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Food Crop Marketing and Agricultural Productivity in a High Price Environment: Evidence and Implications for Mozambique

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Abstract. *The recent high food price environment is an opportunity for Africa's smallholder farmers. This paper assesses the relationship between agricultural productivity and market participation/performance in smallholder response to a high food price environment in Mozambique. We use panel data before and after the change in price regime to identify the relative importance of market access/participation versus household and farm-level factors in explaining productivity differences. Conversely, we look at the relative importance of productivity investments and outcomes versus marketing investments in explaining household market performance. Results suggest that creating an enabling environment for greater access to markets can have important effects on productivity of cereals and groundnuts/beans, but direct investments that lead to increased adoption of productivity enhancing technologies are also important to maximize market access benefits. Finally, we highlight investment priorities to strengthening agricultural market participation and performance and improve productivity.*

Keywords: Agricultural productivity, endogeneity, intensification, and marketing performance.

JEL codes: C31, C36, D13, and D24.

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1. Introduction

Historically, rural households in Mozambique have had relatively low levels of both agricultural productivity and market participation (Walker et al., 2004, Boughton et al., 2006). Rural households devote most resources to agriculture and earn, on average, over two thirds of their income from crop production. Evidence from household surveys indicates that rural households are substantially subsistence oriented and that the poorest 40% of smallholders hardly sell any of their production in the market (Benfica and Tschirley, 2012). In general, yields for many crops are far below potential, and Mozambique lags behind most of its neighbors (Howard et al., 1998 and Fox et al., 2007).[1]

In recent years, particularly since 2008, prices of major food crops have soared in international markets. Prices received by Mozambican farmers have also risen since that time. Those increases have been, at least in part, driven by strong increases in local demand related to growing urban populations and incomes, and consumer demand for poultry, meat, and other products whose production rely on cereals as feed.

Most analyses of the implications of this new price environment have focused on its impacts on consumers. This is understandable as many households in rural and urban areas of developing countries are net food buyers and are severely impacted. Yet, higher prices should also influence farmer behavior, potentially in positive ways (Benfica and Tschirley, 2012). Evidence suggests that improved market participation in a high price environment can provide households with the necessary incentives to invest in improved agricultural technologies and put more effort in increasing agricultural productivity. On the other hand, higher productivity can generate higher levels of marketable surplus that, with market access, can result in increased market participation leading to potential improvements in overall household welfare.

In this paper we investigate the relationship between household level marketing performance and

[1] Average cereal yields in Mozambique are a third the level of yields in Malawi and a quarter of those in Zambia (World Bank, 2012).

agricultural productivity in Mozambique in response to higher market prices in recent years. A summary of the literature on market participation by smallholder farmers (in the relevant context) has been completed recently by Mather et al. (2013). Following the method advocated by Rios, Masters and Shively (2008)[2], we investigate the factors associated with marketing performance and agricultural productivity and test whether productivity changes are independent from better market access, participation and performance, and vice-versa. The study assesses the correlation between household level productivity and marketing outcomes and identifies the relative importance of market access/participation and outcomes, compared to direct household and farm level determinants in explaining productivity differences. Similarly, it identifies the relative importance of productivity outcomes compared to direct household and market access determinants in explaining marketing performance differences. The analysis is focused on selected food crop groups: cereals, beans and groundnuts, and roots and tubers.

Based on the results, we derive implications for public and private sector investments intended to improve access to markets and encourage agricultural intensification aimed at increasing agricultural productivity and household welfare. Given limited public and private investment resources it is important to know the relative payoffs, in terms of farm-level productivity and market participation and performance, to investment in market access versus productivity enhancing investments. The study is based on a household panel survey for 2008 and 2011 of about 1,186 households in Mozambique's agricultural heartland (the central and northern provinces of Sofala, Manica, Tete, Zambézia and Nampula).

The paper is organized as follows. First, we outline the research questions to be addressed. Second, a methodological discussion follows outlining the conceptual framework and hypotheses, definition of key outcome variables and the econometric approach used. Third, we describe the data and present some descriptive statistics of the outcome variables and selected agricultural intensification variables in 2008 and 2011. Next we present and discuss results of the econometric models. The paper concludes with a summary of key results and policy implications.

[2] Rios, Masters and Shively (2008) analyze this question in a multi-country context for overall agricultural productivity and marketing outcomes. This study looks at the case of central and northern Mozambique and focuses on selected food crop groups.

2. Food Market Behavior and Agricultural Productivity

This paper investigates the relationship between smallholder output market performance and agricultural productivity in Mozambique in response to higher food prices. It looks at several questions. First, how did food market participation and intensity change in face of higher price expectations? Second, what is the relationship between food marketing performance and agricultural productivity after controlling for endogeneity and specific factors? More specifically, (i) does increased marketing of crops induced by the high price environment consistently increase productivity? (ii) do the improvements in agricultural productivity increase market sales shares, even where market access is poor? Answers to these questions are used to derive implications for policy and investment priorities in Mozambique.

3. Conceptual Framework and Methodology

This paper recognizes the potential simultaneity in the relationship between agricultural productivity and market participation performance. Figure 1 presents the conceptual framework and the hypotheses underlying the analysis.

To address the research questions at hand, the analysis looks at the direction of causality by testing two competing hypothesis (Rios, Masters, and Shively, 2008): hypothesis 1 (H1) states that stronger market participation intensity leads to higher agricultural productivity; and hypothesis 2 (H2) states that higher agricultural productivity leads to stronger market participation intensity.

3.1. Definition of Outcomes

Following Govereh and Jayne (1999), Govereh, Jayne and Nyoro (1999), and Rios et al. (2008), we define *market participation intensity (household marketing performance)* as a "sales index" computed as value of sales relative to total value of output. So, for each food group, we have

$$(1) \quad SI_{hi} = \frac{\sum_{j=1}^{j} \mathrm{VS}_{hj}}{\sum_{j=1}^{j} \mathrm{VP}_{h,j}} \;, \quad for\ j = 1, \ldots, j \text{ crops of food group } i$$

where, SI_{hi} is the Sales Index of food group *i* for household *h*, $VS_{h,j}$ is the value of sales of crop *j* from food group *i* for household *h*, and VP_{hj} is the value of production of crop *j* from food group *i* for household *h*.

This index will be zero for non-sellers and greater than zero for sellers. The higher the value of sales relative to the value of production for a given food crop group, the higher will be the index of sales. The highest index is one (1) when the value of sales equals the value of production.

There are several ways in which productivity can be defined and calculated. For descriptive purposes we use three definitions. First, *value of production per hectare*, i.e., the product of crop production and its average real market price divided by the total area planted for each crop. Second, value of production per adult, i.e., the product of crop production and its average real market price divided by the total number of adults in the household. Finally, a measure of *technical efficiency* for crop production that essentially compares the actual levels of value of output of each farmer to that of the farmer in the district that achieves the highest level of value of output (Rios, Masters and Shively, 2008). For each crop in each district, this indicator varies in the continuum from 0 (households that have no value of output) to 1 (those achieving value of output levels equal to the highest level in the district). So, for each food group, we have:

$$(2) \quad TE_{hid} = \frac{\sum_{j=1}^{j} \mathrm{VP}_{hjd}}{Max(\sum_{j=1}^{j} \mathrm{VP}_{hjd})} \quad , \quad for\ j = 1, \ldots ,\ j \text{ crops of food group } i$$

where, TE_{hid} is the Index of Technical Efficiency of household *h* for food group *i* in district *d*, and VP_{hjd} is the value of production of crop *j* from food group *i* for household *h* in district *d*

By defining this measure per district it allows for differing technology frontiers across space at the district level. For the econometric analysis we use the last measure, production efficiency, as the productivity/efficiency indicator.

3.2. Econometric Approach

While the use of panel data can resolve time invariant household-specific endogeneity due to unobserved variables (e.g., management skills), endogeneity among variables that jointly determine market participation decisions and productivity outcomes can still result in the application of Ordinary Least Squares (OLS) generating biased estimates.

For the hypothesis testing, in order to deal with potential endogeneity of market participation, we use a Two Stage Lease Squares (2SLS) approach. Equations (3) and (4) represent the 2SLS model for each crop group i for testing H1.

(3) $\mathrm{TE}_h = \alpha_0 + \alpha_1 X_{1,h} + \alpha_2 SI_h{}^p + \varepsilon_{1,h}$

(4) $\mathrm{SI}_h = \beta_0 + \beta_1 X_{1,h} + \beta_2 X_{2,h} \quad + \eta_{1,h}$

Where TE_h is productivity as described in equation (2) for crop group i (expressed in logarithm form), SI_h is market participation intensity as described in equation (1) for crop group i (expressed in logarithm form), $X_{1,h}$ is a vector of exogenous variables assumed to be associated with agricultural productivity and market participation intensity. They include household characteristics, such as head's gender, age and education, household size, income diversification, access/use of services; farm characteristics such as asset endowments (Boughton et al, 2007) and a time dummy. $SI_{hi}{}^p$ is the predicted value of the sales index used to measure market participation in crop group i, $X_{2,h}$ is a vector of instrumental variables for market participation. $\varepsilon_{1,hi}$ and $\eta_{1,h}$ are error terms, $E(\varepsilon_{1,h})$ = 0, $E(\eta_{1,h}) = 0$, and cov $(\varepsilon_{1,h}; \eta_{1,h})$ = 0. The analysis runs the model for each individual crop group i, separately.

In the analysis we use as instruments for the sales index, ownership of means of transportation (bicycles) and access to market information. The instruments need to be valid. A key requirement for their validity is that they are correlated with the endogenous variable and uncorrelated with the error term. In other words, they do not affect productivity directly, but only through market participation.[3]

The first stage in the 2SLS procedure consists in running equation (4) as a Tobit model (given the truncation of the SI_h variable). A predicted value of the sales index is generated from this first stage ($SI_h{}^p$). The second stage consists in running an OLS of equation (3) as described above.

[3] Other candidate instruments for the sales index included proximity to main roads, membership in farmer associations, among others.

The testing of H2, i.e., the potential effect of productivity on market participation intensity can be described exactly as H1 with the direction of the test reversed.

(5) $\mathrm{SI}_h = \alpha_0 + \alpha_1 \mathrm{X}_{1,h} + \alpha_2 \mathrm{TE}_h{}^p + \varepsilon_{1,h}$

(6) $\mathrm{TE}_h = \beta_0 + \beta_1 \mathrm{X}_{1,h} + \beta_2 \mathrm{X}_{2,h} + \eta_{1,h}$

In this case, the vector of instruments for agricultural productivity ($X_{2,h}$) will include household composition that represents labor endowments (adult equivalents), and use of animal traction.[4]

The 2SLS models used to test hypotheses 1 and 2 use pooled data from the 2008 and 2011 surveys with a year dummy (2011). Post estimation tests are run for assessing the endogeneity of the variables of interest. To test the validity of the instruments, tests of over-identifying restrictions (validity of second instrument) and joint significance of the instruments (strength of the instrument) are also run.

4. Data

The data for this analysis comes from the Partial Panel Survey of 2011. The survey includes 1,186 rural households visited in 2008 (TIA08) and 2011 in five provinces (Nampula, Zambézia, Manica, Sofala, and Tete). The survey instrument contains information on household demographics, education and employment, agricultural production and marketing, use of inputs and technologies, access to resources (land, finance), income from economic activities, on and off-farm, and village level information on infra-structure, resources, and other aspects.[5]

5. Descriptive Trends/relationship in Outcomes and Intensification

Before focusing on the econometric results, this section looks at some descriptive statistics for outcome variables and other variables of interest to this topic. Using the available survey data, we look at changes in marketing and productivity outcomes, the relationship between these two outcomes, and trends in agricultural intensification between 2008 and 2011, i.e., before and after the outset of higher prices.

4 Other candidates for instrumenting agricultural productivity include productivity enhancing inputs (fertilizers, pesticides, herbicides), land quality measures, access to agricultural extension, etc.

5 See http://fsg.afre.msu.edu/mozambique/survey/pp2011.htm for the survey instrument and how to access to the survey data sets.

5.1. Changes in Market Participation and Marketing Outcomes

Overall, cereal sales have dominanted those of otherfood crops, although beans and groundnuts have gained some ground in recent years. The relative importance of roots and tubers in aggregate food marketing volumes remains relatively weak, consistent with its essentially subsistence-oriented nature (Table 1). The following results stand out. First, over the period, there has been a statistically significant increase (37 to 45 percent) in the share of households selling cereal crops, and a reduction (63 to 54 percent) of those selling roots/tubers.[6] The proportion of those selling beans and groundnuts remained high but unchanged at about 57 percent. Looking at annual food crops as a whole, there has been a relatively large and statistically significant increase in the proportion of households participating in the market over the period (13 percentage points). Cunguara *et al.* (2012) report increases in the proportion of households producing these crops, which indicates that increased market participation was accompanied by increased production.

Second, in terms of share of sales in production (marketing intensity), we find that, among those that produce, there have been statistically significant increases in the share of sales (sales index) for cereals (2 percentage points, an increase of 14.1%) and beans and groundnuts (3 percentage points, an increase of 13.6% from the base 2008 value).

There was a statistically insignificant increase in the share of sales of root crops, 1.3 percentage points, an increase of 25% from a very low base. In the aggregate, there has been a 3.5 percentage point increase in the share of sales of annual food crops, which represents an aggregate gain of 26.7% (Table 1).

5.2. Changes in Productivity and Production Efficiency Outcomes

Overall, the structure of the value of production of food is consistent with the structure of marketing described in the previous section, dominated by cereals. The share of roots and tubers remains relatively high at over 25%, but stagnant, while beans and groundnuts have gained ground in recent years. There are some observed changes in terms of defined productivity outcomes that are worth highlighting. By all three measures considered in this study,

[6] While the percentage of households selling some roots/tubers is relatively high, the average volume marketed is relatively low when compared to other food groups.

productivity gains have been observed for all food groups over the period 2008 - 2011. First, the value of output per hectare increased by 24% for cereals and 25% for beans and groundnuts, but remained unchanged for roots and tubers. Aggregate gains (all food groups) are estimated at 25% over base levels.

Second, smaller increases were observed for value of crop production per adult. We find an increase of 25% for both beans and groundnuts, and 12% for roots and tubers, and 12% for cereals. Aggregate gains in labor productivity were 14% over overall base levels. While there have been increases in land and labor productivity for all groups, statistically significant increases are observed only for beans and groundnuts. Third, statistically significant increases for all groups were observed for technical production efficiency, measured as the index of the actual levels of value of output of each farmer to that of the farmer in the district that achieves the highest level of output. Those increases were 20% for cereals and roots and tubers, and 15% for beans and groundnuts. Aggregate gains are estimated at 25% over base levels (Table 2).

In this analysis we focus our attention on the production efficiency index. This measure is very much correlated with the other measures, but also gives a sense of the relative performance among farmers and hence allows for the assessment of the effects of production scale and household composition (factors that directly enter the construction of the other two measures and hence make them less suitable for that assessment).

5.3. Marketing-Productivity Relationship

There is a clear positive relationship between agricultural market participation intensity and agricultural productivity in the region. As stated earlier, there is also a clear reverse causality, which means that effects are not strictly defined one way. In our econometric analysis we will employ Instrumental Variable (IV) methods to be able to assess and compare the effects in each direction and from there derive implications for policy. In this section, we start to explore on a strictly bivariate sense how those two variables relate to each other by exploring their relationship in each of the years, 2008 (dotted line) and 2011 (solid line). For simplicity we just look at the case of cereal crops, the dominant crop group).

Figure 2 presents the relationship between sales index (ranked in x-axis) and production efficiency index (y-axis) in panel (a), on the one hand, and production efficiency (ranked in the x-axis) and sales index (y-axis) in panel (b), on the other. While this is just a bivariate relationship (it does not control for a wealth of factors that can help understand the relationships) a few points can be highlighted. First, there is a clear positive relationship between these outcomes, i.e., higher market (productivity) performers have higher productivity (sales shares).

Second, the relationship has been quite stable over time in terms of marketing outcomes across productivity levels (only minor improvements are observed among top performers between 2008 and 2011) – panel (b). A quite distinct, but still consistent, picture emerges in terms of productivity outcomes across sales shares levels, where we observe that over time (among farmers with high sales shares) productivity has been quite higher in the most recent past- panel (a).

5.4. Agricultural Intensification Trends

In spite of greater market access, improvements in market participation, and some improvements in productivity outcomes, results indicate that there has been a slow pace in intensification. This limits productivity gains and hence the potential for positive effects on further improvements in marketing outcomes and ultimately household food security and welfare. The analysis here looks at the changes in the levels of intensification between 2008 and 2011, and assesses the bivariate relationship between those and the ranked levels of productivity and marketing outcomes. The idea is to assess whether households that ultimately achieve high levels of productivity are any more likely to have intensified production through the use of productivity enhancing inputs/technologies or hiring of outside labor. We find some key results. First, the proportion of households using fertilizer in food crops has increased (5.3 to 8.6 percent), but remains relatively low (Table 3). While in 2008 there is a weak association between fertilizer use and productivity, in 2011 households with higher productivity are more likely to have used fertilizer (Figure 3a). Similar results are found over most of the range when we look at the relationship across market participation levels for the two periods.

Second, the use of animal traction has also increased from 13 to 17 percent. In each year, animal traction use is highly correlated with the levels of marketing and productivity outcomes (Figure 3b). Third, the use of temporary hired labor in agriculture has increased significantly from 19 to 28%. There is a clear positive association between the levels of both marketing and productivity outcomes and the likelihood that a household has used hired agricultural labor (Figure 3c). Finally, the use of pesticides and irrigation remained low and stagnant, below 3 and 5 percent, respectively.

Overall, on the one hand, these results suggest little progress in intensification, even in the presence of a favorable price environment for outputs. One reason for this outcome may have to do with access to and/or the relative prices between the costs of inputs (scarcely available) and the prices of outputs. So, under these circumstances, the choice to intensify might not be profitable. The next question, then, is why are prices of outputs relatively lower than those of inputs and factors? Udry (2010) points to inadequate infrastructure, particularly roads and poorly developed marketing systems that keep the cost of fertilizer high relative to the price of output. Likewise, poor infrastructure is related to high cost of irrigation and electricity, inputs that can't, therefore, be used intensively.

For the case of Mozambique, one could argue that in spite of increases in the price of output, the weight of access factors still force relative prices of input/output to be high. It should be also stated that, complementary to this, and also valid even if relative prices would allow for increased intensification, is the farmer's level of human capital that can affect yields directly or via the complementarity with non-labor inputs, further constraining the ability to intensify through increased use of non-labor inputs.

On the other hand, however, it shows that farmers betting on intensification are the ones that are capable of achieving relatively high performance. But that intensification is still at relatively low levels. It is, therefore, important to improve access to productivity enhancing inputs and, more broadly, affordable technologies, while improving output markets to render intensification profitable.

6. Econometric Model Results

As discussed in section 3, we use 2SLS techniques to address the endogeneity of agricultural productivity in testing H1, and market participation in testing H2, while controlling for household level factors, farm characteristics, economic diversification, access and use of services, and location specific fixed effects. Market participation is instrumented by household ownership of bicycles and access to market information, and productivity is instrumented with household composition (available labor adult equivalents) and use of animal traction.

To verify the appropriateness of our models in addressing endogeneity through IV (i.e., adequacy of the instruments), in addition to the standard results, we run post-estimation diagnostic tests: Wu-Hausman endogeneity, Sargan over-identifying restrictions, and joint significance of the instruments. In this section we first present the descriptive statistics of the independent variables and instruments. Then, we discuss the model results with respect to each hypothesis under consideration.

6.1. Descriptive statistics and Trends in Independent Variables

In the previous section we presented descriptive results on the trends observed for the outcome variables and those related to intensification. In Table 3, we look into the trends of other sets of explanatory variables, such as demographic characteristics, farm characteristics, economic diversification, access to extension services, and participation in farmer associations. We also look at trends in the variables used as instruments.

Several results stand out. First, in terms of demographic characteristics, there has not been a statistically significant change in the proportion of male-headed households, and the average years of schooling of household heads. The observed increase in the age of the household head of approximately 3 years is consistent with the panel nature of the sample, spaced over that period over the same subjects. Second, in terms of farm characteristics and technology, area size of panel households has increased marginally from 0.61 to 0.66 ha per AE, and the proportion of households using irrigation and pesticides has also remained stagnant. However, as observed earlier, there has been a statistically significant increase in the proportion of households using fertilizer in food crops from 5.3 to approximately 9 percent, though in absolute terms this is still a very low level. Hiring of labor from outside the household has increased significantly from 19 to 28 percent. Relatively stagnant crop area planted and increased use of fertilizer and hired labor suggest that part of the observed growth in output has resulted from intensification. However, the still relatively low level of intensification indicates that there is a tremendous potential for expansion on a growth path driven by that source.

Third, in terms of economic diversification, results indicates that, on the one hand, panel households have experienced a statistically insignificant increase in crop diversification (non-food cash crops) as indicated by the share of households growing cotton and tobacco over the period. This is an expected results has households in trying to respond to food price incentives put relatively less effort in expanding cash crop production. On the other hand, however, significant expansion has occurred in the proportion of heads of households engaging in wage employment and non-farm self-employment activities. These trends are consistent with an economy in expansion motivated by high prices of food crops, and the consequent more dynamic rural labor and agricultural marketing economy. Fourth, over the period, there has been a statistically significant increase in association membership by households, from 7 to just below 10 percent. Use of extension services has almost doubled from 10% of the households in 2008 to close to 20% in 2011. These trends are indicative that some factors associated with potentially higher technology adoption in production, and lower transaction costs in marketing are evolving in the right direction. Finding ways to strengthen those trends will be crucial to ensure continued intensification leading to more promising productivity and marketing outcomes that will ultimately lead to better incomes and household food security.

Fifth, with respect to factors used as instruments for productivity, we find that over the period, there has been a statistically significant increase in the availability of labor, from 4.6 to 5.1 adult equivalents. Likewise, the proportion of households using animal traction, a technology that can improve the ability of households to expand area planted and save labor and time, has increased from 12.6 to 17.2 percent, a level that is still relatively low but encouraging. Finally, in terms of factors used as instruments for market participation and performance, the proportion of households owning bikes (that can increase the ability of farmers to better reach markets) remained high at over 50% without a statistically significant change. Access to market information, another important factor that likely drives market participation, has increased significantly over the period, almost doubling from 26% in 2008 to 42% in 2011.

6.2. Hypothesis Testing

The analysis turns now to the testing of the hypotheses discussed earlier through the 2 SLS econometric models, looking separately at the three crop groups considered: Cereals, beans/groundnuts, and roots/tubers. We first look at H1 that tests the effects of marketing intensity on agricultural production efficiency, a proxy for agricultural productivity. We then, look at H2 to investigate how improvements in productivity impact marketing performance.

<u>*Testing Hypothesis 1: Stronger market participation intensity leads to higher productivity*</u>

The econometric analysis uses a pooled data set with year dummy and district level fixed-effects. For each of the crop groups, the first stage consists of a Tobit regression of log share of sales on household characteristics, farm characteristics/technology, economic diversification, access to services and participation in groups, productivity and market access factors (instruments). Results are presented in <u>Table 4</u>. In all cases, except for roots/tubers, there is a strong and statistically significant correlation between the share of sales and the chosen instruments (ownership of bicycles and access to market information), which is a first order requirement for their adequacy.

Other factors strongly associated with the share of sales include: land area per AE and employment of temporary labor (for all crop groups), male headship and household labor availability (for cereals and beans/groundnuts), years of schooling and use of fertilizer in food crops (for beans/groundnuts), and self-employed head (for roots/tubers).

The testing of H1 is interpreted in the second stage of the 2SLS model. Accounting for the potential endogeneity of sales through IVs, and controlling for a wealth of factors, an increase of 10% in the share of sales leads to a statistically significant increase of approximately 2.2% in productivity of cereals; about 2.3% increase in productivity of beans/groundnuts, and no effects in the productivity of roots and tubers. While these results highlight the importance of marketing in raising productivity, the effects of productivity factors such as labor availability and the use of animal traction are no less important. In fact, controlling for all factors, using animal traction increases production efficiency in a significant way for cereals and beans/groundnuts, suggesting that investments in productivity enhancing technologies are essential for significant gains in efficiency, even when market access and market participation is improved.

We run post estimation tests to assess the degree of endogeneity of the variables of interest, and test the validity of the instruments selected. In this model, we reject the exogeneity of share of sales for all crop groups, except roots/tubers (Hu-Hausman F-test at the bottom of Table 4). This confirms the need to address endogeneity in the models. The Sargan Chi2 test of over-identifying restrictions is rejected, validating therefore the second instrument for both the cereals and the beans/groundnuts models. Instruments are jointly significant for all crop groups except roots/tubers.

Testing Hypothesis 2: Higher agricultural productivity leads to stronger market performance

The analysis uses the same data set with year dummy and district level fixed-effects to test H2. For each of the crop groups, the first stage consists of a Tobit regression of log productivity (production efficiency index) on household characteristics, farm characteristics and technology, economic diversification, access to services and participation in groups, market access, and productivity factors (instruments). Results are presented in Table 5. In all cases, except for roots/tubers, there is a strong and statistically significant correlation between the share of sales and the chosen instruments (household composition and use of animal traction dummy), indicating compliance with a requirement for their adequacy. Other factors strongly associated with production efficiency include: land area per AE and (for all crop groups), male headship, use of fertilizer, employment of temporary labor, and ownership of means of transportation (for cereals and beans/groundnuts), and years of schooling and receipt of extension (for cereals only).

Accounting for the potential endogeneity of productivity (through IVs) and controlling for a significant number of factors, an increase of 10% in production efficiency leads to a statistically significant increase of approximately 8.4% in the share of sales for cereals. For beans/groundnuts a 10% increase in production efficiency leads to a positive (2.6%) but not statistically significant increase in marketing intensity. No effects are observed in the marketing outcomes of roots and tubers when productivity increases. We find a relatively greater magnitude of the effects of productivity vis-à-vis marketing factors *per se*, though the effect of access to market information cannot be neglected, particularly for beans/groundnuts.

Regarding post estimation tests to evaluate endogeneity and the validity of the instruments, we reject the exogeneity of productivity for all crop groups, except roots/tubers (Hu-Hausman F-test at the bottom of Table 5), justifying, therefore, the use of 2SLS. The Sargan Chi2 test of over-identifying restrictions is rejected, validating therefore the second instrument for both the cereals and the beans/groundnuts models. Instruments are jointly significant for all crop groups.

Some additional considerations are worth making with respect to these results. First, regarding the effects on market participation intensity in cereals from productivity gains versus marketing factors per se (such as ownership of means of transportation or access to market information), we find that, while those factors are also important, productivity gains have an even stronger effect. These results are consistent with earlier studies (Boughton et al., 2007; Mather et al., 2013) and support the idea that investments in productivity improvements are essential for a successful rural development strategy driven by agricultural growth. Second, while the results we find with respect to beans/groundnuts (no statistically significant effect of productivity on marketing intensity) may be related to market access conditions that need to be improved, there are alternative explanations. For example, if these crops have a high income-elasticity of consumption then households may achieve greater utility from increasing home consumption of increased bean and groundnut production rather than increasing sales in response to an increase in productivity and/or an increase in household income. Indeed, this may be a more plausible explanation since there is no reason, a priori, for market access for beans and groundnuts to be more constraining than for cereals for any given household since they are higher value crops per unit weight.

Finally, the results we find for roots and tubers are quite distinct than those for the other groups. In reality, roots and tubers are distinct from cereals or beans/groundnuts in the farming systems in the study areas. Both cereals and beans/groundnuts are cash crops whereas roots and tubers are generally a food reserve/insurance crop. Unlike the former, they can be stored on the ground to be drawn on when needed, and can be used to substitute for cereals in own consumption when market prices for cereals are attractive. This may result in limited market participation in roots and tubers, even when there are productivity gains.

7. Conclusions and Policy Implications

Rural households in Mozambique exhibit low levels of both agricultural productivity and market participation. In recent years, particularly since 2008, prices of major food crops have soared in international markets. Mozambique also observed rising domestic food prices. This paper assessed the relationship between agricultural productivity and market participation intensity in this high price environment.

The analysis finds that between 2008, prior to price increases, and 2011, there were major changes in agricultural market participation. First, there has been a statistically significant increase in the proportion of households selling cereal crops, a reduction for those selling roots/tubers, and a relatively high but stagnant proportion of those selling beans and groundnuts. Aggregating across all food crops, the proportion of households selling grew by 13 percentage points. Second, in terms of share of sales in production (among those that produce), there have been statistically significant increases in the share of sales for cereals and beans/groundnuts. There was a statistically insignificant increase in the share of sales of root crops. In the aggregate, there has been a close to 4 percentage point increase in the share of sales of annual food crops, which represents an aggregate gain of 26.7%.

Likewise, modest increases are found in terms of productivity for all crop groups. By all measures considered in this study, productivity gains have been observed for all the three food groups over the period 2008 to 2011. The real value of output per hectare increased for cereals and for beans and groundnuts, but remained unchanged for roots and tubers. Aggregate gains are estimated at 25% over base levels. Positive but smaller increases were observed for value of output per adult, where aggregate gains in labor productivity were 14% over base levels. Statistically significant increases for all groups were observed for technical production efficiency, measured as the index of the actual levels of value of output of each farmer to that of the farmer in the district that achieves the highest level of output. Those increases were 20% for cereals and roots and tubers, and 15% for beans and groundnuts. Aggregate gains (accounting for all food crops) are estimated at 25% over base levels.

The study finds a strong correlation between market participation and productivity. In spite of greater market access, we find a slow pace of intensification: increasing but still low levels of use fertilizers and animal traction, and a stagnant use of pesticides and irrigation. There is, however, a significance increase in use of hired labor. In order to answer the fundamental questions of this research, the econometric analysis was used to test the effects of agricultural market intensity on productivity (H1), and the effects of productivity on household food marketing intensity (H2), while controlling for household level factors, farm characteristics, economic diversification, access and use of services, and location specific fixed effects.

First, with respect to testing H1 (effects of marketing intensity on productivity), accounting for the potential endogeneity of sales shares through IVs, and controlling for a wealth of factors, an increase of 10% in the share of sales leads to a statistically significant increase of approximately 2.2% in productivity of cereals; about 2.3% increase in productivity of beans/groundnuts, and no effects in the productivity of roots and tubers. While these results highlight the importance of marketing in raising productivity, access to productivity enhancing factors (e.g., using animal traction) increase productivity even more than market participation for cereals and beans/groundnuts. This implies that investments in productivity enhancing technologies are essential for significant gains in efficiency in addition to improved market access and participation.

Second, regarding testing H2 (effects of productivity on marketing intensity), an increase of 10% in the production efficiency leads to a statistically significant increase of 8.4% in market participation intensity for cereals, a positive (2.6%) but not statistically significant increase for beans/groundnuts, and no effects for roots and tubers. There is a relatively greater magnitude of the effects of productivity vis-à-vis marketing factors *per se*. This supports the idea that investments in productivity improvements are essential for a successful rural development strategy driven by agricultural growth. In an environment where market access conditions are improved, investing in productivity can strengthen the benefits for a great deal of smallholder farmers through an appropriate response to those opportunities.

In light of the significant effects of productivity on market participation, and acknowledging low levels of productivity (vis-à-vis slow intensification), productivity investments are unquestionably necessary. For beans/groundnuts, where there are no effects of productivity on market performance, investments in productivity alone without investing in market access can have limited return and may not be sustainable. For cereals productivity investments can help boost market participation intensity significantly in a time when market participation rates are on the rise. Finally, while the distinct results found for roots/tubers stem from their role as food reserve/insurance crops, investing in processing facilities and creating demand for processed root products (value addition) combined with improvements in production may have long run prospects for these crops.

On a policy and investment standpoint, as it relates to strengthening agricultural market participation and performance while improving agricultural productivity, it is worth highlighting some important priorities. In order to improve market participation and performance for smallholder farmers, there are increased and sustained investments that are needed. First, road infrastructure investment is a very strategic area. Mozambique still faces massive limitations with respect to primary, secondary and tertiary roads that hinder trade prospects in rural areas. Therefore, primary road investments/maintenance need to continue in order to improve trade flows between major regions. Secondary and tertiary road investments need to be coordinated and should support local employment generation. Project implementation for construction and maintenance of secondary and tertiary roads needs to be primarily done through labor intensive public works programs that involve local communities and help increase rural employment (incomes) while improving access conditions for smallholders (Benfica and Mather, 2013).

Second, investments in agricultural market price information need to be given top priority as they increase market efficiency. A focus is needed in improving coverage, frequency and adequacy of information, keeping up with the use of modern information technology capable of reaching a larger set of users in a timely manner. Third, low cost rural storage capacity needs to be improved. In addition to current efforts of silos construction to use as food reserves managed directly or indirectly by the state, efforts need to be coordinated with private sector (middle/large scale farmers) to promote simpler and cheaper storage technologies and practices. To gain economies of scale in storage and marketing, Government needs to work with farmer associations to provide support for investments in low-cost storage infrastructure and technologies. Finally, the full functionality and efficiency of value chains, particularly those involving perishable goods (horticulture and floriculture), requires an adequate supply of electricity. In the medium and long run, efforts to expand the electricity grid need to be coordinated between the Energy sector, and Agriculture and commerce, to ensure the right priorities are set to maximize benefits for rural communities where those developments take place or are expect to take place. In the short run, efforts should be made to create an incentive for the use of low-cost solar power by prospective developments (Benfica and Mather, 2013).

There are also important productivity-enhancing investments that need to be undertaken in the next decade. First, addressing the constraints that prevent smallholders from increasing the use of animal traction to expand to larger cultivated areas. This will require the allocation of sufficient public investments to control or eradicate tsetse fly. Experiences from neighboring countries such as Zimbabwe and Zambia, particularly from areas of similar agro-climatic conditions, should be explored and shared (Cunguara and Uaiene, 2013). Second, related to that effort, invest in service centers directed to service provision related to animal traction and use of tractors. Smallholder farmers would be able to rent animal traction and tractor equipment and receive the necessary information through those service centers. Third, moving beyond the near absence of chemical fertilizer use, which is a big challenge for achieving high productivity, will require policymakers to address constraints to private sector development of input markets, and effectively linking agro-dealer network development with improved extension services that will also need to be scaled up. Finally, invest more in irrigation, taking into account regional differences. These investments should consider various aspects, including salinity and management of irrigation infrastructure. At present, emphasis is given to large schemes that only benefit a few smallholders. Alternative and less expensive but equally effective irrigation models should be considered (Cunguara and Uaiene, 2013).

The Government of Mozambique is committed to investing in productivity enhancing investments such as irrigation, research and extension and targeted input subsidies. This effort is part of the Investment Plan under the CAADP (Comprehensive Africa Agricultural Development Program). Simulations of those investment projected for a five year period indicate benefits in terms of agricultural production and productivity gains, as well has economic growth and poverty reduction. Investments in roads and other areas of the marketing system are also planned and will likely yield substantial benefits.

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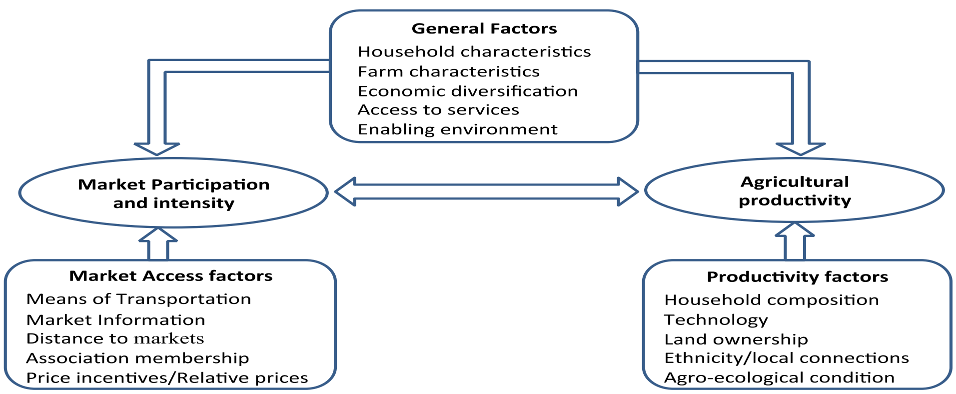
Figures and Tables

Figures

Figure 1. Conceptual Framework and Hypotheses



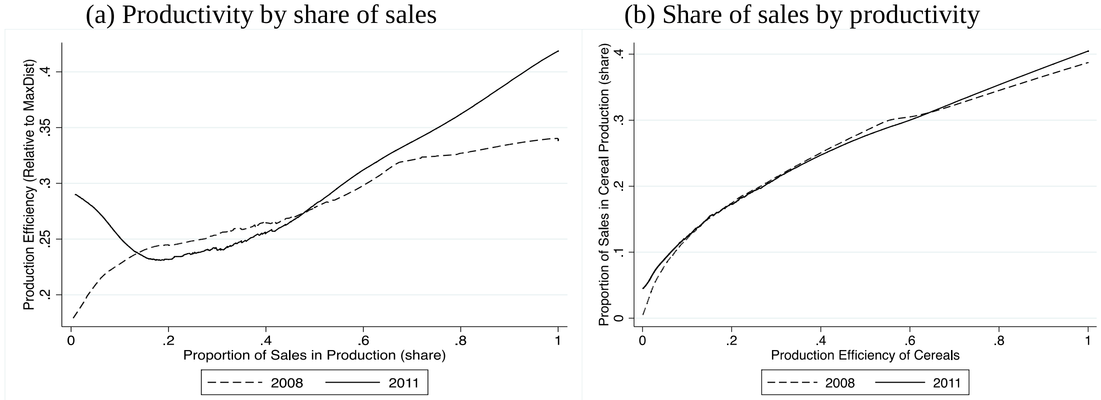
Hypotheses:

H1: Stronger market participation leads to higher agricultural productivity

H2: Higher agricultural productivity leads to stronger market participation

Figure 2. Cereals: Production Efficiency and Marketing Performance

(a) Productivity by share of sales (b) Share of sales by productivity

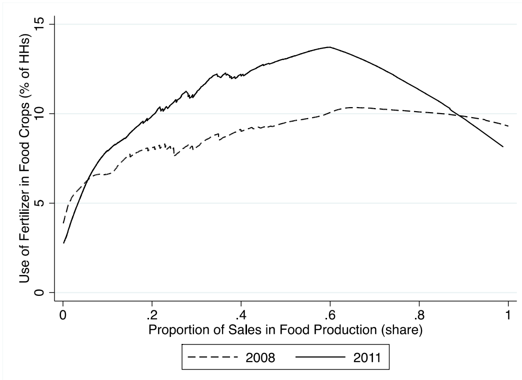


Source: Partial Panel Survey (2008 and 2011)

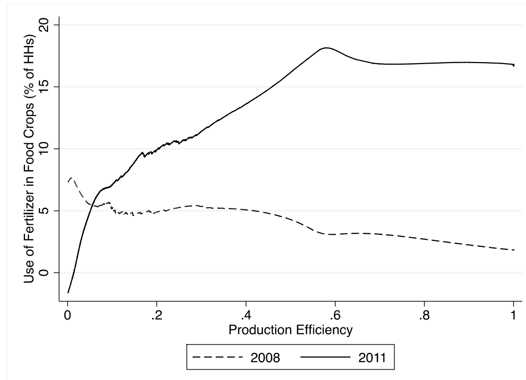
Figure 3. Agricultural Intensification and Outcomes, 2008 and 2011

(a) Households using fertilizer, 2008 – 2011

Fertilizer use by sales

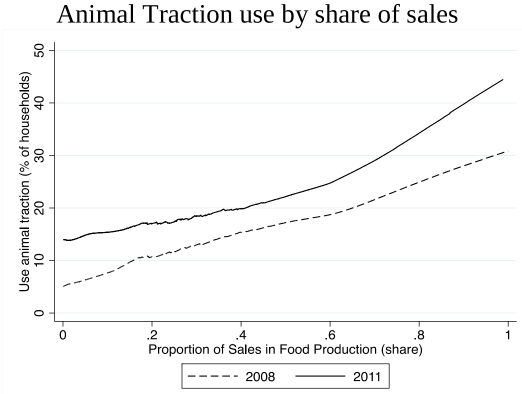


Fertilizer use by productivity

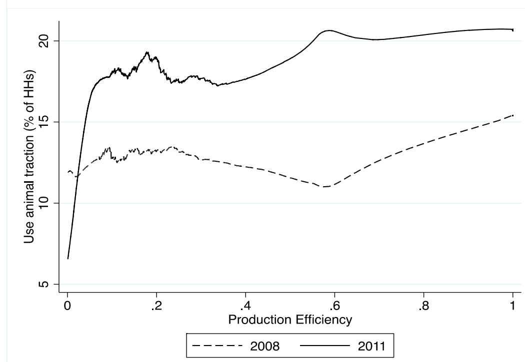


(b) Households using of animal traction, 2008 - 2011

Animal Traction use by share of sales



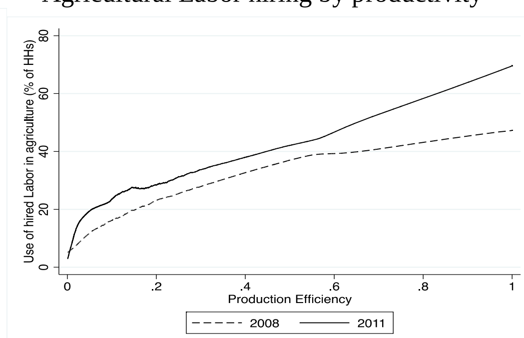
Animal traction use by productivity



(c) Households hiring agricultural labor, 2008-2011

Agricultural Labor hiring by share of sales

Agricultural Labor hiring by productivity



Source: Partial Panel Survey (2008 and 201

Tables

Table 1. Descriptive Statistics of Marketing Outcomes, 2008 – 2011

Marketing Indicators	Survey Years		Difference	
	2008	2011	Diff	p-value
Value of Sales Share of Food Groups (%)				
Cereals	51.8	46.8	-5.0	0.032
Beans and Groundnuts	36.6	40.3	+3.7	0.111
Roots and Tubers	11.6	12.9	+1.3	0.367
All Annual Food Crops	100.0	100.0		
Market Participation (% of Households)				
Cereals	37.4	44.6	+7.2	0.000
Beans and Groundnuts	57.1	56.7	-0.4	0.868
Roots and Tubers	63.0	54.0	-9.0	0.000
All Annual Food Crops	50.7	63.7	+13.0	0.000
Share of Sales (% of Production)				
Cereals	13.5	15.4	+1.9	0.057
Beans and Groundnuts	19.8	22.5	+2.7	0.056
Roots and Tubers	5.1	6.4	+1.3	0.127
All Annual Food Crops	13.1	16.6	+3.5	0.000

Source: Partial Panel Survey (2008 and 2011)

Table 2. Descriptive Statistics of Productivity Outcomes, 2008 – 2011

Productivity Indicators	Survey Years		Difference	
	2008	2011	Diff	p-value
Value of Production Share of Food Groups (%)				
Cereals and Grains	57.6	53.6	-4.0	0.001
Beans and Groundnuts	16.6	21.0	+4.4	0.000
Roots and Tubers	25.8	25.3	-0.5	0.678
All Annual Food Crops	100.0	100.0		
Value of Output/hectare (000 MZN)				
Cereals	6.7	8.3	+1.6	0.148
Beans and Groundnuts	6.5	8.1	+1.6	0.038
Roots and Tubers	4.5	4.5	0.0	0.994
All Annual Food Crops	8.5	10.6	+2.1	0.059
Value of Output/adult (000 MZN)				
Cereals	2.5	2.8	+0.3	0.254
Beans and Groundnuts	0.8	1.0	+0.2	0.006
Roots and Tubers	1.7	1.9	+0.2	0.249
All Annual Food Crops	5.0	5.7	+0.7	0.040
Production Efficiency (Index)				
Cereals and Grains	0.15	0.18	+0.03	0.001
Beans and Groundnuts	0.13	0.15	+0.02	0.032
Roots and Tubers	0.10	0.12	+0.02	0.005
All Annual Food Crops	0.16	0.20	+0.04	0.000

Source: Partial Panel Survey (2008 and 2011)

Table 3. Descriptive Statistics of Explanatory Variables, 2008 – 2011

Variables	Survey Year		Difference	
	2008	2011	Diff	p-value
Household head characteristics				
Male headed households (%)	83.0	82.0	-1.0	0.552
Age of Head (years)	41.8	44.4	2.6	0.000
Head Schooling (years complete)	2.9	3.0	0.1	0.696
Farm Characteristics/Technology				
Land Area per AE (he/AE)	0.61	0.66	0.05	0.151
Use Fertilizer in Food Crops (%)	5.3	8.6	3.3	0.002
Use Pesticides (%)	2.9	2.4	-0.5	0.440
Use Irrigation (%)	4.9	4.1	-0.8	0.277
Employs temporary hired Labor (%)	18.5	28.2	9.7	0.000
Economic Diversification				
Head is Self-Employed (%)	34.4	42.2	7.8	0.000
Head has Wage Income (%)	24.5	34.3	9.8	0.000
Grow Cotton (%)	4.9	5.9	1.0	0.319
Grow Tobacco (%)	5.9	6.6	0.7	0.497
Access to Services				
Belong to Association (%)	6.9	9.5	2.6	0.020
Participated in extension (%)	10.0	18.4	8.4	0.000
Productivity Factors (Instruments)				
Household Composition (AEs)	4.6	5.1	0.5	0.000
Use Animal Traction (%)	12.6	17.2	4.6	0.002
Market Access Factors (Instruments)				
Household Owns Bike (s) (%)	55.5	53.5	-2.0	0.343
Access to Market Information (%)	26.0	42.2	16.2	0.000

Source: Partial Panel Survey (2008 and 2011)

Table 4. Testing Hypothesis 1: Effects of Market Participation Intensity on Productivity, Pooled 2SLS by Crop Group

Independent Variables	IV 2SLS: Log Productivity, Endogenous Log Share of Sales					
	Cereals and Grains		Beans and Groundnuts		Roots and Tubers	
	1st Stage: Log Share of Sales	2nd Stage: Log Productivity	1st Stage: Log Share of Sales	2nd Stage: Log Productivity	1st Stage: Log Share of Sales	2nd Stage: Log Productivity
Log Share of Sales		0.224**		0.235*		-0.179
Household head characteristics						
Sex of Head (1=Male)	1.260**	-0.053	1.062**	0.016	-0.112	0.085
Age of Head	-0.024**	0.004	-0.020	0.003	-0.004	-0.001
Head years of Schooling	-0.054	0.038**	0.101+	-0.005	0.030	0.007
Farm Characteristics/Technology						
Land Area per AE	2.211**	-0.005	1.558**	0.078	1.284+	0.881**
Land Area per AE (Squared)	-0.133**	0.001	-0.121**	-0.005	-0.050	-0.121
1=Use Fertilizer in Food Crops	0.886	0.201	2.559**	-0.095	-0.391	-0.129
1=Use Pesticides (dummy)	0.977	-0.313	0.260	-0.233	1.329	0.404
1=Use Irrigation	0.618	-0.166	-0.774	0.178	-0.550	-0.751**
1=HH Employs Temporary Labor	1.008**	0.224+	1.321**	0.145	0.821*	0.240
Economic Diversification						
1=Head is Self-Employed	0.322	-0.099	0.383	0.038	0.658*	0.243
1=Head has Wage Income	-0.246	-0.051	0.236	-0.145+	0.493	-0.033
1=HH Grow Cotton	-1.138*	0.511**	-0.420	0.350+	-0.232	-0.024
1=HH Grows Tobacco	1.240*	-0.138	0.553	0.042	1.284+	0.872*
Access to Services						
1=HH belongs to Association	0.117	0.057	0.390	-0.081	0.239	-0.023
1=HH received extension	0.316	0.036	0.132	-0.026	0.767+	0.281
Productivity Factors						
Household Composition (LAE)	0.140*	0.071**	-0.028	0.068**	-0.034	0.078**
1=Use Animal Traction	-0.120	0.535**	0.426	0.305*	0.294	0.012
Year (1=2011)	0.757**	-0.062	1.058**	-0.277+	0.394	-0.176
District Fixed-Effects	YES	YES	YES	YES	YES	YES
Market Access Factors (Instruments)						
1= HH Owns Bike	0.300+	-	0.225+	-	-0.358	-
1= HH accesses Market Information	0.654*	-	0.626*	-	0.364	-
Constant	-13.431**	-0.225	-10.548**	-0.626	-11.666**	-4.758+
Observations	2,276	2,276	1,797	1,797	1,339	1,339
POST ESTIMATION TESTS						
Test of Endogeneity (Ho: var. is exogenous)						
Wu-Hausman F-test (p-value)		7.01 (0.008)		3.15 (0.076)		1.98 (0.159)
Tests of over-identifying restrictions						
Sargan Chi2 (p-value)		4.84 (0.028)		4.72 (0.030)		1.91 (0.167)
Tests of Joint Significance of instruments						
Score chi2 (p-value)		3.79 (0.023)		2.31 (0.099)		1.28 (0.279)

Note: Significance level of the point estimates: 1% (**), 5% (*), and 10% (+). Source: Partial Panel Survey (2008 and 2011

Table 5. Testing Hypothesis 2: Effects of Productivity on Market Participation Intensity, Pooled 2 SLS by Crop Group

Independent Variables	IV 2SLS: Log Share of Sales, Endogenous Log Productivity					
	Cereals and Grains		Beans and Groundnuts		Roots and Tubers	
	1st Stage: Log Productivity	2nd Stage: Log Share of Sales	1st Stage: Log Productivity	2nd Stage: Log Share of Sales	1st Stage: Log Productivity	2nd Stage: Log Share of Sales
Log of Productivity		0.835+		0.261		-0.475
Household head characteristics						
Sex of Head (1=Male)	0.210**	1.104**	0.239**	0.980*	0.064	-0.073
Age of Head	-0.001	-0.022*	-0.001	-0.020+	0.000	-0.004
Head years of Schooling	0.025**	-0.075+	0.018	0.097+	0.000	0.031
Farm Characteristics/Technology						
Land Area per AE	0.478**	1.726**	0.432**	1.515**	0.609**	1.548*
Land Area per AE (Squared)	-0.027**	-0.105**	-0.033**	-0.117**	-0.103*	-0.093
1=Use Fertilizer in Food Crops	0.390**	0.527	0.492**	2.460**	-0.075	-0.421
1=Use Pesticides (dummy)	-0.104	1.068	-0.171	0.299	0.150	1.387
1=Use Irrigation	-0.030	0.640	-0.007	-0.775	-0.666**	-0.847
1=HH Employs Temporary Labor	0.439**	0.616+	0.434**	1.216*	0.068	0.866*
Economic Diversification						
1=Head is Self-Employed	-0.027	0.335	0.128*	0.350	0.116	0.719
1=Head has Wage Income	-0.096*	-0.152	-0.076	0.251	-0.113	0.428
1=HH Grow Cotton	0.247	-1.343*	0.236+	-0.490	0.016	-0.218
1=HH Grows Tobacco	0.133	1.175*	0.161	0.486	0.639**	1.588+
Access to Services						
1=HH belongs to Association	0.083	0.057	0.012	0.376	-0.075	0.211
1=HH received extension	0.113+	0.211	0.010	0.131	0.121	0.837+
Market Access Factors						
1= HH Owns Bike	0.195**	0.171	0.220**	0.150	0.168*	-0.278
1= HH accesses Market Information	0.081+	0.601*	0.080	0.595+	0.035	0.385
Year (1=2011)	0.121**	0.661**	-0.009	1.053**	-0.249**	0.285
District Fixed-Effects	YES	YES	YES	YES	YES	YES
Productivity Factors (Instruments)						
Household Composition (AE)	0.509**	-	0.403**	-	-0.045	-
1=Use Animal Traction	0.100**	-	0.059**	-	0.079**	-
Constant	-3.237**	-10.504**	-3.110**	-9.919**	-2.667**	-12.929**
Observations	2,276	2,276	1,797	1,797	1,339	1,339
POST ESTIMATION TESTS						
Test of Endogeneity (Ho: var. is exogenous)						
Wu-Hausman F-test (p-value)		4.40 (0.036)		2.99 (0.084)		1.65 (0.198)
Tests of over-identifying restrictions						
Sargan Chi2 (p-value)		3.01 (0.082)		0.868 (0.351)		0.21 (0.648)
Tests of Joint Significance of instruments						
Score chi2 (p-value)		68.02 (0.000)		15.65 (0.000)		8.06 (0.000)

Note: Significance level of the point estimates: 1% (**), 5% (*), and 10% (+). Source: Partial Panel Survey (2008 and 2011