# Linkages between Market Participation and Productivity: Results from a Multi-Country Farm Household Sample

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**Abstract**

We build upon international trade literature to analyze the direction of causality between market participation and productivity. Cross-country household data from Tanzania, Vietnam and Guatemala are used in a 2SLS approach with market participation and productivity as endogenous variables. Results indicate that households with higher productivity tend to participate in agricultural markets regardless of market access factors. In contrast, having better market access does not necessarily lead to higher productivity. This finding suggests that investments in market access infrastructure provide minimal, if any, improvements in agricultural productivity; whereas programs targeted at enhancements in farm structure and capital have the potential to increase both productivity and market participation.

## 1. Introduction

The poorest people in the world are farmers with low agricultural productivity and low rates of market participation. Increasing either one could help to improve the other, and both could boost living standards: higher market participation could drive productivity by providing incentives, information and cash flow for working capital, while higher productivity could drive market participation since households with higher productivity are more likely to have crop surpluses above their immediate consumption needs. Many studies address the impact of either market participation or productivity on farmers' income, and some studies relate them to each other.[1] There is, however, surprisingly little research on the extent to which these factors influence each other, and almost no research that examines empirical evidence at the whole-farm level across a range of countries.[2]

In this study we build upon the international trade literature to analyze the direction of causality between participation and productivity. We join a small but growing literature employing merged samples from multiple cross-country household surveys[3] to address whether

[1] Examples of studies addressing the two channels include Binswanger and von Braun, 1991; von Braun, 1995; Ashley and Maxwell, 2001; IFAD, 2001, 2003; Irz et al., 2001; Rahman and Westley, 2001; and Barrett, 2007. Studies that focus particularly on market participation include Strauss, 1984; Goetz, 1992; Key, Sadoulet and de Janvry, 2000; Heltberg and Tarp, 2001; Vakis, Sadoulet and de Janvry, 2003; Bellemare and Barrett, 2006; Edmeades, 2006; Boughton et al., 2007. Many others have addressed agricultural productivity, such as Ahluwalia, 1978; Datt and Ravallion, 1998; Irz et al., 2001; de Janvry and Sadoulet, 2002; Minten and Barrett, 2006.

[2] Previous analyses of how market participation affects productivity include Govereh and Jayne, 1999; Strasberg et al., 1999; and Govereh, Jayne and Nyoro, 1999. These are among the closest precursors to our work, and there are of course many studies of market participation in particular markets such as for rice in Thailand (Deaton, 1989) and Madagascar (Barrett and Dorosh, 1996); cocoa and coffee in Côte d'Ivoire (Benjamin and Deaton, 1993); maize in Kenya (Jayne et al, 2001; Renkow, Hallstrom and Karanja, 2004) and South Africa (Makhura, Kirsten and Delgado, 2001); bananas in Uganda (Edmeades, 2006); potatoes in Peru (Vakis, Sadoulet and de Janvry, 2003); cotton in Zimbabwe (Govereh and Jayne, 1999); maize, cotton and tobacco in Mozambique (Boughton et al., 2007). Few studies have analyzed market participation for groups of crops. Strauss (1984) considered root crops and other cereals, oils and fats, and miscellaneous foods in Sierra Leone; Budd (1993) food crops in Côte d'Ivoire; Strasberg et al. (1999) total crop production in Kenya; Heltberg and Tarp (2001) total crop production, food crops and cash crops in Mozambique. The only study that we are aware of with a multi-country analysis of household market participation is the Govereh, Jayne and Nyoro (1999) paper with data from Kenya, Mozambique and Zimbabwe.

[3] Examples of merged surveys include Behrman, Duryea and Székely, 1999; Blanchflower, Oswald and Stutzer, 2001; Guerin, Crete and Mercier, 2001; Russell and O'Connell, 2001; Bassanini and Brunello, 2003; Spiess and

higher farm sales have led to higher agricultural productivity, or whether higher agricultural productivity has led to a higher volume of sales. These tests target important questions in development strategy. For example, are improvements in agricultural productivity commonly achieved independently of market access conditions? Have improvements in agricultural productivity increased the volume of agricultural sales, even where market access is poor? Conversely, does increased commercialization brought by new roads and improved market access consistently raise productivity?

## 2. Data

This study analyzes the direction of causality between market participation and agricultural productivity using a large sample of merged cross-country household surveys. This approach increases the variance above what can be observed within any one country or any single time period, and allows the identification of common patterns across countries and over time. The entire sample consists of observations on 11,209 farm households gathered from panel and cross-section LSMS surveys conducted by the World Bank in Tanzania, Vietnam and Guatemala. These surveys contain detailed information on household characteristics, farm characteristics, production, consumption and community infrastructure that provides candidates for instruments of market participation and productivity. The data represent low income farming in Africa, Asia and Latin America across a range of human, economic and ecological conditions.

A key aspect of our study is to compare farmers from these disparate regions in an internationally-comparable manner. The Tanzania data come from the Kagera Health and Development Survey Datasets (KHDS), a longitudinal economic survey conducted in epicenter

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Schneider, 2003; Davis and Greenstein, 2004; Holst and Spiess, 2004; Hank and Jürges, 2005, Sana and Massey, 2005; and Seo and Mendelsohn, 2005.

of the AIDS outbreak in East Africa. This study uses data from three waves to represent two complete years of data: wave 1, conducted between September 1991 and May 1992; wave 2, conducted between April and November 1992 and; wave 3, conducted between November 1992 and May 1993 (World Bank, 2004). Data from Asia come from two Vietnam Living Standards Surveys (VLSS) conducted nation-wide, one conducted between September 1992 and October 1993 (World Bank, 1994) and the other between December 1997 and December 1998 (World Bank, 2001). Data from Guatemala come from Encuesta de Condiciones de Vida (ENCOVI) conducted between July and November 2000 (World Bank, n.d.).

To make the data comparable across countries and years, we computed annual variables measuring common characteristics related to household composition, education, housing, farm land, agricultural production, non-farm business, consumption expenditure, credit, assets and community infrastructure.[4] All physical quantities were painstakingly converted into standard units of measurement, and monetary variables were converted from local currency into U.S. dollars at each year's purchasing power parity (PPP) exchange rate, from the Penn World Tables version 6.2 (Heston, Summers and Aten, 2006).[5]

[4] Kagera Health and Development Survey Datasets waves 2 and 3 contain semi-annual data. Annual data for the 1992-93 period results from combining waves 2 and 3. Data for categorical and ordinal variables and value of assets are obtained from wave 3 (end of an annual period). Variables measured in monetary units are obtained by adding up values from waves 2 and 3.

[5] PPP's exchange rates for each sample follow: Tanzania 1991-92, 91.05TZS/US$; Tanzania 1992-9305TZS/US$, 107.89; Vietnam 1992-93, 1317.91 VND/US$; Vietnam 1997-98, 2328.98VND/US$; Guatemala 2000, 2.97GTQ/US$.

## 3. Methodology

We analyze the direction of causality between market participation and productivity by testing two competing hypotheses:

Hypothesis 1: more sales lead to higher agricultural productivity

Hypothesis 2: higher agricultural productivity leads to more sales

In both cases, we expect some degree of reverse causality or omitted variable bias, and therefore require instrumental variables to identify exogenous or quasi-experimental sources of variation in the observed regressors. We begin by defining how these concepts are measured, then describe our identification strategy, presenting the estimators used to obtain unbiased and efficient results despite the truncation of several key variables.

Market participation is defined here in terms of sales as a fraction of total output, for the sum of all agricultural crop production in the household; this includes annuals and perennials, locally-processed and industrial crops, fruits and agro-forestry. This "sales index" would be zero for a household that sells nothing, and could be greater than unity for households that add value to their crop production via further processing and/or storage.[6] The measure is intended to measure market orientation or commercialization in a scale-neutral manner, independently of the household's wealth or productivity. Its definition is:

$$Sales\ \ index_i = \frac{\sum_{j=1}^{J} crop\ sales_{i,j}}{\sum_{j=1}^{J} crop\ \ production_{i,j}} = \begin{cases} = 0\ non\text{-}seller \\ > 0\ seller \end{cases} \quad (1)$$

[6] A somewhat similar measure is called the household commercialization index (HCI) by Govereh and Jayne (1999), Govereh, Jayne and Nyoro (1999), and Strasberg et al. (1999).

where household *i* produces *J* distinct crops, *crop sales* include transactions with people and institutions outside the household as well as production used as input in the agricultural unit (i.e. seed, livestock feed), *crop production* is the value of crop production at harvest.

Agricultural productivity is calculated in terms of technical efficiency for crop production, relative to other farmers in each country and year. Technical efficiency compares the actual output with a maximum output produced by other farmers in the sample. We construct our efficiency scores using data envelopment analysis (DEA), computing scores separately for each sample so as to allow differing technology frontiers among countries and across years.[7] Measures of technical efficiency are obtained by solving the following linear programming problem for each household, under an assumption of variable returns to scale:

$$\max_{y,\lambda^1,\ldots,\lambda^I} \quad \phi \tag{2}$$

subject to:

$$\sum_{i=1}^{I} y^i \lambda^i \geq \phi y^i$$

$$\sum_{i=1}^{I} x_n^i \lambda^i \leq x_n^0$$

$$\sum_{i=1}^{I} \lambda^i = 1$$

$$\lambda^i \geq 0$$

where there are *I* households in the sample, $\phi$ is the technical efficiency index, $y^i$ is total agricultural crop production in the $i^{th}$ household (in US$)[8], $x_n^i$ denotes total expenditure on the $n^{th}$ ($n$ = 1,…,N) input used in household *i* (in US$), $x_n^0$ is the total expenditure on the $n^{th}$ input

[7] Technology involved in agricultural production includes technology *per se* plus agro-ecological characteristics affecting production (i.e. soil fertility, precipitation and climate). Differences in technology levels and agro-ecological characteristics could result in different production frontiers among countries and across time.

[8] In this study US$ are amounts in real dollars at annual average PPP for the appropriate country and year.

used in the household whose efficiency is being tested (in US$), and $\lambda^i$ is the weight given to household *i* in forming a convex combination of the input vectors. Agricultural crop production is assumed to require the use of nine inputs: land (in hectares); chemical fertilizers (in US$); organic fertilizers (in US$); herbicides, pesticides and insecticides (in US$); transport (in US$); hired labor (in US$); family labor (opportunity cost valued at market wages); unpaid labor[9] (opportunity cost valued at market wages) and miscellaneous (in US$).[10] Technical efficiency indices by construction range between zero and one. Higher technical efficiency indices indicate higher efficiency levels. Technically efficient households are those with a technical efficiency index equal to one.

Our ability to investigate the links between sales and productivity is limited by their endogeneity, but the LSMS surveys offer a number of candidate variables to serve as instruments in a 2SLS approach. We subject these instrumental variables to a range of tests. The tests have limited power to reject weak or invalid instruments, however, so their value ultimately depends on our a priori knowledge of how they relate to household decisions. In this case, our candidate instruments for the sales index are the household's own transportation equipment, their membership in the dominant ethnic network, [11] and their proximity to an all-weather road. Each is a plausible instrumental variable, whose validity depends on the degree to which it is correlated with a household's productivity only through their use of the market and not through any direct link to production. Likewise, our candidate instruments for productivity are the household's age structure (working-age adults as a fraction of all household members) and their access to irrigation opportunities (as measured by the irrigation equipment on hand).

[9] In Tanzania samples data limitations prevented the inclusion of unpaid labor.
[10] Miscellaneous includes seeds, seedlings, rent of agricultural machinery and equipments, rent of animal traction, maintenance and repair of agricultural machinery and equipments, fuels, sacks, storage and drying.
[11] The dominant ethnicities in our dataset are Kinh in Vietnam, Mhaya in Tanzania and non-indigenous in Guatemala.

The statistical procedure for testing hypothesis 1 follows a large recent literature that computes households' productivity and then analyzes its determinants.[12] In our case, productivity is computed by solving equation (2). We then regress productivity on a range of possible determinants including the farm's level of market participation, and a variety of control variables drawn from the productivity literature including characteristics of the farm household and its location. To overcome the endogeneity of market participation, that regression is estimated using 2SLS. The main equation is a two-tailed Tobit because technical efficiency ranges from 0 to 1 (Ray, 2004), while the auxiliary regression is a one-tailed Tobit because the endogenous regressor is bounded at zero.[13] The two stages are equations (3) and (4),

$$\phi_i = \beta_{00} + \beta_1' X_{1,i} + \beta_2' \hat{\omega}_i + \varepsilon_{1,i} \tag{3}$$

$$\omega_i = \gamma_{00} + \gamma_1' X_{1,\mathrm{i}} + \gamma_2' X_{2,i} + v_{1,i} \tag{4}$$

where $\phi_i$ is productivity (measured as the technical efficiency index) for agricultural crop production in household *i*, $\beta_{00}, \beta_1, \beta_2, \gamma_{00}, \gamma_1, \gamma_2$ are unknown parameters of interest, $X_{1,i}$ is a vector of common exogenous variables hypothesized to be correlated with both agricultural productivity and market participation, $\hat{\omega}_i$ is the predicted value of the sales index used to measure market participation, $\omega_i$ is the sales index itself, $\varepsilon_{1,i}$ is an error term, $X_{2,i}$ is a vector of instruments for market participation, $v_{1,i}$ is an error term, $E(\varepsilon_{1,i}) = 0$ and $\mathrm{cov}(\varepsilon_{1,i}, v_{1,i}) = 0$.

[12] Examples include Tadesse and Krishnamoorthy, 1997; Gilligan, 1998; Shafiq and Rehman, 2000; Fletschner and Zepeda, 2002; Nyemeck et al., 2003; Dhungana, Nuthall and Nartea, 2004; Helfand and Levine, 2004; Zeng, 2005; Rios and Shively, 2006. Simar and Wilson (2007) indicate that estimators from the two-step methodology may suffer from serial correlation and bias. The authors propose bootstrap, a computationally expensive procedure, to overcome this problem. For computational simplicity, this study uses a two-step methodology.

[13] Logit models transformed into OLS are an alternative to estimate relationships when the dependent variable is continuous but limited in range (Manning, 1996). We did not employ this procedure because Tobit models are commonly used in the production efficiency literature. Also, as noted by Manning (1996), OLS estimates are not efficient in the presence of measurement error in the dependent variable.

The second hypothesis is a complement to the first, with the direction of the test reversed. Here, the first stage employs a two-tailed Tobit model to instrument productivity measured as the technical efficiency index, a variable bounded between 0 and 1. Because market participation is measured using the sales index, a variable bounded at values below zero, the second stage uses a one-tailed Tobit to identify factors associated with volume of sales. The 2SLS procedure is described in equations (5) and (6),

$$\omega_i = \beta_0 + \beta_3' X_{3,i} + \beta_4' \hat{\phi}_i + \varepsilon_{2,i} \tag{5}$$

$$\phi_i = \gamma_0 + \gamma_3' X_{3,\mathrm{i}} + \gamma_5' X_{4,i} + \nu_{2,i} \tag{6}$$

where $\omega_i$ is the sales index in household $i$, $\beta_0, \beta_3, \beta_4, \gamma_0, \gamma_3, \gamma_5$ are unknown parameters of interest, $X_{3,i}$ is a vector of common exogenous variables believed to be associated with both market participation and productivity, $\hat{\phi}_i$ is productivity as an endogenous explanatory variable, $\varepsilon_{2,i}$ is an error term, $\phi_i$ is productivity for agricultural crop production, $X_{4,i}$ is a vector of instruments for productivity, $\nu_{2,i}$ is an error term, $E(\varepsilon_{2,i}) = 0$ and $\mathrm{cov}(\varepsilon_{2,i}, \nu_{2,i}) = 0$.

**4. Results**

The farm household characteristics used in our regressions are summarized in Table 1. Descriptive statistics indicate a heterogeneous sample with respect to household head characteristics, household characteristics, agricultural production unit, community infrastructure and market participation. For example, the average farm size in the sample is 1.83 hectares ranging between a country average of 0.68 hectares in Vietnam to 4.86 hectares in Guatemala. Farms are significantly smaller in Vietnam but market participation and expenditures on

agricultural inputs (chemical fertilizers, pesticides and hired labor) are significantly higher.[14] Vietnamese households are significantly more highly educated, nearly all are home owners and a significantly higher percentage of households have primary and secondary schools in their community. Land ownership is significantly higher in Tanzania, but farm asset ownership and input expenditures are significantly lower. Households in Tanzania are significantly closer to the market but they are more likely to face inaccessible roads. Guatemalan households have significantly larger farms but the rate of land ownership is the lowest among the samples. Ethnic minorities and off-farm employment are significantly higher in Guatemala. Expenditure per capita varies among countries and it is significantly lower in Tanzania (US$417) followed by Vietnam (US$801).

Agricultural productivity, measured in terms of technical efficiency for total crop production, is calculated for each sample separately using GAMS software (GAMS Development Corporation, 2006). Results for productivity are presented in Table 2. Average technical efficiency indices ranged between 0.20 and 0.45, indicating a wide dispersion in efficiency across households, with the average household having an output level that is less than half of what others achieved using similar inputs in that country and year. On average, the Tanzania 1992-93 sample has higher technical efficiency indices followed by Vietnam 1997-98. Vietnam displays higher technical efficiency indices, on average, than Guatemala (0.33 and 0.36 vs. 0.23). The sample is characterized by a small percentage of similarly fully efficient households along the frontier, remaining below 5% in all countries.

[14] In this study the term “significantly” generally refers to statistical significance at the 90% confidence level.

*Hypothesis 1: Higher Farm Sales Lead to Higher Agricultural Productivity*

Estimation results for the effect of sales-orientation on productivity (equation 3) are shown in Table 3A. The second row shows the coefficient on predicted values of market participation, drawn from a first-stage regression whose results are shown in Appendix Table A1. Before discussing the actual results, a more detailed motivation for our estimation procedure and hypothesis tests is provided here.

The first stage (equation 4) is estimated with a one-tailed Tobit due to truncation of the market participation variable, and it includes instruments to capture the attributes of the household that might affect productivity only through participation: a binary indicator of whether the household head belongs to the country's dominant ethnicity (1 for ethnic majority, 0 otherwise); a binary indicator of whether the household owns equipment designed only for transportation (1 if they own a bike, motorbike or automobile, 0 otherwise), and a binary indicator of whether the household is in a community whose access road is often impassable (1 if yes, 0 otherwise). These could facilitate market participation to the extent that shared ethnicity reduces barriers to communication and cooperation, ownership of transport equipment reduces marginal cost of movement, and the viability of access roads influences its speed and cost.

The second stage results in Table 3A are estimated with a two-tailed Tobit due to truncation of the dependent variable, which is agricultural productivity measured by the technical efficiency index. Explanatory variables in the model include the instrumented sales index, household head characteristics, household characteristics, farm characteristics and other factors believed to be correlated with productivity. Household head characteristics and household characteristics are included to capture attributes previously found to be correlated with market participation and the overall productivity of agricultural households. Household head

characteristics are related to gender (1 for male; 0 female), experience (age in years) and education level. [15] Household characteristics include household size (number of members) and share of income earned off-farm. We hypothesize that the size of the household could affect market participation and productivity through the demand for household production and availability of labor. Higher off-farm income shares that lead to larger capital endowments (land and assets) may result in higher levels of sales and productivity. Conversely, households with higher off-farm income share may reduce the time allocated to farm management resulting in lower market participation and lower productivity.

Farm characteristics measure wealth as the endowment of factors of production. Productive assets are cited as influential determinants of agricultural production (Schultz, 1964) and market participation (Boughton et al., 2007). Secure land rights are often advocated as a means of creating incentives for farmers to invest in technologies and land conservation practices that increase long-term productivity (Pingali and Rosegrant, 1995). Thus, we include farm area (in hectares),[16] land tenure security (percentage of farm area owned),[17] farm assets (agricultural machinery and agricultural equipment) and livestock (value of owned animals).

Other factors collectively referred to as "productivity factors" aim to capture differences in productivity due to heterogeneity in family labor and land. The composition of family labor may have an impact on the productivity of the farm in that labor of children and the elderly may be less productive. In addition, productivity between irrigated and rainfed land may differ. In Mexico, for example, yields in irrigated land were almost five times higher than those in rainfed land (de Janvry and Sadoulet, 2000). In the Philippines, irrigation raised annual rice production

[15] Education level refers to the highest level of education achieved by the household head (0 none; 1 pre-school or elementary; 2 secondary; 3 college or graduate school; 4 other).
[16] Farm area is defined as land owned plus land rented from another household minus land rented out.
[17] In the Vietnam sample land ownership refers to long term use land.

approximately two-fold (Shively, 2001). Consequently, we include household composition (fraction of household members between 15 and 50 years of age) and value of irrigation equipment to account for heterogeneity in productivity factors.

Because part of our interest lies in testing whether patterns are common across countries and time periods, models are estimated for individual samples and merged sample. Models for merged samples add location and time characteristics to the set of variables considered in sample models. These include dummy variables for country (Vietnam, Tanzania) in model A and sample dummies (Tanzania 1991-92, Tanzania 1992-93, Vietnam 1992-93, Vietnam 1997-98) in model B. Country dummies aim to capture differences that might arise due to diversity in human, economic and ecological conditions among households located in different countries. Individual sample dummies add the time component, that is, changes that might occur from one year to another (i.e. more/less rainfall than the previous year). Merged sample models have Guatemala 2000 as reference group.

Before proceeding to model results, we discuss three procedures applied in the selection and specification of models. First, Maddala (1983) indicates that ignoring heteroscedasticity in limited-dependent-variable models results in inconsistent estimators. We employ likelihood-ratio tests to evaluate the homoscedasticity of error terms in Tobit models that treated market participation as exogenously determined. These tests consider heteroscedasticity that might arise due to farm size in individual sample models, and heteroscedasticity due to farm size and country characteristics in merged samples. The null hypothesis of homoscedastic error terms is rejected. Thus, we proceed using White's heteroscedasticity-consistent covariance matrix estimators.

Second, a critical step in the analysis is finding instruments for market participation (measured as the sales-orientation of the household). The goal is to select instruments that are

both relevant and valid, uncorrelated with the error term and correctly excluded from the estimated equation. Relevant instruments are identified from factors commonly found in the refereed literature which suggests that market participation is influenced by a combination of human factors, capital endowment and infrastructure (e.g. Goetz, 1992; Key, Sadoulet and de Janvry, 2000; Heltberg and Tarp, 2001; Boughton et al., 2007).

Human factors account for cultural preferences and language barriers; capital endowments and infrastructure are typically used as proxies for market access and transactions costs. Limited market participation among indigenous-headed households is reported in Peruvian potato farmers (Vakis, Sadoulet and de Janvry, 2003). Market participation has been found to be positively correlated with transport ownership (Heltberg and Tarp, 2001) and motorized transport (Makhura, Kirsten and Delgado, 2001; Renkow, Hallstrom and Karanja, 2004).

The literature reports conflicting findings on the relationship between infrastructure and market participation decisions. Some studies report infrastructure as an influential factor in market participation (Goetz, 1992; Key, Sadoulet and de Janvry, 2000; Heltberg and Tarp, 2001; Renkow, Hallstrom and Karanja, 2004; Boughton et al., 2007) while other studies indicate infrastructure is not correlated with market participation (Lapar, Holloway and Ehui, 2003; Holloway and Lapar, 2007). Moreover, the correlation between infrastructure and market participation is found to differ among sellers and buyers (Goetz, 1992; Key, Sadoulet and de Janvry, 2000).

The validity of the instruments is tested using the Amemiya-Lee-Newey overidentification test (Baum et al. 2006).[18] As we fail to reject the null hypothesis of validity of ethnicity, transport ownership and inaccessibility, these instruments can be accepted as being valid in our model specifications.[19]

Third, Wooldridge (2000) indicates that OLS estimators are more efficient than 2SLS when the explanatory variable is exogenous. In order to identify whether 2SLS is necessary, exogeneity of sales-orientation is tested. Smith-Blundell tests reject exogenous sales-orientation in models where the volume of sales is instrumented using OLS.[20] Thus, we conclude that the volume of sales is endogenously determined within the household and focus our discussion on models estimated using 2SLS.

Regression results are presented in Tables 3A and 3B. Models reported in Table 3A include sales-orientation as an endogenously-determined variable. Exogenous market participation (as a seller) is assumed in models reported in Table 3B. The first five columns of Tables 3A and 3B show results for individual sample models (Tanzania 1991-92, Tanzania 1992-93, Vietnam 1992-93, Vietnam 1997-98 and Guatemala 2000). Results for merged samples (models A and B) are provided in the last two columns.[21] We focus the discussion of results on variables with a statistically significant effect (unless noted).[22]

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[18] Test based on a two-step estimation of a 2SLS approach using OLS to instrument market participation. Amemiya-Lee-Newey test statistics follow: Tanzania 1991-92, 1.41; Tanzania 1992-93, 0.04; Vietnam 1992-93, 24.67; Vietnam 1997-98, 5.16; Guatemala 2000, 2.73; Model A, 3.57; Model B, 8.55.

[19] Distance to market could be considered as a potential instrument of market access under the hypothesis that the longer the distance to the market, the lower the sales-orientation of the household. Interestingly, the validity of this instrument is rejected so we define models excluding distance to market.

[20] Smith Blundell test statistics follow: Tanzania 1991-92, 1.75; Tanzania 1992-93, 0.77; Vietnam 1992-93, 28.64; Vietnam 1997-98, 0.00; Guatemala 2000, 22.88; Model A, 40.53; Model B, 39.76.

[21] Although there are important reasons for pooling the data, caution must be exercised in doing so, and in interpreting the coefficient estimates from merged sample regressions, particularly when they differ greatly in sign and magnitude from those in the individual country regressions. This is because the results from Chow tests conducted on model A under assumption of exogenous and endogenous market participation cannot reject the hypothesis that model coefficients differ across countries.

[22] Results for the first stage of the 2SLS approach are provided in Appendix Table A.1.

Results presented in Table 3A indicate that, on average, Vietnam and Tanzania 1992-93 samples exhibit higher productivity than Guatemala. The association between sales-orientation and productivity is positive in most models, but significant only in Vietnam 1992-93 and Guatemala. Moreover, the magnitude of this association differs among countries and is stronger in Vietnam.

Vietnam 1997-98 and Guatemala samples display stronger association between household head attributes and productivity. In these countries, households with a male head or an older household head tend to have greater observed productivity than their counterparts. Interestingly, education has a weak effect on productivity in all models.

Household characteristics such as household size and off-farm income share are significant correlates with productivity. Household size is positively associated with productivity in most models, perhaps indicating higher availability of farm labor. Households with higher off-farm income shares have lower productivity. This result might be due to time constraints on agricultural production and farm management as off-farm employment competes with farm activities for the household's endowment of time. This pattern has been documented for farmers in the Philippines by Shively and Fisher (2004).

Among factors of production, in three models livestock ownership is correlated with higher productivity levels, possibly as a result of use of animal traction for land preparation, transport activities and/or incorporation of manure into farm land. The Tanzania 1991-92 sample exhibits a convex relationship between farm area and productivity, suggesting that larger farms in the sample have higher levels of productivity. Vietnam 1992-93, Guatemala and a merged sample display higher productivity in households with higher asset ownership. Similar to

findings from an earlier study of rice producers in Madagascar (Stifel, Minten and Dorosh, 2003), the relationship between land ownership and productivity is weak in all models.

Vietnam 1997-98, Guatemala and merged samples exhibit a positive correlation between household composition and productivity. In Vietnam and merged samples households with higher investments in irrigation equipment have higher productivity.

*Hypothesis 2: Higher Agricultural Productivity Leads to a Higher Volume of Sales*

The potential effect of productivity on sales-orientation is examined using a similar 2SLS approach as for hypothesis 1, with few modifications. The first stage uses a two-tailed Tobit model to derive an instrument for agricultural productivity measured as technical efficiency. Instruments for technical efficiency include those factors believed to be associated with market participation in no way other than by influencing productivity. These include household composition (fraction of household members between 15 and 50 years of age) and the value of irrigation equipment. The second stage employs a one-tailed Tobit model using volume of sales, measured as the sales index, as the dependent variable.

Model specification and instrument selection is based on the following criteria. First, as before, likelihood-ratio tests are used to evaluate homoscedasticity of error terms in Tobit models that assume exogenous productivity. Test results indicate heteroscedasticity of error terms. Hence, we employ White's heteroscedasticity-consistent covariance matrix estimators. Second, we investigate the validity of the instruments using the Amemiya-Lee-Newey overidentification test (Baum et al. 2006),[23] which does not reject the null hypothesis of valid instruments so we conclude that they can be accepted in this context. Third, since relevant and valid instruments

[23] Test based on two-step estimation of a 2SLS approach using OLS to instrument productivity. Amemiya-Lee-Newey test statistics follow: Tanzania 1991-92, 0.36; Tanzania 1992-93, 2.49; Vietnam 1992-93, 2.12; Vietnam 1997-98, 2.06; Guatemala 2000, 8.30; Model A, 0.01; Model B, 0.08.

are available we test for exogeneity of productivity. Smith-Blundell tests reject exogeneity in 2SLS models where productivity is instrumented using OLS.[24] We thus conclude that productivity is endogenous and discuss results of models that treat productivity as endogenously determined.

Tables 4A and 4B present regression results for models for sales-orientation. Models presented in Table 4A treat productivity as an endogenously determined variable. Exogenously determined productivity is assumed in models presented in Table 4B. The first five columns of Tables 4A and 4B show results for individual sample models (Tanzania 1991-92, Tanzania 1992-93, Vietnam 1992-93, Vietnam 1997-98 and Guatemala 2000). Merged sample results (models A and B) are provided in the last two columns.[25] Discussion of results centers on variables with significant effect in those models that treat productivity as endogenously determined (Table 4A).[26]

Households in the Vietnam sample display higher sales-orientation followed by households in Guatemala. In all models, except the Tanzania sample, productivity is positively associated with market participation after controlling for market access factors. The magnitude of this association varies among countries and is strongest in Guatemala.

Consistent with previous studies (Heltberg and Tarp, 2001; Lapar, Holloway and Ehui, 2003; Edmeades, 2006), households size is negatively correlated with volume of sales, perhaps because consumption of household production increases as households become larger, reducing sales of agricultural crop production. Households with lower shares of off-farm income have

[24] Smith Blundell test statistics are Tanzania 1991-92, 0.51; Tanzania 1992-93, 0.37; Vietnam 1992-93, 5.92; Vietnam 1997-98, 27.96; Guatemala 2000, 12.08; Model A, 58.96; Model B, 56.36.

[25] In models that treat productivity as endogenously determined (Table 4A), caution must be exercised in interpreting the coefficient estimates from merged sample regressions, particularly when they differ greatly in sign and magnitude from those in the individual country regressions. This is because, in most cases, the results from Chow tests conducted on model A cannot reject the hypothesis that model coefficients differ across countries.

[26] Results for the first stage of the 2SLS approach are provided in Appendix Table B.1.

lower sales-orientation. One possible explanation is that sales of agricultural output require skills and information that individuals with off-farm employment might posses or acquire more easily than their counterparts.

Among farm characteristics measuring the endowment of productive factors, in most models, larger farms display higher sales. This further supports findings by Govereh and Jayne (1999) and Makhura, Kristensen and Delgado (2001) indicating a positive association between farm size and volume of sales. However, results indicate that the rate of sales-orientation declines as farms become larger. Similar to models for productivity, in all samples the association between the volume of sales and land ownership is weak.

In Vietnam 1997-98, Guatemala and merged samples, livestock ownership exhibits a small negative correlation with volume of sales. A possible explanation is that owners of livestock reduce the amount of time devoted to crop production and marketing, thereby leading to lower production and lower sales. Among households in Vietnam, ownership of transport is associated with lower sales-orientation. Perhaps owners of transport are less dependent on agriculture for their subsistence. Lower income shares of agricultural production among transport owners (0.71 vs. 0.74 and 0.66 vs. 0.73 in Vietnam 1992-93 and Vietnam 1997-98 respectively) further support this hypothesis.

## 5. Summary and implications

This study analyzes links between participation in output markets and productivity using merged cross-country household surveys. The specific objective is to address whether higher farm sales lead to higher agricultural productivity or whether higher agricultural productivity leads to a higher volume of sales. A summary of findings and implications follow.

*Hypothesis 1: Higher Farm Sales Lead to Higher Agricultural Productivity*

Vietnam 1992-93 and Guatemala samples display a positive correlation between sales-orientation and productivity. In these samples the effect of sales-orientation on agricultural productivity is larger than the effect of factors accounting for heterogeneity in labor and land productivity. These results suggest that investments in market access are productivity-enhancing in some areas; hence, policies focused on increasing agricultural productivity should also consider complementary investments in infrastructure. This view is consistent, for example, with results of Zhang and Fan (2004) indicating that road development contributes to agricultural productivity growth in the long run.

*Hypothesis 2: Higher Agricultural Productivity Leads to a Higher Volume of Sales*

Results for the merged sample and most sub-samples confirm a positive correlation between productivity and market participation. Moreover, productivity is more frequently a significant correlate of market participation than is market participation a correlate of productivity. Households with higher productivity tend to be sales-oriented regardless of market access factors. In contrast, our results indicate that having better market access does not necessarily lead to higher rates of agricultural productivity. A parallel with the international trade literature can be drawn: a range of evidence indicates that firms with high productivity become exporters whereas participation in the export market does not lead to productivity growth (e.g. Bernard and Wagner, 1998; Bernard and Jensen, 1999). We find that high rates of agricultural productivity are likely to increase market participation, but that market integration has a weak influence over-productivity gains.

These findings have important policy implications. Increasing market access through infrastructure investments, such as construction of roads may not consistently lead to improvements in agricultural productivity. In contrast, enhancing output directly through investments in such features as irrigation equipment and improved seed is likely to have a more consistent impact on both productivity *and* market participation. Our results suggest the influence of productivity on sales-orientation remains strong under a wide range of human, economic and ecological conditions. This common pattern among countries and across time should be subjected to wider examination, as we believe it has important ramifications for policy design in regions where resource limitations preclude country or region-specific research.

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Table 1. Characteristics of Farm Households per Country and Merged Sample

| | *Tanzania* | *Vietnam* | *Guatemala* | *Merged Sample* |
|---|---|---|---|---|
| *Household head* | | | | |
| Male headed households (%) | 73.80*,† | 78.90*,‡ | 90.30†,‡ | 81.10 |
| | (44.00) | (40.80) | (29.60) | (39.20) |
| Ethnic majority (%) | 59.20*,† | 83.70*,‡ | 41.80†,‡ | 71.30 |
| | (49.20) | (36.90) | (49.30) | (45.30) |
| Age household head (years) | 47.81*,† | 46.00*,‡ | 44.56†,‡ | 45.84 |
| | (18.83) | (14.20) | (15.00) | (14.95) |
| Married (%) | 62.90* | 83.30*,‡ | 60.60‡ | 75.80 |
| | (48.30) | (37.30) | (48.90) | (42.80) |
| Higher education (%) | 2.60* | 30.40*,‡ | 3.10‡ | 21.10 |
| | (15.80) | (46.00) | (17.50) | (40.80) |
| *Household* | | | | |
| Household size (members) | 5.82*,† | 4.96*,‡ | 6.00†,‡ | 5.30 |
| | (3.05) | (2.00) | (2.67) | (2.35) |
| Household composition | 0.40*,† | 0.48*,‡ | 0.42†,‡ | 0.46 |
| | (0.23) | (0.21) | (0.21) | (0.21) |
| Off-farm employment (% with off-farm income) | 44.40† | 45.00‡ | 63.80†,‡ | 49.40 |
| | (49.70) | (49.80) | (48.10) | (50.00) |
| Home owner (%) | 97.00*,† | 98.00*,‡ | 86.80†,‡ | 95.20 |
| | (17.00) | (13.90) | (33.90) | (21.30) |
| House material (% with brick or stone walls) | 4.80*,† | 44.70*,‡ | 20.90†,‡ | 35.00 |
| | (21.50) | (49.70) | (40.70) | (47.70) |
| Ownership of transport (%) | 14.80*,† | 69.90*,‡ | 28.70†,‡ | 54.50 |
| | (35.50) | (45.90) | (45.20) | (49.80) |
| Expenditure (US$) | 2,229*,† | 3,681*,‡ | 5,857†,‡ | 4,051 |
| | (1,666) | (2,338) | (4,049) | (2,999) |
| Expenditure per capita (US$) | 416*,† | 776*,‡ | 1,094†,‡ | 815 |
| | (281) | (433) | (763) | (553) |
| *Farm* | | | | |
| Farm area (ha) | 2.11*,† | 0.71*,‡ | 4.57†,‡ | 1.77 |
| | (1.90) | (1.01) | (20.89) | (10.37) |
| Land ownership (% of farm area) | 84.68*,† | 67.26*,‡ | 64.86†,‡ | 68.45 |
| | (22.25) | (38.63) | (44.76) | (39.28) |
| Farm assets (1,000 US$) | 0.05*,† | 0.58*,‡ | 0.44†,‡ | 0.50 |
| | (0.27) | (2.47) | (2.77) | (2.43) |
| Livestock ownership (1,000 US$/ha) | 0.05*,† | 2.40*,‡ | 0.93†,‡ | 1.81 |
| | (0.51) | (6.75) | (5.13) | (6.09) |
| Irrigation equipment (1,000 US$/ha) | 0.00*,† | 0.12*,‡ | 0.04†,‡ | 0.09 |
| | (0.03) | (1.00) | (0.50) | (0.85) |
| Chemical fertilizer (1,000 US$/ha) | 0.01*,† | 0.68*,‡ | 0.22†,‡ | 0.50 |
| | (0.26) | (0.67) | (1.10) | (0.81) |
| Pesticides (1,000 US$/ha) | 0.00*,† | 0.15*,‡ | 0.10†,‡ | 0.13 |
| | 0.00 | (0.23) | (1.19) | (0.61) |
| Hired labor (1,000 US$/ha) | 0.07*,† | 0.16* | 0.18† | 0.16 |
| | (0.64) | (0.36) | (0.82) | (0.53) |
| *Community infrastructure* | | | | |
| School (%) | 5.40*,† | 81.20*,‡ | 23.10†,‡ | 59.70 |
| | (22.60) | (39.00) | (42.20) | (49.00) |
| Inaccessible road (%) | 51.50*,† | 14.40*,‡ | 5.70†,‡ | 16.10 |
| | (50.00) | (35.10) | (23.20) | (36.70) |
| *Market participation* | | | | |
| Sales index | 0.26*,† | 0.54*,‡ | 0.39†,‡ | 0.48 |
| | (0.57) | (0.37) | (0.32) | (0.39) |
| Number of observations | 1,136 | 7,405 | 2,668 | 11,209 |

Note: standard deviations in parentheses. *, †, ‡ indicate means are significantly different in paired t-test at 10% test level. Household composition measured as the fraction of household members between 15 and 50 years of age.

Table 2. Technical Efficiency Indices in each Sample

| | *Tanzania 1991-92* | *Tanzania 1992-93* | *Vietnam 1992-93* | *Vietnam 1997-98* | *Guatemala 2000* |
|---|---|---|---|---|---|
| Average level | 0.20 | 0.45 | 0.33 | 0.36 | 0.23 |
| Standard deviation | 0.20 | 0.24 | 0.19 | 0.21 | 0.22 |
| % Efficient | 2.25 | 4.85 | 2.16 | 2.91 | 2.29 |
| Number of observations | 579 | 557 | 3,520 | 3,885 | 2,668 |

Table 3A. 2SLS Models for Productivity, Endogenous Market Participation

| | *Tanzania 1991-92* | *Tanzania 1992-93* | *Vietnam 1992-93* | *Vietnam 1997-98* | *Guatemala 2000* | *Model A* | *Model B* |
|---|---|---|---|---|---|---|---|
| Constant | -0.276 | 0.399*** | -0.201* | 0.083 | -0.125** | 0.022 | -0.009 |
| | (0.288) | (0.088) | (0.113) | (0.058) | (0.057) | (0.056) | (0.074) |
| Sales index | 0.682 | -0.215 | 0.748*** | 0.032 | 0.236* | 0.204 | 0.243 |
| | (0.469) | (0.266) | (0.210) | (0.072) | (0.132) | (0.148) | (0.187) |
| *Household head characteristics* | | | | | | | |
| Male (1=yes, 0=no) | 0.068 | -0.010 | 0.001 | 0.030*** | 0.053*** | 0.018*** | 0.019*** |
| | (0.088) | (0.027) | (0.014) | (0.008) | (0.015) | (0.007) | (0.007) |
| Age (years) | 0.016 | -0.000 | 0.002 | 0.003* | 0.005*** | 0.001 | 0.002** |
| | (0.010) | (0.002) | (0.003) | (0.002) | (0.002) | (0.001) | (0.001) |
| Age squared | -0.000 | -0.000 | -0.000 | -0.000 | -0.000** | -0.000 | -0.000 |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| Education level | 0.043 | -0.005 | 0.015 | -0.008 | 0.014 | 0.001 | 0.003 |
| | (0.031) | (0.010) | (0.009) | (0.005) | (0.008) | (0.003) | (0.004) |
| *Household characteristics* | | | | | | | |
| Household size (members) | 0.012** | 0.019*** | 0.008** | 0.003 | 0.016*** | 0.014*** | 0.014*** |
| | (0.006) | (0.006) | (0.003) | (0.002) | (0.002) | (0.001) | (0.001) |
| Off-farm income share | -0.516 | -0.218*** | -0.081** | -0.134*** | -0.186*** | -0.163*** | -0.159*** |
| | (0.353) | (0.077) | (0.040) | (0.014) | (0.028) | (0.018) | (0.022) |
| *Farm characteristics* | | | | | | | |
| Farm area (ha) | -0.170*** | 0.015 | 0.031 | 0.051*** | 0.001 | 0.002* | 0.002 |
| | (0.055) | (0.022) | (0.025) | (0.012) | (0.001) | (0.001) | (0.001) |
| Farm area squared | 0.014*** | -0.000 | -0.001 | -0.002 | -0.000 | -0.000 | -0.000 |
| | (0.004) | (0.001) | (0.002) | (0.001) | (0.000) | (0.000) | (0.000) |
| Land ownership (% farm area) | -0.002 | 0.000 | 0.000** | 0.001*** | -0.000* | 0.000 | -0.000 |
| | (0.001) | (0.001) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| Farm assets (1000 US$/ha) | -0.013 | 0.010 | 0.013*** | -0.000 | 0.010*** | 0.002* | 0.002 |
| | (0.263) | (0.061) | (0.004) | (0.001) | (0.004) | (0.001) | (0.001) |
| Livestock (1000 US$/ha) | 0.251** | 0.221 | 0.001 | 0.004** | 0.000 | 0.001 | 0.001* |
| | (0.125) | (0.181) | (0.001) | (0.002) | (0.001) | (0.001) | (0.001) |
| *Productivity factors* | | | | | | | |
| Household composition | 0.078 | -0.033 | -0.041 | 0.064*** | 0.083*** | 0.051*** | 0.046** |
| | (0.077) | (0.056) | (0.038) | (0.017) | (0.027) | (0.018) | (0.021) |
| Irrigation equipment (1000 US$/ha) | -0.084 | 1.919 | 0.020* | 0.042*** | -0.005 | 0.030*** | 0.028*** |
| | (0.284) | (1.178) | (0.011) | (0.008) | (0.010) | (0.008) | (0.009) |
| *Location and time characteristics* | | | | | | | |
| Tanzania | – | – | – | – | – | 0.084*** | – |
| | | | | | | (0.024) | |
| Vietnam | – | – | – | – | – | 0.060*** | – |
| | | | | | | (0.022) | |
| Tanzania 1991-92 | – | – | – | – | – | – | -0.042* |
| | | | | | | | (0.025) |
| Tanzania 1992-93 | – | – | – | – | – | – | 0.230*** |
| | | | | | | | (0.038) |
| Vietnam 1992-93 | – | – | – | – | – | – | 0.042* |
| | | | | | | | (0.022) |
| Vietnam 1997-98 | – | – | – | – | – | – | 0.063** |
| | | | | | | | (0.032) |
| Number of observations | 579 | 557 | 3,520 | 3,885 | 2,668 | 11,209 | 11,209 |

Note: dependent variable is agricultural productivity measured in terms of technical efficiency. Robust standard errors in parentheses. *, **, and *** indicate coefficient estimate is significantly different from zero at 90%, 95% and 99% confidence levels respectively.

Table 3B. Tobit Models for Productivity, Exogenous Market Participation

| | *Tanzania 1991-92* | *Tanzania 1992-93* | *Vietnam 1992-93* | *Vietnam 1997-98* | *Guatemala 2000* | *Model A* | *Model B* |
|---|---|---|---|---|---|---|---|
| Constant | 0.109 | 0.379*** | 0.143*** | 0.040 | -0.051 | 0.075*** | 0.063*** |
| | (0.070) | (0.079) | (0.033) | (0.046) | (0.038) | (0.023) | (0.022) |
| Sales index | -0.010 | -0.093 | 0.047*** | 0.117*** | 0.010 | 0.052*** | 0.055*** |
| | (0.007) | (0.066) | (0.012) | (0.027) | (0.015) | (0.012) | (0.011) |
| *Household head characteristics* | | | | | | | |
| Male (1=yes, 0=no) | 0.017 | -0.014 | -0.001 | 0.030*** | 0.066*** | 0.022*** | 0.022*** |
| | (0.021) | (0.026) | (0.008) | (0.008) | (0.012) | (0.005) | (0.005) |
| Age (years) | 0.004 | -0.000 | -0.000 | 0.004* | 0.006*** | 0.001 | 0.002** |
| | (0.003) | (0.002) | (0.001) | (0.002) | (0.002) | (0.001) | (0.001) |
| Age squared | -0.000 | -0.000 | 0.000 | -0.000 | -0.000*** | -0.000 | -0.000 |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| Education level | 0.008 | -0.006 | 0.021*** | -0.011*** | 0.019** | 0.002 | 0.006** |
| | (0.009) | (0.010) | (0.004) | (0.004) | (0.008) | (0.002) | (0.003) |
| *Household characteristics* | | | | | | | |
| Household size (members) | 0.009*** | 0.021*** | 0.008*** | 0.004** | 0.015*** | 0.014*** | 0.014*** |
| | (0.003) | (0.004) | (0.002) | (0.002) | (0.002) | (0.001) | (0.001) |
| Off-farm income share | -0.153*** | -0.229*** | -0.087*** | -0.135*** | -0.231*** | -0.177*** | -0.178*** |
| | (0.035) | (0.070) | (0.016) | (0.015) | (0.011) | (0.008) | (0.008) |
| *Farm characteristics* | | | | | | | |
| Farm area (ha) | -0.093*** | 0.006 | 0.102*** | 0.040*** | 0.002*** | 0.003*** | 0.003*** |
| | (0.014) | (0.014) | (0.009) | (0.008) | (0.001) | (0.001) | (0.001) |
| Farm area squared | 0.009*** | 0.000 | -0.006*** | -0.001 | -0.000* | -0.000*** | -0.000*** |
| | (0.001) | (0.001) | (0.001) | (0.001) | (0.000) | (0.000) | (0.000) |
| Land ownership (% farm area) | -0.000 | 0.000 | 0.000** | 0.001*** | -0.000** | 0.000 | -0.000 |
| | (0.000) | (0.001) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| Farm assets (1000 US$/ha) | 0.227** | 0.003 | 0.011*** | 0.000 | 0.009** | 0.001 | 0.001 |
| | (0.095) | (0.056) | (0.004) | (0.000) | (0.004) | (0.001) | (0.001) |
| Livestock (1000 US$/ha) | 0.314*** | 0.215 | 0.001* | 0.005*** | -0.000 | 0.001 | 0.001 |
| | (0.093) | (0.180) | (0.001) | (0.001) | (0.000) | (0.001) | (0.001) |
| *Productivity factors* | | | | | | | |
| Household composition | 0.030 | -0.041 | 0.018 | 0.060*** | 0.109*** | 0.065*** | 0.063*** |
| | (0.044) | (0.054) | (0.017) | (0.016) | (0.021) | (0.010) | (0.010) |
| Irrigation equipment (1000 US$/ha) | -0.359*** | 1.705* | 0.035*** | 0.037*** | 0.004 | 0.035*** | 0.035*** |
| | (0.103) | (1.034) | (0.009) | (0.006) | (0.009) | (0.006) | (0.006) |
| *Location and time characteristics* | | | | | | | |
| Tanzania | – | – | – | – | – | 0.063*** | – |
| | | | | | | (0.010) | |
| Vietnam | – | – | – | – | – | 0.083*** | – |
| | | | | | | (0.006) | |
| Tanzania 1991-92 | – | – | – | – | – | – | -0.060*** |
| | | | | | | | (0.010) |
| Tanzania 1992-93 | – | – | – | – | – | – | 0.194*** |
| | | | | | | | (0.012) |
| Vietnam 1992-93 | – | – | – | – | – | – | 0.063*** |
| | | | | | | | (0.007) |
| Vietnam 1997-98 | – | – | – | – | – | – | 0.095*** |
| | | | | | | | (0.006) |
| Number of observations | 579 | 557 | 3,520 | 3,885 | 2,668 | 11,209 | 11,209 |

Note: dependent variable is agricultural productivity measured in terms of technical efficiency. Robust standard errors in parentheses. *, **, and *** indicate coefficient estimate is significantly different from zero at 90%, 95% and 99% confidence levels respectively.

Table 4A. 2SLS Models for Market Participation, Endogenous Productivity

| | *Tanzania 1991-92* | *Tanzania 1992-93* | *Vietnam 1992-93* | *Vietnam 1997-98* | *Guatemala 2000* | *Model A* | *Model B* |
|---|---|---|---|---|---|---|---|
| Constant | 0.525** | 0.294 | 0.266*** | 0.351*** | 0.369*** | 0.217*** | 0.258*** |
| | (0.250) | (0.449) | (0.089) | (0.090) | (0.077) | (0.043) | (0.042) |
| Productivity index | 0.503 | -0.240 | 1.338*** | 1.136*** | 1.353*** | 1.271*** | 1.294*** |
| | (0.651) | (1.355) | (0.277) | (0.181) | (0.425) | (0.126) | (0.133) |
| *Household head characteristics* | | | | | | | |
| Male (1=yes, 0=no) | -0.088 | 0.027 | -0.003 | -0.026* | -0.036 | -0.005 | -0.010 |
| | (0.139) | (0.031) | (0.018) | (0.016) | (0.037) | (0.012) | (0.012) |
| Age (years) | -0.021** | 0.000 | -0.003 | -0.008** | -0.006 | -0.002 | -0.004** |
| | (0.009) | (0.002) | (0.004) | (0.004) | (0.004) | (0.002) | (0.002) |
| Age squared | 0.000* | -0.000 | 0.000 | 0.000* | 0.000 | 0.000 | 0.000 |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| Education level | -0.058 | 0.001 | -0.018 | 0.040*** | 0.002 | 0.002 | 0.006 |
| | (0.036) | (0.010) | (0.013) | (0.007) | (0.014) | (0.005) | (0.006) |
| *Household characteristics* | | | | | | | |
| Household size (members) | -0.009 | -0.014 | -0.009** | -0.017*** | -0.023*** | -0.018*** | -0.018*** |
| | (0.010) | (0.032) | (0.005) | (0.003) | (0.007) | (0.003) | (0.003) |
| Off-farm income share | 0.557 | 0.032 | 0.107* | 0.160*** | 0.080 | 0.119*** | 0.119*** |
| | (0.515) | (0.341) | (0.060) | (0.042) | (0.098) | (0.030) | (0.032) |
| *Farm characteristics* | | | | | | | |
| Farm area (ha) | 0.158** | 0.073*** | -0.031 | 0.089*** | 0.001 | 0.002*** | 0.002*** |
| | (0.071) | (0.017) | (0.033) | (0.019) | (0.001) | (0.001) | (0.001) |
| Farm area squared | -0.013* | -0.003** | 0.001 | -0.008*** | -0.000 | -0.000** | -0.000** |
| | (0.007) | (0.001) | (0.002) | (0.002) | (0.000) | (0.000) | (0.000) |
| Land ownership (% farm area) | 0.002* | -0.000 | -0.001*** | -0.000 | 0.000 | -0.000 | -0.000 |
| | (0.001) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| Farm assets (1000 US$/ha) | 0.010 | 0.042 | -0.013*** | -0.003** | -0.008 | -0.005** | -0.005** |
| | (0.083) | (0.069) | (0.004) | (0.001) | (0.007) | (0.002) | (0.002) |
| Livestock (1000 US$/ha) | -0.044 | 0.114 | -0.001 | -0.011*** | -0.003** | -0.003* | -0.003* |
| | (0.180) | (0.331) | (0.002) | (0.002) | (0.002) | (0.001) | (0.001) |
| *Market access factors* | | | | | | | |
| Ethnic majority (1=yes, 0=no) | -0.015 | -0.011 | 0.044 | 0.103*** | -0.022 | 0.009 | 0.010 |
| | (0.068) | (0.024) | (0.030) | (0.016) | (0.021) | (0.012) | (0.012) |
| Ownership of transport (1=yes, 0=no) | 0.057 | 0.211 | -0.042** | -0.037** | 0.029 | -0.008 | -0.019* |
| | (0.045) | (0.213) | (0.018) | (0.015) | (0.024) | (0.010) | (0.010) |
| Inaccessibility (1=yes, 0=no) | -0.062 | -0.022 | 0.040** | -0.066*** | -0.015 | -0.023* | -0.023* |
| | (0.050) | (0.027) | (0.019) | (0.016) | (0.040) | (0.012) | (0.012) |
| *Location and time characteristics* | | | | | | | |
| Tanzania | – | – | – | – | – | -0.193*** (0.031) | – |
| Vietnam | – | – | – | – | – | 0.043** (0.019) | – |
| Tanzania 1991-92 | – | – | – | – | – | – | 0.002 (0.041) |
| Tanzania 1992-93 | – | – | – | – | – | – | -0.411*** (0.037) |
| Vietnam 1992-93 | – | – | – | – | – | – | 0.036* (0.020) |
| Vietnam 1997-98 | – | – | – | – | – | – | 0.050** (0.020) |
| Number of observations | 579 | 557 | 3,520 | 3,885 | 2,668 | 11,209 | 11,209 |

Note: dependent variable is participation in output markets measured as the sales index. Robust standard errors in parentheses. *, **, and *** indicate coefficient estimate is significantly different from zero at 90%, 95% and 99% confidence levels respectively.

Table 4B. Tobit Models for Market Participation, Exogenous Productivity

| | *Tanzania 1991-92* | *Tanzania 1992-93* | *Vietnam 1992-93* | *Vietnam 1997-98* | *Guatemala 2000* | *Model A* | *Model B* |
|---|---|---|---|---|---|---|---|
| Constant | 0.582** | 0.262*** | 0.434*** | 0.408*** | 0.365*** | 0.333*** | 0.364*** |
| | (0.234) | (0.079) | (0.073) | (0.078) | (0.061) | (0.031) | (0.032) |
| Productivity index | -0.160* | -0.140*** | 0.232*** | 0.311*** | 0.021 | 0.195*** | 0.212*** |
| | (0.086) | (0.047) | (0.033) | (0.031) | (0.035) | (0.018) | (0.018) |
| *Household head characteristics* | | | | | | | |
| Male (1=yes, 0=no) | -0.072 | 0.029 | -0.002 | -0.002 | 0.047** | 0.019* | 0.014 |
| | (0.138) | (0.018) | (0.016) | (0.013) | (0.022) | (0.011) | (0.011) |
| Age (years) | -0.018** | 0.000 | -0.004 | -0.004 | 0.002 | -0.000 | -0.001 |
| | (0.009) | (0.002) | (0.004) | (0.003) | (0.003) | (0.001) | (0.001) |
| Age squared | 0.000* | -0.000 | 0.000 | 0.000 | -0.000 | -0.000 | 0.000 |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| Education level | -0.055 | 0.001 | -0.000 | 0.035*** | 0.022** | 0.003 | 0.012** |
| | (0.035) | (0.007) | (0.012) | (0.006) | (0.011) | (0.005) | (0.005) |
| *Household characteristics* | | | | | | | |
| Household size (members) | -0.003 | -0.017*** | -0.001 | -0.015*** | -0.005** | -0.003* | -0.003* |
| | (0.007) | (0.006) | (0.004) | (0.003) | (0.003) | (0.002) | (0.002) |
| Off-farm income share | 0.455 | 0.057 | 0.004 | 0.059* | -0.219*** | -0.073*** | -0.076*** |
| | (0.510) | (0.111) | (0.050) | (0.035) | (0.021) | (0.021) | (0.021) |
| *Farm characteristics* | | | | | | | |
| Farm area (ha) | 0.096*** | 0.073*** | 0.087*** | 0.140*** | 0.004*** | 0.006*** | 0.005*** |
| | (0.035) | (0.017) | (0.014) | (0.015) | (0.001) | (0.001) | (0.001) |
| Farm area squared | -0.007** | -0.003*** | -0.006*** | -0.011*** | -0.000*** | -0.000*** | -0.000*** |
| | (0.003) | (0.001) | (0.002) | (0.002) | (0.000) | (0.000) | (0.000) |
| Land ownership (% farm area) | 0.002* | -0.000 | -0.001*** | 0.000 | -0.000 | -0.000 | -0.000** |
| | (0.001) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| Farm assets (1000 US$/ha) | -0.052 | 0.041 | -0.000 | -0.002 | 0.005 | -0.001 | -0.001 |
| | (0.045) | (0.062) | (0.002) | (0.001) | (0.005) | (0.001) | (0.001) |
| Livestock (1000 US$/ha) | 0.099 | 0.091 | 0.001 | -0.008*** | -0.004** | -0.002 | -0.002 |
| | (0.092) | (0.126) | (0.001) | (0.002) | (0.002) | (0.001) | (0.001) |
| *Market access factors* | | | | | | | |
| Ethnic majority (1=yes, 0=no) | 0.002 | -0.012 | 0.092*** | 0.125*** | 0.010 | 0.033*** | 0.033*** |
| | (0.067) | (0.024) | (0.024) | (0.014) | (0.013) | (0.010) | (0.010) |
| Ownership of transport (1=yes, 0=no) | 0.064 | 0.218 | -0.003 | -0.025* | 0.079*** | 0.019** | 0.012 |
| | (0.044) | (0.188) | (0.013) | (0.014) | (0.015) | (0.008) | (0.008) |
| Inaccessibility (1=yes, 0=no) | -0.046 | -0.022 | -0.007 | -0.060*** | -0.073** | -0.038*** | -0.037*** |
| | (0.045) | (0.022) | (0.013) | (0.013) | (0.029) | (0.010) | (0.010) |
| *Location and time characteristics* | | | | | | | |
| Tanzania | – | – | – | – | – | -0.127*** (0.027) | – |
| Vietnam | – | – | – | – | – | 0.128*** (0.014) | – |
| Tanzania 1991-92 | – | – | – | – | – | – | -0.064* (0.039) |
| Tanzania 1992-93 | – | – | – | – | – | – | -0.204*** (0.020) |
| Vietnam 1992-93 | – | – | – | – | – | – | 0.099*** (0.016) |
| Vietnam 1997-98 | – | – | – | – | – | – | 0.147*** (0.014) |
| Number of observations | 579 | 557 | 3,520 | 3,885 | 2,668 | 11,209 | 11,209 |

Note: dependent variable is participation in output markets measured as the sales index. Robust standard errors in parentheses. *, **, and *** indicate coefficient estimate is significantly different from zero at 90%, 95% and 99% confidence levels respectively.

# Appendix A: Hypothesis 1

## Table A.1. First Stage 2SLS: Productivity, Endogenous Market Participation

| | *Tanzania 1991-92* | *Tanzania 1992-93* | *Vietnam 1992-93* | *Vietnam 1997-98* | *Guatemala 2000* | *Model A* | *Model B* |
|---|---|---|---|---|---|---|---|
| Constant | 0.528*** | 0.189*** | 0.472*** | 0.452*** | 0.328*** | 0.330*** | 0.361*** |
| | (0.205) | (0.068) | (0.078) | (0.079) | (0.062) | (0.031) | (0.032) |
| *Market access factors* | | | | | | | |
| Ethnic majority (1=yes, 0=no) | 0.037 | -0.015 | 0.068*** | 0.121*** | 0.020 | 0.043*** | 0.044*** |
| | (0.026) | (0.025) | (0.022) | (0.015) | (0.013) | (0.010) | (0.009) |
| Ownership of transport (1=yes, 0=no) | 0.010 | 0.230 | 0.036*** | -0.025* | 0.079*** | 0.026** | 0.025** |
| | (0.028) | (0.184) | (0.009) | (0.014) | (0.014) | (0.010) | (0.012) |
| Inaccessibility (1=yes, 0=no) | 0.027 | -0.024 | -0.046*** | -0.059*** | -0.082*** | -0.042*** | -0.040*** |
| | (0.022) | (0.023) | (0.011) | (0.013) | (0.028) | (0.010) | (0.011) |
| *Household head characteristics* | | | | | | | |
| Male (1=yes, 0=no) | -0.074 | 0.028 | -0.002 | 0.005 | 0.052** | 0.024** | 0.018* |
| | (0.133) | (0.018) | (0.016) | (0.013) | (0.022) | (0.011) | (0.011) |
| Age (years) | -0.018** | -0.000 | -0.005 | -0.004 | 0.001 | -0.001 | -0.002 |
| | (0.009) | (0.002) | (0.004) | (0.003) | (0.003) | (0.001) | (0.001) |
| Age squared | 0.000* | -0.000 | 0.000 | 0.000 | -0.000 | 0.000 | 0.000 |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| Education level | -0.060 | 0.002 | 0.002 | 0.032*** | 0.020* | 0.002 | 0.012** |
| | (0.040) | (0.007) | (0.011) | (0.006) | (0.010) | (0.005) | (0.005) |
| *Household characteristics* | | | | | | | |
| Household size (members) | -0.005 | -0.020*** | 0.001 | -0.015*** | -0.004 | -0.000 | 0.000 |
| | (0.007) | (0.005) | (0.004) | (0.003) | (0.003) | (0.002) | (0.002) |
| Off-farm income share | 0.509 | 0.089 | -0.027 | 0.014 | -0.227*** | -0.118*** | -0.124*** |
| | (0.532) | (0.119) | (0.050) | (0.036) | (0.019) | (0.022) | (0.022) |
| *Farm characteristics* | | | | | | | |
| Farm area (ha) | 0.120*** | 0.071*** | 0.107*** | 0.153*** | 0.004*** | 0.006*** | 0.006*** |
| | (0.039) | (0.017) | (0.014) | (0.016) | (0.001) | (0.001) | (0.001) |
| Farm area squared | -0.009** | -0.003*** | -0.008*** | -0.011*** | -0.000*** | -0.000*** | -0.000*** |
| | (0.004) | (0.001) | (0.002) | (0.002) | (0.000) | (0.000) | (0.000) |
| Land ownership (% farm area) | 0.002* | -0.000 | -0.001*** | 0.001** | -0.000 | -0.000 | -0.000** |
| | (0.001) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| Farm assets (1000 US$/ha) | 0.299 | 0.021 | -0.005* | -0.004** | -0.003 | -0.004** | -0.004** |
| | (0.258) | (0.057) | (0.002) | (0.002) | (0.003) | (0.002) | (0.002) |
| Livestock (1000 US$/ha) | 0.111 | 0.050 | 0.001 | -0.007*** | -0.004** | -0.002 | -0.002 |
| | (0.076) | (0.123) | (0.001) | (0.003) | (0.002) | (0.001) | (0.001) |
| *Productivity factors* | | | | | | | |
| Household composition | -0.068 | 0.066 | 0.065* | 0.036 | 0.092*** | 0.089*** | 0.086*** |
| | (0.083) | (0.047) | (0.039) | (0.024) | (0.034) | (0.019) | (0.018) |
| Irrigation equipment (1000 US$/ha) | -0.358 | 1.892 | 0.019** | 0.054*** | 0.041*** | 0.032*** | 0.032*** |
| | (0.256) | (1.382) | (0.009) | (0.012) | (0.012) | (0.010) | (0.010) |
| *Location and time characteristics* | | | | | | | |
| Tanzania | – | – | – | – | – | -0.119*** | – |
| | | | | | | (0.026) | |
| Vietnam | – | – | – | – | – | 0.132*** | – |
| | | | | | | (0.014) | |
| Tanzania 1991-92 | – | – | – | – | – | – | -0.082** |
| | | | | | | | (0.039) |
| Tanzania 1992-93 | – | – | – | – | – | – | -0.166*** |
| | | | | | | | (0.019) |
| Vietnam 1992-93 | – | – | – | – | – | – | 0.099*** |
| | | | | | | | (0.016) |
| Vietnam 1997-98 | – | – | – | – | – | – | 0.151*** |
| | | | | | | | (0.015) |
| Number of observations | 579 | 557 | 3,520 | 3,885 | 2,668 | 11,209 | 11,209 |

Note: dependent variable is participation in output markets measured as the sales index. Robust standard errors in parentheses. *, **, and *** indicate coefficient estimate is significantly different from zero at 90%, 95% and 99% confidence levels respectively.

# Appendix B: Hypothesis 2

## Table B.1. First Stage 2SLS: Market Participation, Endogenous Productivity

| | *Tanzania 1991-92* | *Tanzania 1992-93* | *Vietnam 1992-93* | *Vietnam 1997-98* | *Guatemala 2000* | *Model A* | *Model B* |
|---|---|---|---|---|---|---|---|
| Constant | 0.067 | 0.353*** | 0.158*** | 0.086* | -0.039 | 0.094*** | 0.084*** |
| | (0.077) | (0.093) | (0.033) | (0.046) | (0.038) | (0.023) | (0.021) |
| *Productivity factors* | | | | | | | |
| Household composition | 0.029 | -0.050 | 0.016 | 0.052*** | 0.086*** | 0.065*** | 0.063*** |
| | (0.044) | (0.088) | (0.015) | (0.016) | (0.023) | (0.009) | (0.009) |
| Irrigation equipment (1000 US$/ha) | -0.363*** | 1.361 | 0.036*** | 0.046*** | 0.015** | 0.040*** | 0.039*** |
| | (0.104) | (2.840) | (0.008) | (0.007) | (0.008) | (0.006) | (0.006) |
| *Household head characteristics* | | | | | | | |
| Male (1=yes, 0=no) | 0.018 | -0.016 | -0.001 | 0.028*** | 0.065*** | 0.022*** | 0.022*** |
| | (0.022) | (0.027) | (0.008) | (0.009) | (0.012) | (0.005) | (0.005) |
| Age (years) | 0.004 | -0.000 | -0.001 | 0.003 | 0.005*** | 0.001 | 0.002* |
| | (0.003) | (0.002) | (0.001) | (0.002) | (0.002) | (0.001) | (0.001) |
| Age squared | -0.000 | -0.000 | 0.000 | -0.000 | -0.000*** | 0.000 | -0.000 |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| Education level | 0.005 | -0.005 | 0.016*** | -0.007 | 0.015** | 0.001 | 0.005* |
| | (0.008) | (0.010) | (0.004) | (0.004) | (0.008) | (0.002) | (0.003) |
| *Household characteristics* | | | | | | | |
| Household size (members) | 0.008** | 0.023*** | 0.008*** | 0.002 | 0.015*** | 0.014*** | 0.014*** |
| | (0.003) | (0.004) | (0.002) | (0.002) | (0.002) | (0.001) | (0.001) |
| Off-farm income share | -0.148*** | -0.238*** | -0.096*** | -0.133*** | -0.233*** | -0.186*** | -0.186*** |
| | (0.036) | (0.071) | (0.016) | (0.015) | (0.011) | (0.008) | (0.007) |
| *Farm characteristics* | | | | | | | |
| Farm area (ha) | -0.091*** | 0.001 | 0.109*** | 0.059*** | 0.002*** | 0.003*** | 0.003*** |
| | (0.013) | (0.013) | (0.009) | (0.008) | (0.001) | (0.001) | (0.001) |
| Farm area squared | 0.009*** | 0.001 | -0.007*** | -0.002** | -0.000* | -0.000*** | -0.000*** |
| | (0.001) | (0.001) | (0.001) | (0.001) | (0.000) | (0.000) | (0.000) |
| Land ownership (% farm area) | -0.000 | 0.000 | 0.000 | 0.001*** | -0.000 | 0.000 | -0.000** |
| | (0.000) | (0.001) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| Farm assets (1000 US$/ha) | 0.228** | 0.008 | 0.009** | -0.000 | 0.007** | 0.001 | 0.001 |
| | (0.097) | (0.057) | (0.004) | (0.000) | (0.003) | (0.001) | (0.001) |
| Livestock (1000 US$/ha) | 0.319*** | 0.210 | 0.001* | 0.004** | -0.001 | 0.001 | 0.001 |
| | (0.094) | (0.180) | (0.001) | (0.002) | (0.000) | (0.001) | (0.001) |
| *Market access factors* | | | | | | | |
| Ethnic majority (1=yes, 0=no) | 0.024 | 0.007 | 0.042*** | 0.020** | 0.024*** | 0.021*** | 0.021*** |
| | (0.016) | (0.023) | (0.009) | (0.009) | (0.009) | (0.005) | (0.005) |
| Ownership of transport (1=yes, 0=no) | 0.002 | -0.060 | 0.034*** | 0.013 | 0.032*** | 0.020*** | 0.024*** |
| | (0.020) | (0.045) | (0.007) | (0.008) | (0.010) | (0.005) | (0.005) |
| Inaccessibility (1=yes, 0=no) | 0.028* | 0.009 | -0.042*** | 0.007 | -0.042*** | -0.013** | -0.012** |
| | (0.015) | (0.020) | (0.007) | (0.010) | (0.016) | (0.006) | (0.005) |
| *Location and time characteristics* | | | | | | | |
| Tanzania | – | – | – | – | – | 0.060*** (0.010) | – |
| Vietnam | – | – | – | – | – | 0.074*** (0.006) | – |
| Tanzania 1991-92 | – | – | – | – | – | – | -0.063*** (0.010) |
| Tanzania 1992-93 | – | – | – | – | – | – | 0.191*** (0.012) |
| Vietnam 1992-93 | – | – | – | – | – | – | 0.054*** (0.007) |
| Vietnam 1997-98 | – | – | – | – | – | – | 0.085*** (0.007) |
| Number of observations | 579 | 557 | 3,520 | 3,885 | 2,668 | 11,209 | 11,209 |

Note: dependent variable is agricultural productivity measured in terms of technical efficiency. Robust standard errors in parentheses. *, **, and *** indicate coefficient estimate is significantly different from zero at 90%, 95% and 99% confidence levels respectively.