Impact of Drought Index Insurance on Supplemental Irrigation: A Randomized Controlled Trial Experimental Evidence in Northern Ghana

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Outline

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   - Conclusions
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Drought is a significant factor in SSA smallholder production and investment decisions.

- Predominance of rainfed agricultural practices
  - 95% food and feed (FAO, 2007);
  - Source of livelihood of 70% population (Hellmuth et al., 2007);
- Drought accounts for 25% of all natural hazards in Africa.
Drought Implications

- Choice of safer, low-return activities;

- Low access to credit: Micro-creditors are not willing to lend if drought might result in widespread defaults, even if loans can be paid back easily in most years;

- **Even though drought may happen only once every five years, the threat of drought is enough to block farmers prosperity during all years good or bad**;

- Therefore, for millions of poor farmers, drought poses a major challenge that can critically restrict options, limit development and pull them into poverty trap.
Drought Implications

- Adoption of improved agricultural technologies can help enhance farmers’ livelihood.
- However, most novel technologies have experienced low rates of adoption due to drought.
- Novel instruments such as index insurance and supplemental irrigation have been proven to break the rule between drought shock and adoption.
Weather index insurance

- Index insurance is a type of insurance that is linked to an index, such as rainfall, temperature, humidity or crop yields, rather than actual loss which is difficult to observe.
- It helps transfer the risk of drought to the third party
- Mostly available in developed countries but has been piloted in developing countries for the past 10 years.
- Access to index insurance can help protect poor farmers against climate variability while promoting the uptake of productivity enhancing technologies.
Index insurance challenges in SSA

- Infrastructure and technology gaps in SSA;
- Basis risk;
- Farmers who mostly need the insurance are too poor to afford even the fair premium (Binswangen-Mzhize, 2012);
- Low take up demand disappearing as soon as the subsidy is eliminated;
- Difficult to scale up.
New alternatives

- Couple index insurance with drought resistant seed to reduce basis risk and the cost of the premium.

- Couple index insurance with credit as drought risk affect both lenders and farmers. This help to share the cost of the insurance between agric actors.
Supplemental irrigation

- Investment in supplemental irrigation in rainfed agriculture provides another side of the solution;
- Supplemental irrigation is an effective response to alleviating drought adverse effects of rainfed agriculture in SSA;
- It consists of supplying crops with water during key stages of crop growth cycle when rainfall fails to provide sufficient water.
- Runoff harvested water for supplemental irrigation is the most cost-benefit effective source of water Oweis et al. (2012)
**Benefit of supplemental irrigation**

- Provides higher and more stable yields
- Reduces the risk of crop failure
- Significantly increases water productivity
- And has positive spillover in modern technologies adoption (seed and fertilizer).
Benefit of supplemental irrigation

Figure: Maize and rice productivity under supplemental irrigation and rainfed in Northern Savannah agro-ecological zone of Ghana.
Objective

Despite the underlying contributions towards farmers’ livelihood, SI is still a rare innovation among smallholder farmers in SSA

- While both drought index insurance and SI address the risk of drought, they do so in very different fashions.
- As such, smallholder farmers potentially view drought index insurance and SI as either substitutable or complementary risk management instruments;

This paper makes use of the randomized controlled trials experiment to shed light on the existing debate whether drought index insurance and supplemental irrigation as two novel drought risk management instruments are substitute or complementary.
Do farmers prefer most drought index insurance compared to SI? The literature does not adequately respond this question.

Supplemental irrigation and index insurance as Substitute drought risk management
- **Foudi and Erdlenbruch (2012)** French farmers; insurance decreases the adoption of irrigation
- **Buchholz and Musshoff (2014)** in Germany and **Barham et al. (2011)** in Texas; Index insurance offsets the loss in the farmers’ certainty equivalent resulting from the reduction of supplemental irrigation.
- **Dalton et al. (2004)** and **Lin et al. (2008)** found supplemental irrigation to be greater than index insurance

Supplemental irrigation and index insurance as complementary drought risk management
- **Mafoua and Turvey (2003)** in New Jersey; found that insurance may be used to hedge the cost of irrigation in drought years.
Agriculture makes up about 22% of Ghana’s GDP
Employs over half the economically active population
Smallholder account for 80% of the nation’s agricultural output using 40% of the available agricultural land.
Only 0.4% of the total cultivated land is irrigated
Drought and dry spells represent an increasing threat to poor and vulnerable farmers;
This study took place in the Northern Savannah zone of Ghana (Northern, Upper East and Upper West)
- uni-modal rainfall of short duration 4 to 5 months
- high incidence of droughts and excessive evapotranspiration
- the effects of drought on food production in the area are greater than anywhere else in the country
Experimental Design

- Three year RCT funded by the USAID BASIS
- Three sets of data; baseline, Midline and Endline Surveys
- Baseline survey: Two-stages Sampling Technique
- Stage 1: Purposely select 279 smallholder farmer groups out of 791 groups.
- Stage 2: Randomly select 6 farmers per group with the intention to interview the first 3, and the 3 remaining as backup; 837 farmers were interviewed.
**Experimental Design**

**Table 1:** Sample size by region and gender

<table>
<thead>
<tr>
<th>Region</th>
<th>Male</th>
<th>Female</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Northern</td>
<td>156</td>
<td>142</td>
<td>298</td>
</tr>
<tr>
<td>Upper West</td>
<td>64</td>
<td>20</td>
<td>84</td>
</tr>
<tr>
<td>Upper East</td>
<td>182</td>
<td>213</td>
<td>395</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>402</td>
<td>375</td>
<td>777</td>
</tr>
</tbody>
</table>
Experimental Design

- Based on the information collected from the baseline survey, the 279 farmer groups were randomly assigned into three groups:
  - 1- Control; smallholder farmers were offered conventional loans, no drought index insurance;
  - 2- Treatment 1; smallholder farmers were offered insured loans where the farmers themselves were policy holders and any payouts are made directly to them
  - 3- Treatment 2; smallholder farmers were offered insured loans where the bank was the policy holder and payouts were made to the bank and credited towards the outstanding debt of farmer groups
- Randomization took place within two strata; region and loan status of the farmers to ensure balance impact across region and loan status.
Experimental Design

Table 2: Preliminary farmers in treatment and control categories by Regions

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Northern</th>
<th>Upper West</th>
<th>Upper East</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>103</td>
<td>27</td>
<td>131</td>
<td>261</td>
</tr>
<tr>
<td>Treatment 1</td>
<td>96</td>
<td>33</td>
<td>132</td>
<td>261</td>
</tr>
<tr>
<td>Treatment 2</td>
<td>99</td>
<td>24</td>
<td>132</td>
<td>255</td>
</tr>
<tr>
<td>Total</td>
<td>298</td>
<td>84</td>
<td>395</td>
<td>777</td>
</tr>
</tbody>
</table>
Experimental Design

Contingent Valuation Method (CVM) to elicit demand for SI

- Single bounded dichotomous choice questions
- CV contingent questions in the form of hypothetical referenda
  - YES or NO is preferred
  - to mirror the real world market where a price is given and the consumer chooses to purchase or not to purchase
  - to avoid bias induced by asking follow up WTP questions
- The seasonal subscription charged fee per acre is one of seven values which were determined based on the estimated mean fee per acre of GHC20.00 (Ghaba, Kenya, India)
- seven bid values ±5%, ±15%, and ±25% of the estimated means fee (Bids: GHC15, 17, 19, 20, 21, 23, 25).
- Each of this bid was randomly assigned to each respondent
Descriptive Statistics

- Rainfed agriculture (96 %)
- Average Farm size 6.20 acres ¿5.6 acres (national); farm sizes
- 97% own liveqwipjifwqstock with TLU=3.43; main staple crop maize
- Average 46 years old, 83% do not have any formal education;
- Male represents 52 % of the sample, household size is about 11 members with dependency ratio of 1.4
- 2014 Drought (53% of sample experienced); 5 years drought (47% at least 3 times and 91% at least 2 times)
- 53% believe there will drought next cropping season
**Table 3**: Experimental Integrity: WTP at Baseline

<table>
<thead>
<tr>
<th>Variables</th>
<th>Whole sample</th>
<th>Control</th>
<th>Treatment 1</th>
<th>Treatment 2</th>
<th>t- Statistic</th>
</tr>
</thead>
<tbody>
<tr>
<td>WTP Canal CSA</td>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
<td>(2) # (3)</td>
</tr>
<tr>
<td></td>
<td>78.64</td>
<td>80.01</td>
<td>76.25</td>
<td>79.61</td>
<td>3.76</td>
</tr>
<tr>
<td></td>
<td>(0.41)</td>
<td>(0.4)</td>
<td>(0.4)</td>
<td>(0.4)</td>
<td>0.41</td>
</tr>
<tr>
<td>WTP Drip CSA</td>
<td>80.69</td>
<td>84.29</td>
<td>78.16</td>
<td>79.61</td>
<td>6.13</td>
</tr>
<tr>
<td></td>
<td>(0.39)</td>
<td>(0.36)</td>
<td>(0.41)</td>
<td>(0.4)</td>
<td>4.68</td>
</tr>
<tr>
<td>Observations With Compliance</td>
<td>777</td>
<td>261</td>
<td>261</td>
<td>255</td>
<td></td>
</tr>
<tr>
<td>WTP Canal CSA</td>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
<td>(2) # (3)</td>
</tr>
<tr>
<td></td>
<td>77.4</td>
<td>77.95</td>
<td>73.53</td>
<td>80.55</td>
<td>4.42</td>
</tr>
<tr>
<td></td>
<td>(0.42)</td>
<td>(0.42)</td>
<td>(0.44)</td>
<td>(0.40)</td>
<td>-2.6</td>
</tr>
<tr>
<td>WTP Drip CSA</td>
<td>79.36</td>
<td>80.31</td>
<td>77.21</td>
<td>80.55</td>
<td>3.1</td>
</tr>
<tr>
<td></td>
<td>(0.4)</td>
<td>(0.4)</td>
<td>(0.42)</td>
<td>(0.4)</td>
<td>-0.24</td>
</tr>
<tr>
<td>Observations</td>
<td>407</td>
<td>127</td>
<td>136</td>
<td>144</td>
<td></td>
</tr>
</tbody>
</table>
Table 4: Actual (Preliminary) farmers into treatment and control groups by Regions

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Northern</th>
<th>Upper West</th>
<th>Upper East</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>57 (103)</td>
<td>12 (27)</td>
<td>69 (131)</td>
<td>138 (261)</td>
</tr>
<tr>
<td>Treatment 1</td>
<td>75 (96)</td>
<td>30 (33)</td>
<td>78 (132)</td>
<td>183 (261)</td>
</tr>
<tr>
<td>Treatment 2</td>
<td>66 (99)</td>
<td>15 (24)</td>
<td>90 (132)</td>
<td>171 (255)</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>198 (298)</td>
<td>57 (84)</td>
<td>237 (395)</td>
<td>407 (777)</td>
</tr>
</tbody>
</table>

Farmers who actually received the treatment represent 79.22 percent of farmers initially assigned to the treatment.
In treatment one (drought index insurance with farmer as policy holder), the demand of SI increased by 7.8 percent for canal irrigation and by 12.8 percent for drip irrigation.

In treatment two (drought index insurance with bank as policy holder), the demand for SI increased by 13.5 percent for canal irrigation and by 18.4 percent for drip irrigation.
## Table 6: Treatment Effect with Covariate LPM

<table>
<thead>
<tr>
<th>Type of Irrigation</th>
<th>Canal SI</th>
<th>Drip SI</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(Farmer)</td>
<td>(Bank)</td>
</tr>
<tr>
<td>WTPBid</td>
<td>−0.059***</td>
<td>−0.054***</td>
</tr>
<tr>
<td>Insurance</td>
<td>0.088**</td>
<td>0.119***</td>
</tr>
<tr>
<td>Covariate</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

*Note: *** indicates statistical significance at the 1% level, ** at the 5% level, and * at the 10% level.*
### Table 7: Treatment Effect with Covariate Logistic Model

<table>
<thead>
<tr>
<th>Type of Irrigation</th>
<th>Canal SI</th>
<th>Drip SI</th>
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<tr>
<td></td>
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<tr>
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<td>0.109***</td>
</tr>
<tr>
<td>Covariate</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

*Note: Significance levels are indicated as follows: **p < 0.01, ***p < 0.001.*
Interpretation

- First, farmers with drought index insurance might think of implicitly insuring the cost of irrigation.

- Farmers usually have high incentive to protect their yield compared to any other objective.

- Insurance in this case only provides farmers with the opportunity to afford SI which is the drought risk management tools that they really prefer as it secures and increases their production.

- Index insurance coupled with supplemental irrigation; supplemental irrigation for moderate drought and insurance for severe drought.
Conclusions

- We investigate whether a combination of index insurance with supplemental irrigation could increase farmers' livelihood compared to policy that considers these instruments separately.
- We find a significant increase of the demand for supplemental irrigation among insured farmers compared to non-insured farmers.
- Index insurance suffers from the famous basis risk problem. Besides, the cost of the fair premium is high if the insurance is to cover every little drought.
- Supplemental irrigation is very good at helping farmers to overcome two to three weeks dry spells but usually not reliable during severe drought.
- Under the joint contract, supplemental irrigation protects farmers’ yield during moderate drought and index insurance insures farmers’ income risk during severe drought.
Policy that couples supplemental irrigation with drought index insurance that triggers for severe drought may be at optimal benefit for risk averse smallholder farmers. As this have the potential to reduce basis risk and the cost of insurance and irrigation. This would allow smallholder farmers to take out risky but high yield agricultural technologies.
Thank You

Questions and Comments