FOOD CROP MARKETING AND AGRICULTURAL PRODUCTIVITY IN A HIGH PRICE ENVIRONMENT IN CENTRAL AND NORTHERN MOZAMBIQUE

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Michigan State University

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Introduction
Research Questions
Conceptual Framework
Data
Descriptive Trends/relationship in Outcomes and Intensification
Econometric Methods
Descriptive statistics of explanatory variables
Model Results
Conclusions and Policy Implications
INTRODUCTION

- Historically weak market participation by rural households
  - Agricultural production is major economic activity, BUT subsistence oriented
  - Poorest 40% have virtually no participation in markets

- Since 2008, food prices have been on the rise
  - Increases in international prices for food and fuels
  - Increases in urban demand and cereal based livestock feed

- Analyses mostly focused on effects on consumers, generally net buyers

- There is potential for benefits to producers
  - Profitable market opportunities
  - Incentives to intensify => Increase productivity => increase food security => income
Research Questions:

This paper investigates the relationship between food market behavior and agricultural productivity in Mozambique in face of higher food prices.

1. How did food market participation and intensity change in face of higher price expectations?

2. What is the relationship between food marketing behavior and agricultural productivity after controlling endogeneity and specific factors?
   - Does increased marketing of crops induced by the high price environment consistently increase productivity?
   - Do the increases in agricultural productivity increase market sales, even where market access is poor?

3. What are are the implications for policy and investment priorities?
CONCEPTUAL FRAMEWORK AND HYPOTHESES

General Factors
- Household characteristics
- Farm characteristics
- Economic diversification
- Access to services
- Enabling environment

Market Participation and intensity

Market Access factors
- Means of Transportation
- Market Information
- Distance to markets
- Association membership
- Price incentives/Relative prices

Hypothesis:
H1: Stronger market participation leads to higher agricultural productivity
H2: Higher agricultural productivity leads to stronger market participation

Agricultural productivity

Productivity factors
- Household composition
- Technology
- Land ownership
- Ethnicity/local connections
- Agro-ecological condition
DEFINITION OF OUTCOMES

MARKETING BEHAVIOR

✓ Participation in crop markets
  ✓ Cereals, beans/groundnuts, roots/tubers
  ✓ At least one sales episode during the agricultural season

✓ Sales Intensity $SI_i$, by crop group $i$ (j crops)
  ✓ Share of sales in total value of production

$$SI_i = \frac{\sum_{j=1}^{j} CS_{ij}}{\sum_{j=1}^{j} CP_{ij}}, \quad \text{for } j = 1, \ldots, j$$

CS – Crop sales of group $i$ (j crops)
CP – Crop production of group $i$ (j crops)
Agricultural Productivity/Efficiency

- Value of Production per Hectare

\[ AP_i = \frac{\sum_{j=1}^l p_j cY_{i,j}}{\sum_{j=1}^l cA_{i,j}} , \quad \text{for } j = 1, \ldots, j \]

- Value of production per adult

- Technical Efficiency Index
  - Value of Production of household \( h \) relative to Maximum in District
DATA

- Partial Panel of households visited in 2008 (TIA08) and 2011
  - Survey with 1,186 rural households
  - Nampula, Zambézia, Manica, Sofala, and Tete

- Survey Instruments
  - Demographics, education and employment
  - Agricultural production and marketing
  - Use of inputs, technologies, access to resources (land, finance)
  - Income from economic activities, on and off-farm
  - Village level information on infra-structure, resources, etc
TRENDS/RELATIONSHIP IN OUTCOMES AND INTENSIFICATION

- Changes in Marketing Outcomes
- Changes in Productivity Outcomes
- Marketing-Productivity Relationship
- Agricultural Intensification trends
## Changes in Marketing Outcomes 2008-2011

<table>
<thead>
<tr>
<th>Marketing Indicators</th>
<th>Survey Years</th>
<th>Difference</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2008</td>
<td>2011</td>
<td>Diff</td>
</tr>
<tr>
<td>Market Participation (% of Households)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cereals</td>
<td>37.4</td>
<td>44.6</td>
<td>+7.2</td>
</tr>
<tr>
<td>Beans and Groundnuts</td>
<td>57.1</td>
<td>56.7</td>
<td>-0.4</td>
</tr>
<tr>
<td>Roots and Tubers</td>
<td>63.0</td>
<td>54.0</td>
<td>-9.0</td>
</tr>
<tr>
<td>Share of Sales (% of Production)</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Cereals</td>
<td>13.5</td>
<td>15.4</td>
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<td>Beans and Groundnuts</td>
<td>19.8</td>
<td>22.5</td>
<td>+2.7</td>
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<tr>
<td>Roots and Tubers</td>
<td>5.1</td>
<td>6.4</td>
<td>+1.3</td>
</tr>
<tr>
<td>Value of Sales Share of Food Groups (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cereals</td>
<td>51.8</td>
<td>46.8</td>
<td>-5.0</td>
</tr>
<tr>
<td>Beans and Groundnuts</td>
<td>36.6</td>
<td>40.3</td>
<td>+3.7</td>
</tr>
<tr>
<td>Roots and Tubers</td>
<td>11.6</td>
<td>12.9</td>
<td>+1.3</td>
</tr>
<tr>
<td>All Annual Food Crops</td>
<td>100.0</td>
<td>100.0</td>
<td></td>
</tr>
</tbody>
</table>

Source: Partial Panel Survey (2008 and 2011)

- Increase in participation for cereals and drop in root crops
- High but stagnant participation for beans/groundnuts;
- Higher market intensity (sales index) for cereals and beans/groundnuts
- Dominance of cereals in terms of value marketed each year
## Changes in Productivity Outcomes 2008-2011

<table>
<thead>
<tr>
<th>Productivity Indicators</th>
<th>Survey Years</th>
<th>Difference</th>
<th>p-value</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>2008</td>
<td>2011</td>
<td>Diff</td>
</tr>
<tr>
<td><strong>Production Efficiency (Index)</strong></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Cereals</td>
<td>0.15</td>
<td>0.18</td>
<td>0.03</td>
</tr>
<tr>
<td>Beans and Groundnuts</td>
<td>0.13</td>
<td>0.15</td>
<td>0.02</td>
</tr>
<tr>
<td>Roots and Tubers</td>
<td>0.10</td>
<td>0.12</td>
<td>0.02</td>
</tr>
<tr>
<td><strong>Value of Output/hectare (000 MZN)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cereals</td>
<td>6.7</td>
<td>8.3</td>
<td>+1.6</td>
</tr>
<tr>
<td>Beans and Groundnuts</td>
<td>6.5</td>
<td>8.1</td>
<td>+1.6</td>
</tr>
<tr>
<td>Roots and Tubers</td>
<td>4.5</td>
<td>4.5</td>
<td>0.0</td>
</tr>
<tr>
<td><strong>Value of Output/adult (000 MZN)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cereals</td>
<td>2.5</td>
<td>2.8</td>
<td>0.3</td>
</tr>
<tr>
<td>Beans and Groundnuts</td>
<td>0.8</td>
<td>1.0</td>
<td>0.2</td>
</tr>
<tr>
<td>Roots and Tubers</td>
<td>1.7</td>
<td>1.9</td>
<td>0.2</td>
</tr>
<tr>
<td><strong>Value of Production Share of Food Groups (%)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cereals</td>
<td>57.6</td>
<td>53.6</td>
<td>-4.0</td>
</tr>
<tr>
<td>Beans and Groundnuts</td>
<td>16.6</td>
<td>21.0</td>
<td>+4.4</td>
</tr>
<tr>
<td>Roots and Tubers</td>
<td>25.8</td>
<td>25.3</td>
<td>-0.5</td>
</tr>
<tr>
<td>All Annual Food Crops</td>
<td>100.0</td>
<td>100.0</td>
<td>0.0</td>
</tr>
</tbody>
</table>

Source: Partial Panel Survey (2008 and 2011)

- Production efficiency gains observed for all crop groups
- Increase in land and labor productivity for all crop groups but only statistically significant for beans/groundnuts
Marketing-Productivity Relationship
2008 and 2011

Productivity by share of sales (Cereals)

Share of sales by Productivity (Cereals)
Agricultural Intensification and Share of Sales

Fertilizer Use by Share of Sales

Irrigation Use by Share of Sales

Hiring Labor by Share of Sales

Animal Traction Use by Share of Sales
Agricultural Intensification and Production Efficiency

1. Fertilizer Use by Production Efficiency
2. Irrigation Use by Production Efficiency
3. Hiring Labor by Production Efficiency
4. Animal Traction Use by Production Efficiency
ECONOMETRIC METHODS

- There is potentially endogeneity (or reversed causality) of market participation and agricultural productivity => OLS Not Efficient
- IV Two-Stage Least Squares (2SLS)
  - 2 Models to test Hypotheses 1 and 2
  - Pooled data for 2008 and 2011 with year dummy
  - Selection of instruments
    - Relevance and validity
    - Correlated with the endogenous variable and uncorrelated with the error term
    - Related to the outcome only through the endogenous variable
  - Post Estimation Tests
    - Tests of endogeneity
    - Tests of over-identifying restrictions (validity of second instrument)
    - Test of Joint significance of the instruments (strength of the instruments)
MODEL 1: IV 2 SLS FOR HYPOTHESIS 1

H1: Stronger market participation \((SI_i)\) leads to higher agricultural productivity \((AP_i)\)

\[
SI_i = \beta_0 + \beta_1 X_{1,i} + \beta_2 X_{2,i} + \eta_{1,i}
\]

\[
AP_i = \alpha_0 + \alpha_1 X_{1,i} + \alpha_2 SI_i^P + \epsilon_{1,i}
\]

- **Endogenous Variable:** Log Share of Sales \((SI_i)\)
- **Explanatory Variables (\(X1’s\)):** Household and head characteristics, Farm Characteristics/Technology, economic diversification, access to services
- **Instruments (\(X2’s\)):**
  - Ownership of bicycles
  - Access to market information
- **Outcome (Second Stage):** Log Production Efficiency \((AP_i)\)
MODEL 2: IV 2 SLS FOR HYPOTHESIS 2

H2: Higher agricultural productivity ($AP_i$) leads to stronger market participation ($SI_i$)

$$AP_i = \beta_0 + \beta_1 X_{1,i} + \beta_2 X_{2,i} + \eta_{1,i}$$

$$SI_i = \alpha_0 + \alpha_1 X_{1,i} + \alpha_2 AP_i^{p} + \varepsilon_{1,i}$$

- **Endogenous Variable**: Log Production Efficiency ($AP_i$)
- **Explanatory Variables (X1’s)**: Household and head characteristics, Farm Characteristics/Technology, economic diversification, access to services
- **Instruments (X2’s)**:
  - Household Composition (Labor Adult Equivalents)
  - Use of animal traction
- **Outcome (Second Stage)**: Log Share of Sales ($SI_i$)
### Descriptive Statistics of Regressors, 2008-2011

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

Source: Partial Panel Survey (2008 and 2011)
## Testing Hypothesis 1

### Effects of Marketing Intensity on Agricultural Productivity

<table>
<thead>
<tr>
<th>Independent Variables</th>
<th>Cereals</th>
<th>Beans and Groundnuts</th>
<th>Roots and Tubers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1&lt;sup&gt;st&lt;/sup&gt; Stage: Log Share of Sales</td>
<td>2&lt;sup&gt;nd&lt;/sup&gt; Stage: Log Productivity</td>
<td>1&lt;sup&gt;st&lt;/sup&gt; Stage: Log Share of Sales</td>
</tr>
<tr>
<td>Log Share of Sales</td>
<td>0.224**</td>
<td>0.235*</td>
<td>-0.179</td>
</tr>
</tbody>
</table>

### Household head characteristics

- **Sex of Head (1=Male)**
  - Cereals: 1.260**
  - Beans and Groundnuts: 1.062**
  - Roots and Tubers: -0.179
- **Age of Head**
  - Cereals: -0.024**
  - Beans and Groundnuts: 0.004
  - Roots and Tubers: -0.020
- **Head years of Schooling**
  - Cereals: -0.054
  - Beans and Groundnuts: 0.038**
  - Roots and Tubers: 0.101+

### Farm Characteristics/Technology

- **Land Area per AE**
  - Cereals: 2.211**
  - Beans and Groundnuts: 1.558**
  - Roots and Tubers: 0.078
- **Land Area per AE (Squared)**
  - Cereals: -0.133**
  - Beans and Groundnuts: -0.121**
  - Roots and Tubers: -0.095
- **1=Use Fertilizer in Food Crops**
  - Cereals: 0.886
  - Beans and Groundnuts: 2.559**
  - Roots and Tubers: -0.005
- **1=Use Pesticides (dummy)**
  - Cereals: 0.977
  - Beans and Groundnuts: 0.767
  - Roots and Tubers: 1.329
- **1=Use Irrigation**
  - Cereals: 0.618
  - Beans and Groundnuts: 0.767
  - Roots and Tubers: 1.329
- **1=HH Employs Temporary Labor**
  - Cereals: 1.008**
  - Beans and Groundnuts: 1.321**
  - Roots and Tubers: 0.821*

### Access to Services

- **1=HH belongs to Association**
  - Cereals: 0.117
  - Beans and Groundnuts: 0.390
  - Roots and Tubers: -0.081
- **1=HH received extension**
  - Cereals: 0.316
  - Beans and Groundnuts: 0.132
  - Roots and Tubers: -0.026

### Productivity Factors

- **Household Composition (LAE)**
  - Cereals: 0.140*
  - Beans and Groundnuts: 0.071**
  - Roots and Tubers: -0.028
- **1=Use Animal Traction**
  - Cereals: -0.120
  - Beans and Groundnuts: 0.535**
  - Roots and Tubers: 0.426
- **Year (1=2011)**
  - Cereals: 0.757**
  - Beans and Groundnuts: 1.058**
  - Roots and Tubers: -0.277+
- **1=District Fixed-Effects**
  - YES

### Market Access Factors (Instruments)

- **1= HH Owns Bike**
  - Cereals: 0.300+
  - Beans and Groundnuts: 0.225+
  - Roots and Tubers: -0.034
- **1= HH accesses Market Information**
  - Cereals: 0.654*
  - Beans and Groundnuts: 0.626*
  - Roots and Tubers: 0.294
- **Constant**
  - Cereals: -13.431**
  - Beans and Groundnuts: -10.548**
  - Roots and Tubers: -11.666**

### Observations

<table>
<thead>
<tr>
<th></th>
<th>2,276</th>
<th>2,276</th>
<th>1,797</th>
<th>1,797</th>
<th>1,339</th>
<th>1,339</th>
</tr>
</thead>
</table>

**Notes:**
- **(p-value)**: 0.01 < p-value ≤ 0.05 indicates significance at the 5% level.
- **(p-value)**: p-value ≤ 0.01 indicates significance at the 1% level.
- **(p-value)**: p-value ≤ 0.10 indicates significance at the 10% level.
Testing Hypothesis 1
Effects of Marketing Intensity on Agricultural Productivity

- Controlling for productivity and other factors, an increase of 10% in the share of sales leads to
  - Approximately 2.2% increase in productivity of cereals
  - About 2.3% increase in productivity of groundnuts and beans
  - No effects in the productivity of roots and tubers

- Post estimation Tests
  - Reject exogeneity of share of sales for all groups, except roots/tubers
  - Reject over-identifying restriction for all groups, except roots/tubers
  - Instruments jointly significant for all crops
### Testing Hypothesis 2
Effects of Agricultural Productivity on Marketing Intensity

<table>
<thead>
<tr>
<th>Independent Variables</th>
<th>IV 2SLS: Log Share of Sales, Endogenous Log Productivity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cereals</td>
</tr>
<tr>
<td></td>
<td>1st Stage: Log Productivity</td>
</tr>
<tr>
<td>Log of Productivity</td>
<td>0.835+</td>
</tr>
<tr>
<td>Household head characteristics</td>
<td></td>
</tr>
<tr>
<td>Sex of Head (1=Male)</td>
<td>0.210**</td>
</tr>
<tr>
<td>Age of Head</td>
<td>-0.001</td>
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<tr>
<td>Head years of Schooling</td>
<td>0.025**</td>
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<td>Farm Characteristics/Technology</td>
<td></td>
</tr>
<tr>
<td>Land Area per AE</td>
<td>0.478**</td>
</tr>
<tr>
<td>Land Area per AE (Squared)</td>
<td>-0.027**</td>
</tr>
<tr>
<td>1=Use Fertilizer in Food Crops</td>
<td>0.390**</td>
</tr>
<tr>
<td>1=Use Pesticides (dummy)</td>
<td>-0.104</td>
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<tr>
<td>1=Use Irrigation</td>
<td>-0.030</td>
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<tr>
<td>1=HH Employed Temporary Labor</td>
<td>0.439**</td>
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<tr>
<td>Access to Services</td>
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<tr>
<td>1=HH belongs to Association</td>
<td>0.083</td>
</tr>
<tr>
<td>1=HH received extension</td>
<td>0.113+</td>
</tr>
<tr>
<td>Market Access Factors</td>
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<tr>
<td>1= HH Owns Bike</td>
<td>0.195**</td>
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<tr>
<td>1= HH accesses Market Information</td>
<td>0.081-</td>
</tr>
<tr>
<td>Year (1=2011)</td>
<td>0.121**</td>
</tr>
<tr>
<td>District Fixed-Effects</td>
<td>YES</td>
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<tr>
<td>Productivity Factors (Instruments)</td>
<td></td>
</tr>
<tr>
<td>Household Composition (AE)</td>
<td>0.509**</td>
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<tr>
<td>1=Use Animal Traction</td>
<td>0.100**</td>
</tr>
<tr>
<td>Observations</td>
<td>2,276</td>
</tr>
</tbody>
</table>
Testing Hypothesis 2
Effects of Agricultural Productivity on Marketing Intensity

- Controlling for marketing and other factors, an increase of 10% in the efficiency index leads to
  - Not statistically significant effect in marketing intensity of beans/groundnuts and roots/tubers crops;
  - A strong 8.8% increase in the share of sales of cereals

- **Post estimation Tests**
  - Reject exogeneity of productivity for all crop groups, except roots/tubers
  - Reject over-identifying restriction: for all groups, except roots/tubers
  - Instruments jointly significant for all crops
CONCLUSIONS AND POLICY IMPLICATIONS

- Strong increase in agricultural marketing, more in terms of participation rates, but somewhat in intensity of participation
- Some increase in productivity of all crop groups
- High correlation between market participation and productivity
- In spite of greater market access, slow pace of intensification
  - Increasing but still low levels of use fertilizers and animal traction;
  - Stagnant use of pesticides and irrigation; and
  - Significance increase in use of hired labor
Econometric Results suggest the following implications

☑ Creating an enabling environment for greater access to marketing opportunities can have important effects on productivity of cereals and groundnuts/beans, even with limited investments in productivity

☑ However, 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.

Roots are an essentially subsistence crop. Creating demand for processed root products (value addition) combined with improvements in production may have long run prospects.