**Farm Productivity and Household Market Participation:
Evidence from LSMS Data**

by

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Abstract

We analyze the correlation between farm productivity and market participation using comparable household data from Tanzania, Vietnam and Guatemala. Each farm's input use and output levels provide a within-sample measure of relative productivity, which we relate to that household's level of participation in local markets using a wide range of agricultural, demographic and infrastructural variables as controls and as instruments in two-stage regressions. Results indicate that, controlling for differences in market access and the underlying determinants of market participation, households with higher productivity have greater participation in agricultural markets. In contrast, households with greater rates of market participation do not consistently demonstrate higher levels of relative productivity. This result holds only in Vietnam and Guatemala, however. In the Tanzania sample we find no significant correlation in either direction. Combining household surveys in this way offers a promising approach to testing the robustness of key hypotheses across countries and over time.

Key words: market participation, productivity, multi-country sample, household surveys.

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Poverty is a mainly rural phenomenon with seventy five percent of the world's poor living in rural areas (Ashley and Maxwell 2001). Among the rural poor, farming is the main economic activity providing on average over sixty percent of their income (Rahman and Westley 2001). Rural agricultural households are thus a logical focus for poverty alleviation policies. These policies commonly regard increasing rates of market participation and boosting agricultural productivity as key instruments for improving the living standards of agricultural households.[1] Not surprisingly, the shift from semi-subsistence, low-productivity agriculture towards commercialized, high-productivity agriculture has been a core topic for development and agricultural economics for at least fifty years (Barrett 2008).

The importance of agriculture to poverty reduction in developing countries has been widely documented in the literature. A strong association between high agricultural productivity and poverty reduction is reported by Datt and Ravallion (1998), Palmer-Jones and Sen (2003) and Minten and Barrett (2008). High agricultural productivity might benefit the rural poor directly, either by increasing production or generating more employment opportunities, or indirectly, by boosting relative wages or reducing food prices (Datt and Ravallion 1998). Furthermore, indirect benefits might also accrue to urban poor who spend a large share of their income on food (de Janvry and Sadoulet 2000).

Barrett (2008) describes the importance of market participation to economic growth and poverty reduction. Market participation leads to market-oriented production where the household specializes in the production of those goods for which it holds comparative advantage. This could result in a more rapid productivity growth due to larger-scale production and increased technological change combined with welfare gains derived from trade. But in order to participate actively in markets, households require adequate access to production technologies and infrastructure. Market participation is directly associated with the generation of a market surplus, thus production technologies and productive assets affect a household's market participation by influencing its productivity. On the other hand, local market conditions influence incentives to increase productivity: in integrated markets the returns to increased production decrease less rapidly than they do in isolated markets. Moreover, poor infrastructure and weak institutions raise transaction costs that considerably alter production and market participation decisions.

As a result, increasing rates of market participation or productivity could have bi-directional synergies, and increasing both could boost living standards. Many studies address the impact of either market participation or productivity on farmers' income, and some studies relate them to each other.[2] Little research to date, however, asks to what extent these factors influence each other, and almost no research examines empirical evidence on this matter at the whole-farm level across a range of countries.[3] In this paper we join a small but growing literature employing merged samples from multiple cross-country household surveys to compare two kinds of correlation: the link from market participation to agricultural productivity and, conversely, from agricultural productivity to market participation.[4]

To our knowledge, work by Govereh and Jayne (1999) and Strasberg et al. (1999) are the only studies that measure the effect of market participation on productivity. Our analysis differs from this work in two ways. First, previous work is country-specific: Govereh and Jayne (1999) study Kenyan farmers and Strasberg et al. (1999) use data from Zimbabwe. Second, we use technical efficiency as a measure of productivity, whereas Govereh and Jayne (1999) and Strasberg et al. (1999) measure productivity as the gross value of crop production per acre. The measurement of productivity via technical efficiency considers how well inputs are transformed into outputs on a given set of available technology rather than focusing on total output (which ignores input use). Therefore, we provide a more complete measure of productivity because we take into account both output levels and input use.

We analyze the links between household market participation and agricultural productivity using large-sample repeated household surveys from Africa, Asia and Latin America. Given structural differences between these continents (de Janvry and Sadoulet 2002), local economic and agricultural characteristics might influence the linkages between market participation and productivity in each setting. For example, poverty is more prevalent and rural in Africa than on any other continent (Minten and Barrett 2008) and the degree to which the poor are engaged in agriculture varies geographically: in sub-Saharan Africa smallholders account for 77% of the poor, whereas they account for less than 38% of the poor in Asia (Irz et al. 2001). In East and South Asia 35% of farm land is irrigated whereas this less than 5% is irrigated in sub-Saharan Africa (Rahman and Westley 2001). However, landlessness is uncommon in Africa whereas 33-50% of Asian households are without access to land (Irz et al. 2001). The share of the non-agricultural sector's share of rural employment has increased rapidly in Latin America and in Asia it accounts for about 40% of rural employment (Rahman and Westley 2001). Hence our merged sample approach increases the variance above what can be observed within any one country or any single time period, and allows us to identify common patterns across countries and over time.

The entire sample for our analysis consists of observations on 11,209 farm households gathered from five LSMS surveys conducted by the World Bank in Tanzania, Vietnam and Guatemala. We chose these particular datasets because they contain sufficient information on farm inputs to compute relative productivity measures across households in each sample, and also contain data on plausibly exogenous demographic characteristics and community infrastructure to serve as candidate instruments in two-stage regressions.

Our empirical 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 a rise commercialization emanating from new roads and improved market access consistently raise productivity? Our goal is to help answer these fundamental questions.

Methodology

We analyze the two-way causality between market participation and productivity by testing the magnitude and statistical significance of the correlations implied by two important hypotheses:

Hypothesis 1: households that sell more farm output have higher farm productivity

Hypothesis 2: households with higher farm productivity sell more farm output.

In both cases, we can control for other factors but still 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. In the section below we define how these concepts are measured, then describe our identification strategy, and present 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.[5] The measure is intended to measure market orientation or commercialization in a scale-neutral manner, independently of the household's wealth or productivity.[6] Its definition is:

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

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 technology frontiers to differ among countries and across years.[7, 8] Measures of technical efficiency are obtained by solving the following linear programming problem for each household, under an assumption of variable returns to scale:

$$\max_{y,\lambda,\ldots,\lambda} \quad \phi \qquad (2)$$

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, ϕ is the technical efficiency index, y^i is total agricultural crop production in the i^{th} household (in US$)[9], x_n^i denotes total expenditure on the n^{th} (n = 1,…,N) input used in household i (in US$), x_n^0 is the total expenditure on the n^{th} input used in the household whose efficiency is being tested (in US$), and λ is the weight given to household i in forming a convex combination of the input vectors. Agricultural crop production is assumed to require the use of nine inputs: land (in hectares); chemical fertilizers (in US$); 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[10] (opportunity cost valued at market wages) and miscellaneous (in US$).[11] By construction, technical efficiency indices range between zero and one. Higher technical efficiency indices indicate higher efficiency levels, relative to other observations in the sample. Technically efficient households are those with an index value of 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, [12] 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).

The statistical procedure for testing hypothesis 1 follows a large recent literature that computes households' productivity and then analyzes its determinants.[13] 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, we estimate the regression using 2SLS. The main equation is a two-tailed Tobit because the technical efficiency scores lie between 0 and 1 (Ray, 2004), while the auxiliary regression is a one-tailed Tobit because the endogenous regressor is bounded at zero.[14] The two stages are equations (3) and (4),

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

$$\omega_i = \gamma_{00} + \gamma_1' X_{1,i} + \gamma_2' X_{2,i} + v_{1,i} \quad (4)$$

where ϕ_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, ω_i is the sales index itself, $\varepsilon_{1,i}$ is an error term, $X_{2,i}$ is a vector of instruments for market participation, $\nu_{1,i}$ is an error term, $E(\varepsilon_{1,i}) = 0$ and $\text{cov}(\varepsilon_{1,i}, \nu_{1,i}) = 0$.

The second hypothesis is a complement to the first, with the direction of tests 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),

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

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

where ω_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, ϕ_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 $\text{cov}(\varepsilon_{2,i}, \nu_{2,i}) = 0$.

Data

A key aspect of our study is to compare farmers operating under widely differing conditions using internationally-comparable measures of relative productivity, market participation, and related variables. The Tanzania data come from the Kagera Health and Development Survey Datasets (KHDS), a longitudinal economic survey conducted in epicenter 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 defined and computed variables relating to household composition, education, housing, farm land, agricultural production, non-farm business, consumption expenditure, credit, assets and community infrastructure.[15] All physical quantities were 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).[16, 17]

Results

The farm household characteristics used in our regressions are summarized in Table 1. Descriptive statistics indicate a diverse sample with respect to household head characteristics, household characteristics, agricultural production, community infrastructure, and market participation. For example, the average farm size in the sample is 1.83 hectares, and ranges between a country average of 0.68 hectares in Vietnam and 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.[18] 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 appear at significantly higher rates in Guatemala. Expenditure per capita varies among countries and 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 the highest-efficiency farms achieved in that country and year. The average score is highest for the Tanzania 1992-93 sample, implying the least dispersion in productivity, followed by Vietnam 1997-98. Vietnam has higher technical efficiency indices in both years 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.

Hypothesis 1: Households that sell more farm output have higher farm productivity

Estimation results for the effect of market sales on farm productivity (equation 3) are shown in Table 3. The second row shows the coefficient on the predicted values of market participation. Before discussing the actual results, we provide a more detailed motivation for our estimation procedure and hypothesis tests.

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)[19]; 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. For example, Minot, Kherallah and Berry (2000) suggest that ethnicity might capture language barriers, cultural standards, and community networks which reduce transaction costs in trade. Consistent with this view, Ha and Shively (2008) provide evidence that ethnicity helps to explain differences in the response to market signals among Vietnamese smallholders.

The second stage results in Table 3 are estimated with a two-tailed Tobit due to truncation of the dependent variable – 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. [20] 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),[21] land tenure security (percentage of farm area owned),[22] farm assets (agricultural machinery and agricultural equipment) and livestock (value of owned animals).

Our surveys include several variables that could shift productivity directly through family demographics and farm location. The demographic composition of the family matters in that labor of children and the elderly may be less productive than members in the 15-50 age range. In addition, productivity between irrigated and rainfed land differs. 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 approximately two-fold (Shively 2001). To capture these factors, we use the household's dependency ratio (defined inversely, as the fraction of household members who are between 15 and 50 years of age) and value of irrigation equipment (to account for whether households have access to irrigation water).

Because part of our interest lies in testing whether patterns are common across countries and time periods, we estimate our models for individual and merged samples. 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). In the merged sample models Guatemala 2000 is the 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 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).[23] 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.[24]

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.[25] 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 including market participation as an endogenously-determined variable are presented in Table 3.[26] The first five columns 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.[27] We focus the discussion of results on variables with statistically significance, unless noted.[28]

The main result in Table 3 is that our sales index, instrumented by market access variables, is a significant correlate of productivity at a high confidence level in only the Vietnam 1992-93 sample. It is also significant but at a low confidence level in the Guatemala sample. In most of the samples, other factors have a closer correlation with productivity. Almost all cases show a similar pattern for household size and off-farm income share: household size is positively associated with productivity in all but one of the two Vietnam samples, and off-farm income share is negatively associated with farm productivity in all but one of the two Tanzania samples. This result might be due to the combination of economies of size in large farm households, subject to competition from off-farm employment for the household's endowment of time. This pattern has been documented for farmers in the Philippines by Shively and Fisher (2004). Other factors have varying degrees of correlation with productivity in the different samples. In particular, the relationship between land ownership and productivity is quite weak, a result that is consistent with findings from a study of rice producers in Madagascar (Stifel, Minten and Dorosh 2003.

Hypothesis 2: Households with higher farm productivity sell more farm output

The potential effect of productivity on market sales 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),[29] 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 are available we test for exogeneity of productivity. Smith-Blundell tests reject exogeneity in 2SLS models where productivity is instrumented using OLS.[30] We thus conclude that productivity is endogenous and discuss results of models that treat productivity as endogenously determined.

Table 4 presents regression results for models that treat productivity as an endogenously determined variable.[31] As with Table 3, the first five columns show results for individual samples (Tanzania 1991-92, Tanzania 1992-93, Vietnam 1992-93, Vietnam 1997-98 and Guatemala 2000), and the merged sample results (models A and B) are provided in the last two columns.[32] Again discussion of results centers on variables with significant correlations.[33]

The main result in Table 4 is that households' relative productivity, when instrumented by household demographics and irrigation, is strongly correlated with market participation in both Vietnam samples and in Guatemala, while there is no such correlation in Tanzania. The only other factor that is similarly linked to market participation is household size. As in previous studies (Heltberg and Tarp 2001; Lapar, Holloway and Ehui 2003; Edmeades 2006), the number of people in the household is negatively correlated with sales, perhaps because home consumption increases as households become larger. As with productivity, this correlation holds in both Vietnam samples and in Guatemala. In the two Tanzania samples, the only variable that is consistently correlated with market participation is land area per farm. This supports findings by Govereh and Jayne (1999) and Makhura, Kristensen and Delgado (2001), with a positive association between farm size and sales orientation, at a decreasing rate for the largest farms.

Conclusions

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 are associated with higher agricultural productivity, or whether higher agricultural productivity is associated with more market sales. A summary of findings and implications follow.

Hypothesis 1: Higher Farm Sales Lead to Higher Agricultural Productivity

We find some positive correlation between sales-orientation and productivity, but the pattern is significant at the 99 percent level in only one of the five samples (Vietnam 1992-93), and is significant at the 90 percent level in only one other (Guatemala). Across our samples, only a household's size and its off-farm income share are consistently linked to its agricultural productivity: farms belonging to larger households are more productive, while those earning more off-farm income are less so. We conclude that increases in agricultural marketing may be productivity-enhancing over time, as suggested by Zhang and Fan (2004) for example, but that this effect is not generally visible at a point in time within most of our five samples.

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

The correlation between productivity and market participation is highly significant in both Vietnam samples and in Guatemala. 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).[34] This result does not hold in Tanzania, however, where only farm size is consistently (and positively) correlated with market participation.

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 – although even that does not hold everywhere.

Methodologically, this study demonstrates the potential value of constructing comparable datasets from household surveys in multiple countries and time periods, to test the robustness of key relationships across samples. Doing so can subject important hypotheses to a new kind of test, with important ramifications for whether policy lessons from one country can be applied to others.

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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 3. 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 4. 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.

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.

[1] See, for example, 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 2008.

[2] 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 2008. 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.

[3] 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.

[4] 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 Schneider 2003; Davis and Greenstein 2004; Holst and Spiess 2004; Hank and Jürges 2005; Sana and Massey 2005; and Seo and Mendelsohn 2008.

[5] 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).

[6] Participation in agricultural crop markets might be influenced by a variety of factors that are beyond the scope of this study. See, for example, Fafchamps (1992) for an analysis of links between market integration, price volatility and self-sufficiency, and Omamo (1998) for an evaluation of transport costs and the choice between low yielding food crops and cash crops.

[7] For simplicity, DEA analysis is conducted at the country level. This leaves out regional differences that might have an important effect on technical efficiency. These differences include, but are not limited to, infrastructure, rainfall, climate and other environmental factors.

[8] 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.

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

[10] In Tanzania samples data limitations prevented the inclusion of unpaid labor.

[11] 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.

[12] The dominant ethnicities in our dataset are Kinh in Vietnam, Mhaya in Tanzania and non-indigenous in Guatemala.

[13] 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) suggest that estimators from the two-step methodology can potentially exhibit bias due to correlation. They propose a computationally expensive bootstrap procedure to overcome this problem. However, some recent empirical work comparing the two approaches (Larsen 2007) indicates no fundamental difference in outcome, and therefore that potential bias, if any, arising from the use of a two-step procedure may be small. For computational simplicity, we therefore use the two-step approach here.

[14] 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.

[15] 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.

[16] 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$.

[17] Consistency and comparability of the dataset are, however, limited as data were collected using different surveys in each country.

[18] In this study the term "significantly" generally refers to statistical significance at the 90% confidence level.

[19] Ethnic majorities refer to Kinh in Vietnam, Mhaya in Tanzania and non-indigenous in Guatemala.

[20] 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).

[21] Farm area is defined as land owned plus land rented from another household minus land rented out.

[22] In the Vietnam sample land ownership refers to long term use land.

[23] Test based on a two-step estimation of a 2SLS approach where market participation is instrumented using OLS. 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.

[24] 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.

[25] 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.

[26] Regression results for models that treat market participation as an exogenously determined variable are available from the authors upon request.

[27] 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.

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

[29] Test based on two-step estimation of a 2SLS approach where productivity is instrumented using OLS. 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.

[30] 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.

[31] Regression results for models with exogenously determined productivity are available from the authors upon request.

[32] In models that treat productivity as endogenously determined (Table 4), 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.

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

[34] A small body of international trade literature links higher firm productivity to entrance into export markets. See, for example, Chen and Tang 1987; Aw and Hwang 1995; Bernard and Wagner 1998; Tybout and Westbrook 1995; Haddad, 1993; Bernard and Jensen, 1999 and 2004; Clerides, Lach and Tybout 1998.