *Journal of Development Studies, 37(2),* 147 – 176. DOI:10.1080/713600072

FAO. (2011). *Guidelines for Measuring Household and Individual Dietary Diversity*. Food and Agriculture Organization of the United Nations. Retrieved from http://www.fao.org/docrep/014/i1983e/i1983e00.pdf

Fuglie, K. O., & Bosch, D. J. (1995). Economic and environmental implications of soil nitrogen testing: A switching-regression analysis. *American Journal of Agricultural Economics, 77(4),* 891–900. doi: 10.2307/1243812

Goetz, S. J. (1992). A Selectivity Model of Household Food Marketing Behavior in Sub-Sahara Africa. *American Journal of Agricultural Economics*, 74(2), 444–52. doi: 10.2307/1242498

Graffham, A., Karehu, E., McGregor, J. (2007). Impact of EurepGAP on small-scale vegetable growers in Kenya. International Institute for Environment and Development. Fresh Insights No. 6. London.

Hatloy, A., Hallund, J., Diarra, M. M., & Oshaug, A. (2000). Food Variety, Socioeconomic Status and Nutritional Status in Urban and Rural Areas in Koutiala (Mali). *Public Health Nutrition, 3*, 57–65.

Heltberg, R., & Tarp, F. (2002). Agricultural supply response and poverty in Mozambique. *Food Policy,* 27(2), 103–124. doi:10.1016/S0306-9192(02)00006-4

Henson, S. & Reardon, T. (2005). Private agri-food standards: Implications for food policy and the agri-food system. *Food Policy, 30(3),* 241 – 253. doi:10.1016/j.foodpol.2005.05.002

Hernandez, R., Reardon, T., & Berdegue, J. (2007). Supermarkets, wholesalers, and tomato growers in Guatemala. *Agricultural Economics, 36(3),* 281–290.

Hoddinott, J., & Yohannes, Y. (2002). Dietary diversity as a food security indicator. FANTA 2002, Washington. D.C. Retrieved from http://www.aed.org/Health/upload/dietarydiversity.pdf

Jaffee, S. (2003). From challenge to opportunity: Transforming Kenya's fresh vegetable trade in the context of emerging food safety and other standards in Europe. Agricultural and Rural Development Discussion Paper No. 2. Washington, D.C: World Bank.

Jaffee, S., Henson, S., Sewadadh M., Lisazo, M. B., Ignacio, L., van der Meer, K., de Haan, C., & Lamb, J. (2005). Food safety and agricultural health standards: challenges and opportunities for developing country exports. Poverty Reduction and Economic Management Trade Unit and Agriculture and Rural Development Department Report No. 31207. Washington, D.C: World Bank.

Key, N., Sadoulet, E., & De Janvry, A. (2000). Transaction costs and agricultural household supply response. *American Journal of Agricultural Economics, 82(2),* 245–259. doi: 10.1111/0002-9092.00022

Lokshin, M. & Sajaia, Z. (2004). Maximum likelihood estimation of endogenous switching regression models. *Stata Journal, 4(3),* 282–289.

Maddala, G. S. (1986). Disequilibrium, self-selection, and switching models. In Z. Griliches, & D. I. Michael (Eds.), *Handbook of econometrics* (pp. 1633–1682). North-Holland: Elsevier.

Maddala, G. S. (1983). *Limited-dependent and qualitative variables in econometrics*. Cambridge: Cambridge University Press.

MAFF. (2011). *Cambodia's agricultural strategy, Future Development Options for the Rice Sector*. Phnom Penh: Ministry of Agriculture Forestry and Fisheries.

MAFF & MWRM. (2010). *Progress report of the technical working group for agriculture and water*. Phnom Penh: Ministry of Agriculture Forestry and Fisheries and Ministry of Water Resources and Meteorology.

Maertens, M. & Swinnen, F. J. M. (2009). Trade, standards, and poverty: evidence from Senegal. *World Development, 37(1),* 161 – 178. doi:10.1016/j.worlddev.2008.04.006

Maertens, M., Minten, B. & Swinnen J. (2012). Modern food supply chains and development: evidence from horticulture export sectors in Sub-Saharan Africa. *Development Policy Review, 30(4),* 473 – 479. DOI: 10.1111/j.1467-7679.2012.00585.x

Michelson, H. C. (2013). Small farmers, NGOs, and a walmart world: welfare effects of supermarkets operating in Nicaragua. *American Journal of Agricultural Economics, 95(3),* 628–649. doi: 10.1093/ajae/aas139

Muendo, M., & Tschirley, D. (2004). Improving Kenya's domestic horticultural production and marketing system: current competitiveness, forces of change, and challenges for the future. Tegemeo Institute of Agricultural Policy and Development Working Paper No. 08C/2004; vol. III, Nairobi, Kenya.

Muriithi, B. W., & Matz, J. A. (2015). Welfare effects of vegetable commercialization: evidence from smallholder producers in Kenya. *Food Policy, 50(2015),* 80 – 91. doi:10.1016/j.foodpol.2014.11.001

Narrod, C., Roy, D., Okello, J., Avendaño, B., Rich, K., & Thorat, A. (2009). Public–private partnerships and collective action in high value fruit and vegetable supply chains. *Food Policy, 34(1),* 8–15. doi:10.1016/j.foodpol.2008.10.005

Neven, D., & Reardon, T. (2004). The rise of Kenyan supermarkets and the evolution of their horticulture product procurement systems. *Development Policy Review, 22(6),* 669–699. DOI: 10.1111/j.1467-7679.2004.00271.x

Neven, D., Odera, M. M., Reardon, T., & Wang, H. (2009). Kenyan supermarkets, emerging middle-class horticultural farmers, and employment impacts on the rural poor. *World Development, 37(11),* 1802–1811. doi:10.1016/j.worlddev.2008.08.026

NIS. (2010). *Food Security Trend Analysis Report, Cambodia Socio-Economic Survey 2004 and 2009*. Phnom Penh: National Institute of Statistics, Ministry of Planning of Cambodia.

Olwande, J., Smale, M., Mathenge, M. K., Place, F., & Mithöfer, D. (2015). Agricultural marketing by smallholders in Kenya: A comparison of maize, kale and dairy. *Food Policy, 52(2015),* 22–32. doi:10.1016/j.foodpol.2015.02.002

Okello, J., Narrod, C., Roy, D. (2007). Food safety requirements in African green bean exports and their impact on small farmers. IFPRI Discussion Paper No. 00737. Washington, D.C.

Okello, J. J., & Swinton, S. M. (2007). Compliance with international food safety standards in Kenya's green bean Industry: comparison of a small- and a large-scale farm producing for export. *Applied Economic Perspectives and Policy, 29(2),* 269 – 285. doi: 10.1111/j.1467-9353.2006.00342.x

Pingali, P., & Rosegrant, M. W. (1995). Agricultural commercialization and diversification: process and policies. *Food Policy, 20(3),* 171-185. doi:10.1016/0306-9192(95)00012-4

Roa, E. J. O., & Qaim, M. (2011). Supermarkets, Farm Household Income, and Poverty: Insights from Kenya. *World Development, 39(5),* 784–796. doi:10.1016/j.worlddev.2010.09.005

Rao, E. J. O., Brümmer, B., & Qaim, M. (2012). Farmer participation in supermarket channels, production technology, and efficiency: the case of vegetables in Kenya. *American Journal of Agricultural Economics, 94(4),* 891–912. doi: 10.1093/ajae/aas024

Seng, K. (2015). The Effects of nonfarm activities on farm households' food consumption in rural Cambodia. *Development Studies Research, 2(1)*: 77–89. DOI: 10.1080/21665095.2015.1098554

Swindale A., & Bilinsky, P. (2006). Household Dietary Diversity Score (HDDS) for Measurement of Household Food Access: Indicator Guide, Version 2. Food and Nutrition Technical Assistance Project. Washington, D.C: Academy for Educational Development.

Trost, R. P. (1981). Interpretation of error covariances with nonrandom data: An empirical illustration of returns to college education. *Atlantic Economic Journal, 9(3),* 85–90. DOI 10.1007/BF02300600

WB. (2015). *Cambodian Agriculture in Transition: Opportunities and Risks*. Economic and Sector Work, Report No. 96308-KH. Washington, D.C: World Bank.

Appendix

Table A1. Household dietary diversity score

Food Groups (15 Groups)	**Yes=1 No=0**
A. Cereals (rice, bread, corn, wheat flour, rice flour, corn meal, rice cakes, noodles, biscuits, etc.)	1/0
B. Fish (fresh fish, salted and dried fish, canned fish, shrimp, prawn, crab, etc.)	1/0
C. Meat & poultry (beef, buffalo, mutton, lamb, pork, chicken, duck, innards, spleen, dried beef)	1/0
D. Eggs (chicken egg, duck egg, quail egg, fermented/salted egg, etc.)	1/0
E. Dairy products (fresh milk, condensed or powdered milk, ice cream, cheese, other dairy products, etc.)	1/0
F. Oil and fats (rice bran oil, vegetable oil, pork fat, butter, margarine, coconut/frying oil, etc.)	1/0
G. Fresh vegetables (trakun, onion, shallot, cabbage, spinach, carrot, beans, chili, tomato, etc.)	1/0
H. Tuber (cassava, sweet potato, potato, traov, sugar beet, etc.)	1/0
I. Pulses and legumes (green gram, dhal, cowpea, bean sprout, other seeds, etc.)	1/0
J. Prepared and preserved vegetables (cucumber pickles, other pickles, tomato paste, etc.)	1/0
K. Fruit (banana, orange, mango, pineapple, lemon, papaya, durian, water melon, grape, apple, canned and dried fruits, etc.)	1/0
L. Dried nuts and edible seeds (coconut, cashew nut, lotus nut, peanut, gourd seed, other nuts)	1/0
M. Sugar, salt and spices (sugar, jaggery, salt, chocolate, candy, coriander, red pepper spice, garlic, ginger, soy sauce, fish sauce, monosodium glutamate, etc.)	1/0
N. Non-alcoholic beverages (canned or bottled soft drinks, mineral water, fruit juice, fruit syrup, etc.)	1/0
O. Other food products (fried insects, peanut preparation, flavored ice, ice, other food products)	1/0
Total Points	**15**

Table A2. Parameter estimates – Test for admissibility of the selected instrument

Variables	Nonparticipants' HDD (OLS)			Market Participation (Probit)		
	Coef.	Std. Err.	*P*-value	Coef.	Std. Err.	*P*-value
Household head's age	2.512**	1.145	0.028	0.439	1.221	0.719
Household head's age squared	-0.316**	0.154	0.040	-0.044	0.164	0.787
Household head's education	0.037	0.031	0.238	0.115***	0.033	0.000
Household size	-0.417***	0.010	0.000	-0.034***	0.011	0.001
Salary-paid employment	0.152***	0.042	0.000	0.030	0.044	0.493
Self-employment	-0.057	0.040	0.155	-0.116***	0.041	0.005
Remittance	0.106**	0.045	0.017	0.142***	0.045	0.002
Landholding per worker	-0.092	0.020	0.000	0.196***	0.020	0.000
Availability of irrigation	-0.070	0.055	0.202	0.471***	0.051	0.000
Land ownership documents	0.024	0.034	0.492	0.100***	0.035	0.005
Land area damage	0.058	0.029	0.500	-0.032	0.021	0.133
Yield damage	-0.025	0.039	0.524	-0.174***	0.040	0.000
Availability of public transport	-0.039	0.045	0.386	0.489***	0.046	0.000
Constant	-1.106	2.111	0.601	-0.729	2.253	0.746
Observation	2298			5762		
Adj *R*-squared	0.454					
Prob. > chi2				0.000		
Pseudo R^2				0.093		
Log likelihood				-3513.821		

* denotes statistically significant at 10 per cent level.
** denotes statistically significant at 5 per cent level.
*** denotes statistically significant at 1 per cent level.

Table A3. Effects of market participation on HDDS predicted by excluding potential endogenous variables

	Obs.	$E(y_1 \mid I = 1)$	$E(y_0 \mid I = 1)$	ATT	% Change
Whole sample	5762	2.160	1.964	0.196***	10.00
		(0.654)	(0.734)		
Without					
Self-employment	5762	2.161	1.995	0.167***	8.35
		(0.661)	(0.613)		
Salary-paid employment	5762	2.161	1.995	0.167***	8.35
		(0.659)	(0.734)		
Remittance	5762	2.162	1.995	0.170***	8.52
		(0.657)	(0.608)		
Land ownership documents		2.162	1.994	0.168***	8.41
		(0.656)	(0.700)		

Notes: The expected food consumption values for individual households are transformed from log terms. Standard deviations are given in parentheses.
*** denotes statistic test significance at 1 per cent level.