The Agricultural Technology Adoption Initiative (ATAI): Emerging Insights

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FAO – MAFAP meetings

Tuesday November 28, 2017

I. Motivation, Intro to ATAI

II. Constraints to technology adoption

III. “Emerging Insights”

IV. Working together (ATAI, MAFAP, FAO)

What is hampering technology adoption?

Inefficiencies constraining technology adoption

1. Credit markets
2. Risk markets
3. Information
4. Input and output markets
5. Labor markets
6. Land markets
7. Externalities

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Q: What helps and what hinders smallholder farmers' **adoption** of technologies and access to markets?

Which approaches **impact** farmer profits and welfare?

A: ...well, let's tackle this scientifically

- ➔ Review available evidence: identify key research needs since 2009
- ➔ Mobilize research networks: "clearinghouse" rather than consultant model, fund competitively-selected, high-quality randomized evaluations
- ➔ Share findings: inform relevant decision-making

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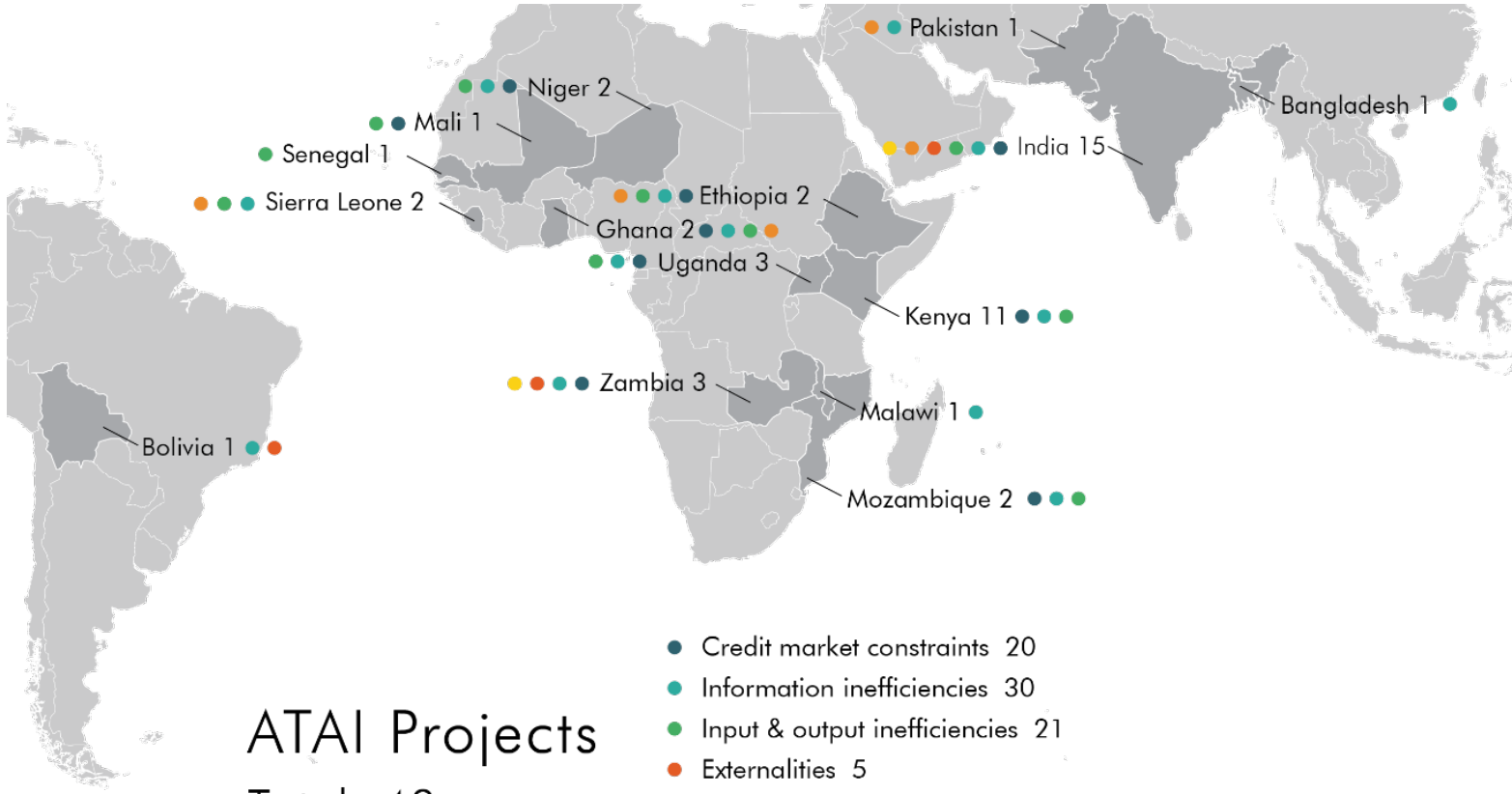
Since 2009 have funded

- 48 evaluations in 15 countries in South Asia and Africa
- each study with field partners
- >100 affiliated researchers



ATAI Projects
Total: 48

- Credit market constraints 20
- Information inefficiencies 30
- Input & output inefficiencies 21
- Externalities 5
- Risk market inefficiencies 11
- Labor inefficiencies 5
- Land inefficiencies 0

Co-managed by:

CEGA Center for Effective Global Action at UC Berkeley

J-PAL ABDUL LATIF JAMEEL POVERTY ACTION LAB at MIT

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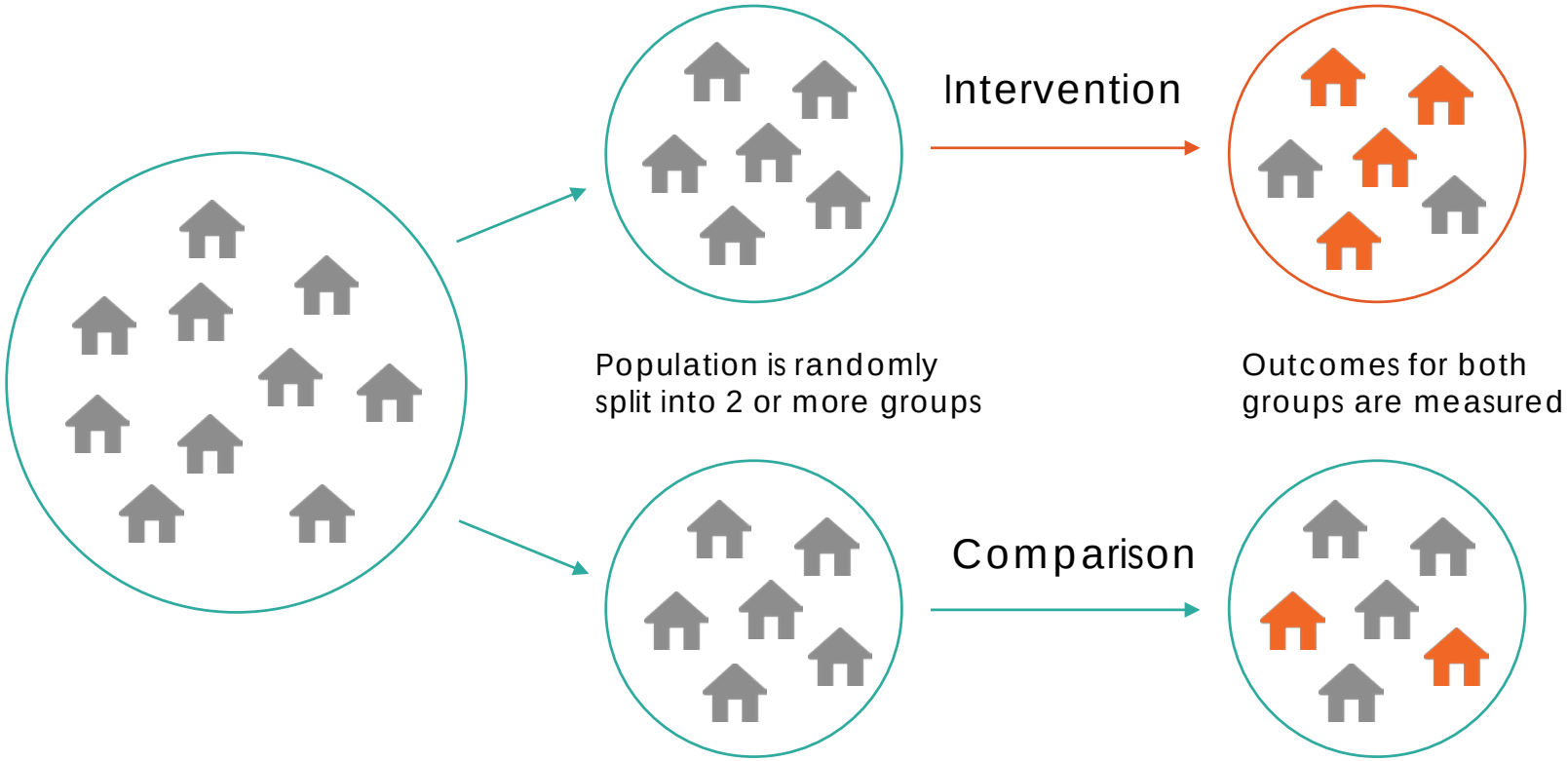
UKaid from the British people

Randomized evaluations provide a highly rigorous estimate of program impact

Before the program starts, eligible individuals are randomly assigned to two or more groups so that they are statistically identical before the program.



Two groups continue to be identical, except for treatment

Any differences in outcomes between the groups can be attributed to the program

Emerging Insights on Constraints to Adoption

1. **Credit markets**
2. Risk markets *(covered in afternoon seminar)*
3. **Information**
4. **Input and output markets**
5. Labor markets
6. Land markets
7. Externalities

Emerging Insights: Credit Markets

Credit constraints in action

There is limited credit available

Farmers struggle to save income from one harvest to the next

Farmers don't have collateral to back a loan

Farmers lack financial literacy

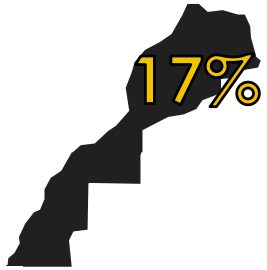
Preview: credit for smallholders

- Farmers' credit needs are different from urban microcredit customers
- Take-up of traditional credit products is often low
- Successful credit interventions
  - Tailor products to reduce costs and risk for lenders
  - Account for seasonal variation in income (and prices)
- Credit constraints exist, but may not be the primary barrier to increasing profitability

Hard to push financing to agriculture

- Lenders dislike agricultural loans
  - Pervasive default risk due to correlated weather shocks
  - Costs of servicing clients are high, particularly for smallholders
  - Smallholder farmers have no credit histories; land tricky as collateral
- Borrowers appear to have low demand for loans
  - Profits in farming may be low absent complementary investments
  - Risks of unavoidable default are high
- Few self-sustaining agricultural credit markets for smallholders
  - Urban microfinance not suited; difficulties in transplanting it to agriculture
  - Few agriculture-specific products
  - Low demand from farmers

Take-up is low



Morocco: 17%, with no other lenders in the area

Sierra Leone: 25%, i.e. 50% lower than break-even rate

Mali: 21%, compared to full take-up of cash grants

Beaman et al. 2014, Casaburi et al 2014, Crepon et al 2015

Impacts on agricultural activity, inconclusive on profits

- Mali
  - Households offered loans spent more on fertilizer, insecticides
  - Cash grants increased farm profits; loans increased value of output but not profits
- Morocco
  - Loans used to invest in agriculture and husbandry (purchase cattle or sheep)
  - Agricultural income increased, other sources decreased
- Kenya
  - Farmers switched to higher-value export crops, (market collapse eliminated any potential profits)
  - Farmers stored or bought grain when prices were low, sold when prices rose: increased profits
- Malawi
  - Farmers allocated more land to paprika, a cash crop
  - Profit estimates positive but imprecise and not statistically significant

Beaman et al 2015; Crepon et al 2015; Ashraf et al 2009; Burke 2017; Yang et al 2012

Interventions to address credit constraints

Supply-side

- Microfinance model is inappropriate for farmers
- Banks often do not lend to the agricultural sector

Demand-side

- Lack of credit may not be the primary binding constraint
- Take up of credit is low

Interventions

A. Improved information about borrowers

B. Flexible collateral

C. Account for seasonal variation (production, prices)

D. Saving to invest: Labeling, Commitment

Ashraf et al. 2006; Banerjee et al. 2013; Basu & Wong 2012; Beaman et al. 2014; Boucher et al. 2008; Burke 2017; Carter et al. 2013; Casaburi et al. 2014; Crepon et al. 2015; De Janvry 2010; De Laat et al. 2016; Duflo et al. 2008; Fink et al. 2014; Gine et al. 2010; Gine et al. 2011; Karlan et al. 2010; Matsumoto et al. 2013; Tarozzi et al. 2013

Improved information about borrowers

Lack of information makes banks unwilling to lend

- hard to assess creditworthiness
- cannot credibly threaten to cut off future credit

Credit bureaus

- transformative institution when lender info is poor, competition high
- can allow borrowers to substitute ‘reputational collateral’ for physical collateral

Alternate technologies such as fingerprinting borrowers

- biometric identification cannot be lost, forgotten, stolen

McIntosh & Wydick 2006; de Janvry et al. 2010; Gine et al. 2011

Flexible collateral

- Land may be an unacceptable form of collateral in smallholder agriculture
  - Banks: titles unclear, seizure under default costly & difficult
  - Farmers: Loss averse

- However, many large agriculture investments can be self-collateralizing (leasing)

- Warehoused grain as collateral

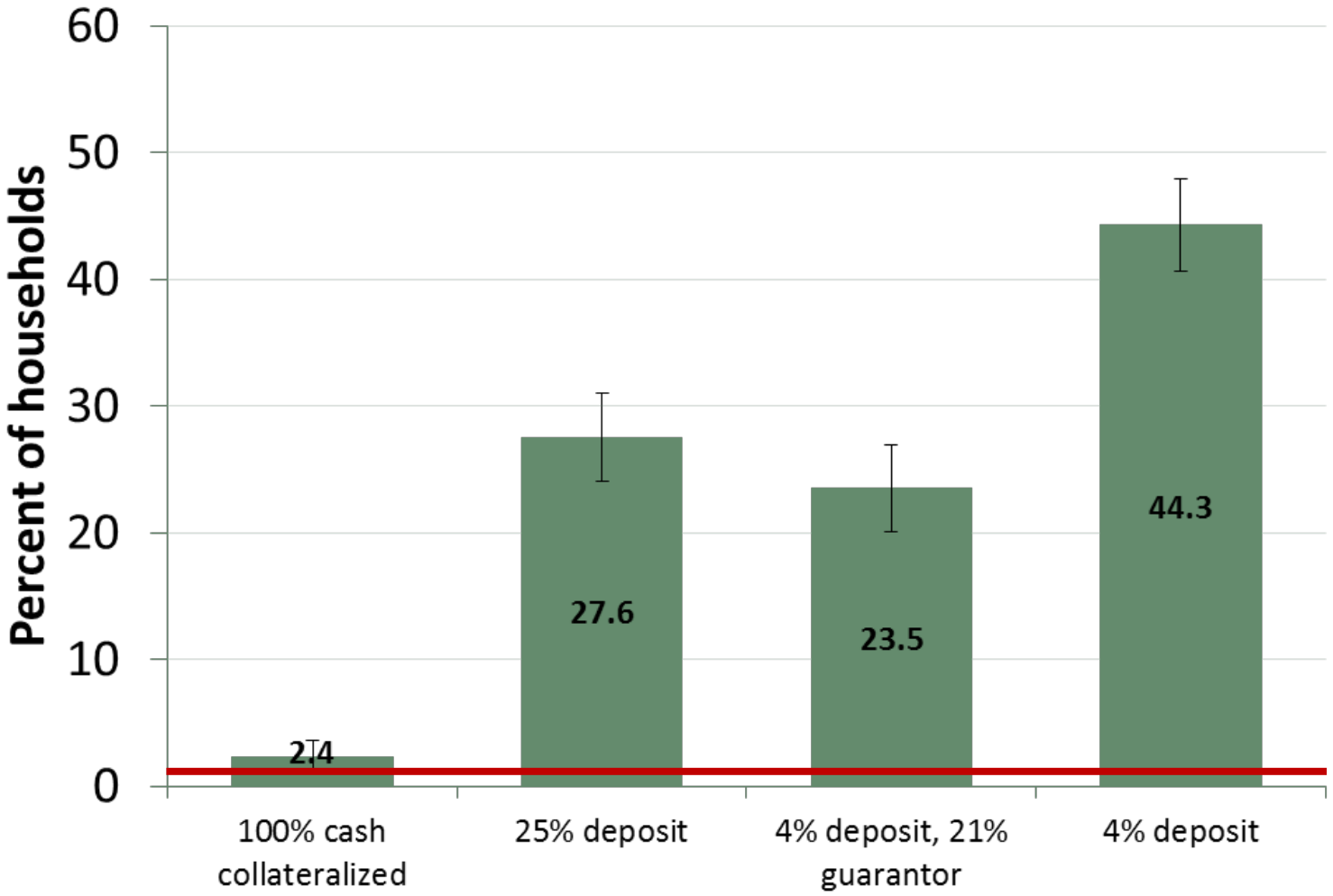
Pender 2008, Basu and Wong 2012; Burke 2014; Casaburi et al. 2014

Rainwater harvesting tanks in Kenya

- Tanks for dairy farmers to collect water for cattle
- Variations in loan offers
  - Standard: 100% secured
  - 25% deposit, tank as collateral
  - 4% deposit, 21% pledge from guarantor, tank as collateral
  - 4% deposit, tank as collateral

De Laat et al. 2015

Rainwater harvesting tanks in Kenya



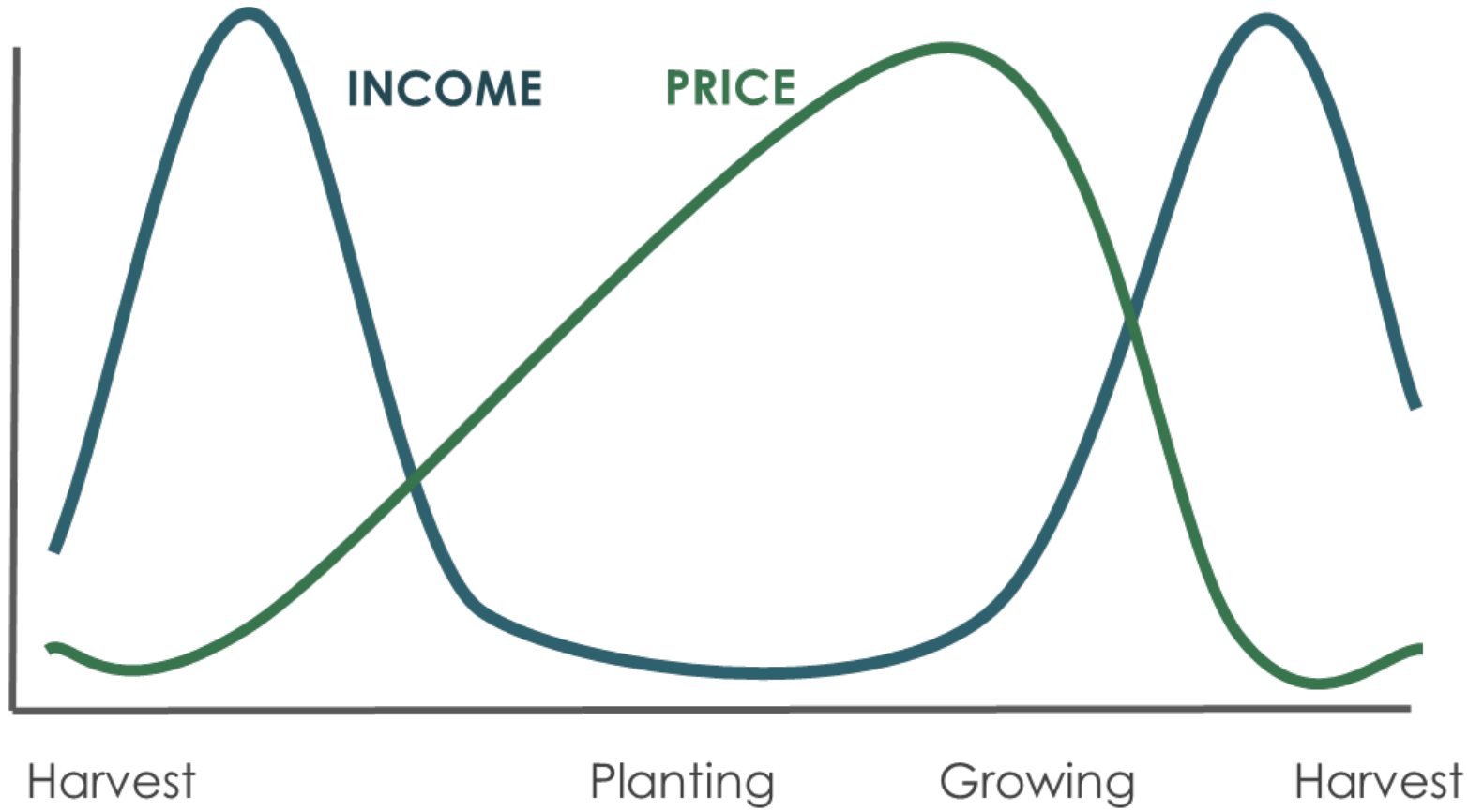
Increased take-up without harming lender's profits

One default in all groups

De Laat et al. 2015

Account for seasonal cycles of production & prices

- Aggregate (not idiosyncratic) risks
- Negative correlation of production and prices
- Seasonal cycles:



Designing products for seasonality

- Delaying repayment of loan until after harvest
- Loans for consumption during “hungry season”
- Storage loans to allow farmers to take advantage of price fluctuations
- Savings products to save from harvest until planting time

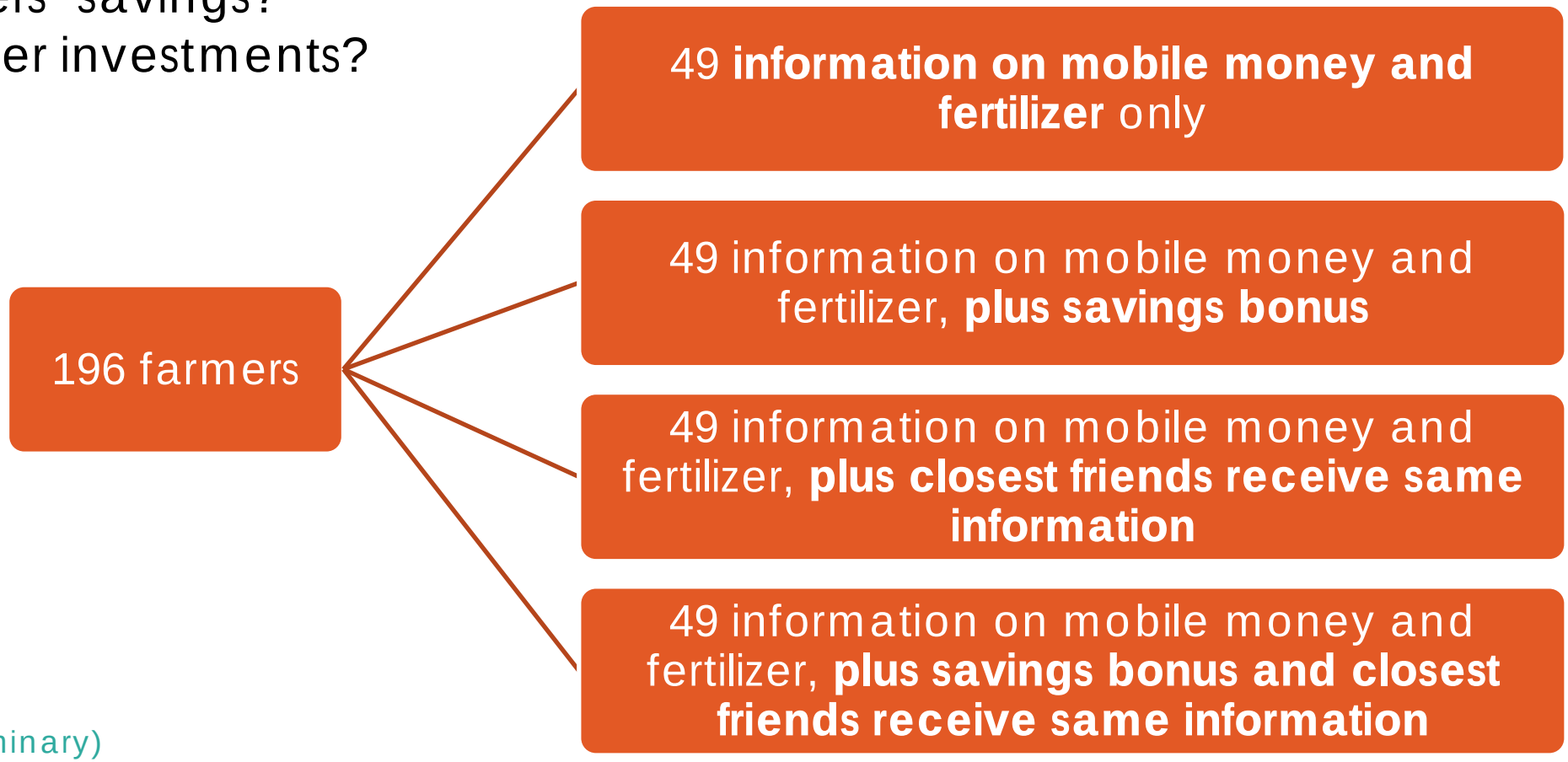
Harvest-time storage loans in Kenya

- Loans allowed farmers to:
  - Buy/keep maize at low prices
  - Store while prices rose
  - Sell later at higher prices
- Temporal arbitrage increased profits, ROI of 28%
  - Profits concentrated in areas where fewer farmers were offered loans
  - See effects of credit intervention on smoothing seasonal price fluctuation: benefits program non-recipients (GE effects)

Burke 2017

Digital Savings Services and Fertilizer in Mozambique

How can we
- increase farmers' savings?
- increase fertilizer investments?



Batista et al. 2015 (preliminary)

Digital Savings Services and Fertilizer in Mozambique

- Effects of savings bonus
  - Increased use of mobile money, including deposits
  - Increased non-frequent expenditures
  - Increased probability of fertilizer use
  - Decreased social pressure to share resources
- Effects of social network
  - Increased use of mobile money
  - Decreased social pressure to share resources

Batista et al. 2015 (preliminary)

Maybe credit is not the binding constraint

In Northern Ghana: compared cash grants, weather index insurance, or combination

- Investment and activity increased about equally in cash groups and insurance groups
- But when risk constraint relieved, farmers were able to find credit from other sources

In Odisha, India: farmers increase borrowing in response to risk-reduction

- Early in growing season of the second year after shifting to flood-tolerant rice production, farmers are 36% more likely to utilize credit from local co-ops

Karlan et al 2013; Emerick et al. 2015

Summary: Credit

- Credit is key to investment, but many markets are too risky and too low-return to be viable without additional investment
- Farmers' credit needs are different
- Take-up is often low
- Complementary institutions critical for 'moving up' with credit: credit bureaus, credit registries
- Some promising ways of using information, timing, and new types of collateral to unlock credit
- Access to credit affects farm activities, but mixed evidence on profit suggests other constraints may be binding
  - Risk is a dominant issue for credit; insurance and credit likely to need to be grown hand-in-hand

Emerging Insights: Risk

How does risk constrain adoption?

- Agriculture is inherently risky activity
  - Weather and disease risks are aggregate, affecting all farmers in geographic area
- Farmers may lose large portion of harvest to extreme weather event
- Without any way to mitigate or insure risks, investment in crops or technologies appears to be an unsafe gamble
  - Higher-value crops may also be more sensitive to weather
- Exacerbated by risk aversion and ambiguity aversion

Summary: Risk

- Risk is a constraint for smallholder farmers
- Commercial index insurance targeted directly at farmers unlikely to solve the problem
  - Price, distrust, lack of financial literacy, basis risk
- Alternatives to help farmers manage risk
  - Rethink insurance: provide subsidized policies as an alternative to cash transfers
  - Sell to institutions such as ag lenders
  - Promising preliminary results on risk-mitigating crops

Emerging Insights: Information

Why do farmers need information?

- Learning about a new agricultural technology is a fundamentally hard learning problem
- Information helps famers assess novel technologies, their risk profile and potential profitability
- If a farmer is to use a new technology effectively they need to know:
  - That it **exists**
  - Something **about its benefits and costs**
  - How to **use it effectively**

Preview: Information

- Agricultural extension is the most common model
- Use of traditional extension services is low, limited evidence of impact
  - May promote unprofitable technology (focused on yields)
- Extension can be effective when
  - Overcoming a behavioral bias (procrastination)
  - Introducing new or novel technologies (risk-reducing seeds)
  - Revealing hidden qualities of ag technology
  - Providing accessible, tailored, and timely information
  - How to mobilize networks (similar farmers, multiple farmers)

Beaman et al. 2015, BenYishay & Mobarak 2014, BenYishay et al. 2015, Blair et al. 2013, Casaburi et al. 2014, Cole & Fernando 2012, Duflo et al. 2008, Duflo et al. forthcoming, Hanna et al. 2012, Islam 2014, Kondylis et al. 2014, Tjernstrom 2015, Waddington et al. 2014

Potentially big costs to ignoring training w/ new tech

Upland NERICA Rice introduced in Sierra Leone

- In villages where seeds coupled **with extension, yields increased by 16%**
- **In villages where seeds were simply distributed, yields fell**

Without extension, hard for farmers to learn about variety's yield potential, and necessary agronomic practices to reap benefits

Glennerster and Suri, forthcoming

Improving extension services

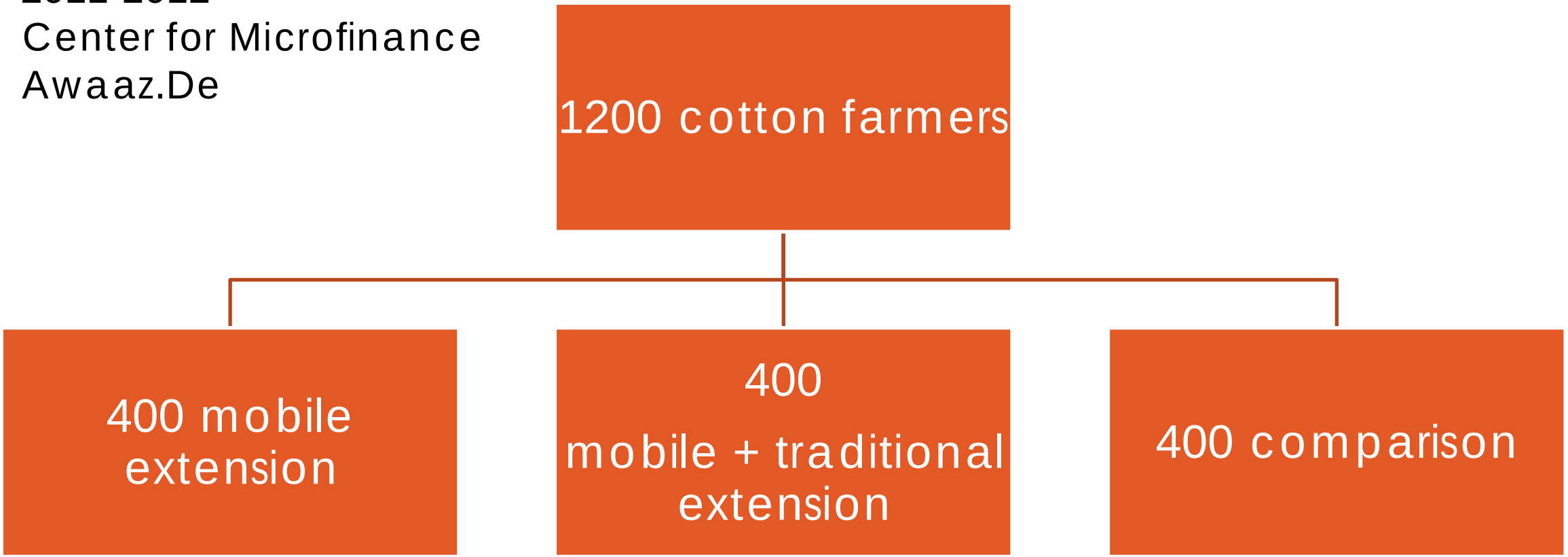
- Incentives may improve adoption
  - Extension officers
  - Lead farmers
- Feedback on extension may help
  - Improves satisfaction
  - Improves knowledge in certain circumstances
- ICT to reach farmers directly
  - Interventions using mobile phones to provide information to farmers have been shown to increase adoption and improve yields

BenYishay and Mobarak 2015, Ben Yishay et al. 2015, Jones and Kondylis 2015, Masset and Haddad 2014

Cole and Fernando 2016, Casaburi et al. 2014

Mobile Phone-Based Agricultural Extension in India

- Gujarat, India
- 2011-2012
- Center for Microfinance
- Awaaz.De



Cole and Fernando 2012, Cole and Fernando 2014

Mobile Phone-Based Agricultural Extension in India

- High take up and use of mobile platform

- Switch to more effective pesticides
- Increased adoption of cumin
- Some evidence of increased yields in cotton and cumin

- Traditional extension had no effect

- Estimated return of $10 per $1 spent

Cole and Fernando 2012, Cole and Fernando 2014

Precision Agriculture for Development (PAD) Gujarat, Kenya, Ethiopia, and others underway

Based on India and Kenya ATAI RCTs and ongoing followups:

1. Aggregating Data Inputs

General data (weather, potential yields, soil quality, satellite imagery) are combined with farm-level data (crop choice, input use, actual yields, soil samples, farmer demographics)

2. Generating Precision Recommendations

Individualized recommendations are generated for each farmer

3. Communicating with Farmers

Recommendations are sent to farmers via a suite of mobile tools including SMS, voice, and video

4. Acting and Optimizing

Farmers implement recommendations and input results data to improve future analysis through machine learning techniques

System Characteristics

Hybrid model data generation (experts and farmers)
Constant experimentation and learning
Farmer feedback – two way communication

ICT and Contract Farming in Kenya

Can simple, well-timed reminders and a service hotline improve adoption of inputs and increase yields?

- High take up of the SMS and hotline interventions
- SMS messages lead to 11.5% yield increases
- Access to hotline decreased the
  - likelihood of not receiving fertilizer
  - likelihood of fertilizer delivery being delayed

CAVEAT: Researchers are replicating the SMS intervention with a larger sample and so far so **no effect on yields**

Casaburi et al. 2014 (forthcoming)

Target Behavioral Barriers

- Help farmers overcome procrastination
  - Reminders to use inputs
  - Well-timed information delivery

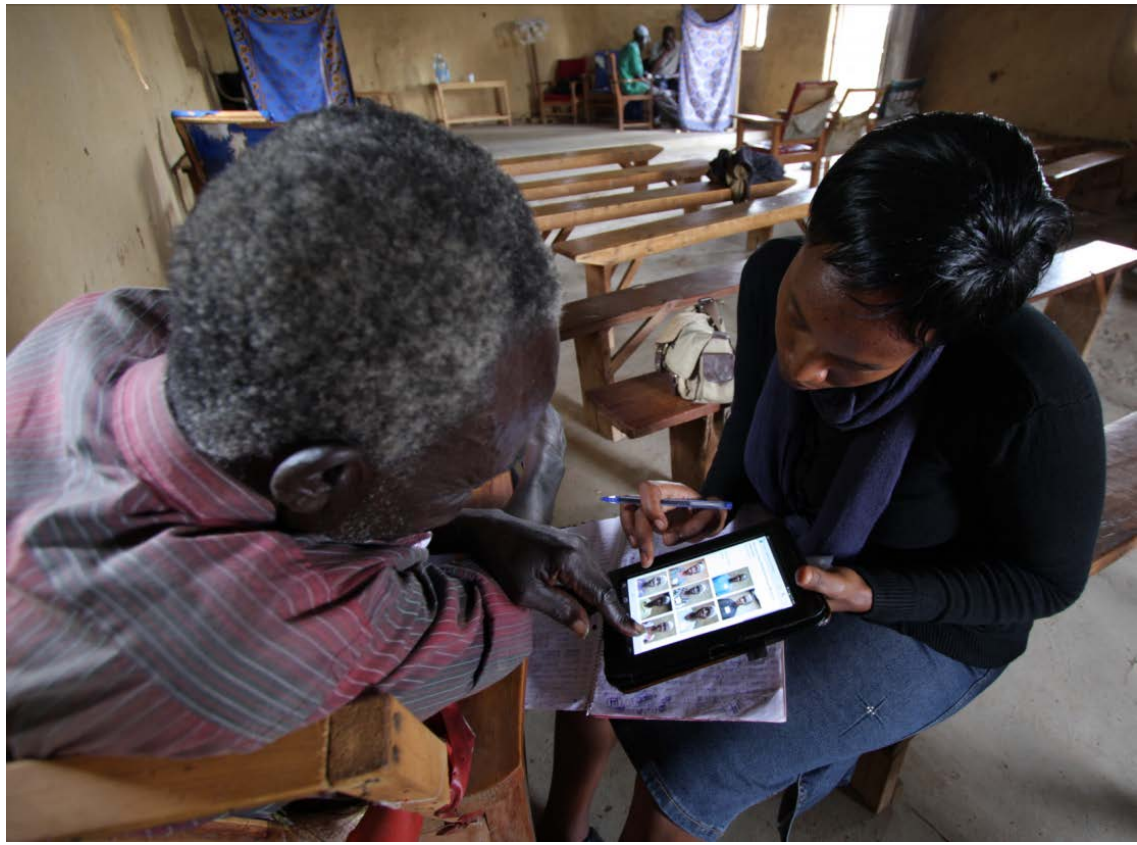
- Help when information is novel, complicated, or highly context-specific and learning is hard
  - Farmer-led experimentation to experience firsthand applied to their personal conditions
  - Simple tools to focus and aid learning

Duflo et al. 2011, Casaburi et al. 2014 , Cole and Fernando 2014;

Hanna et al. 2012, Duflo et al. forthcoming, Islam 2014

Social learning

- (Much) extension relies on social learning for the last mile
  - Too expensive to train everyone who you hope to reach
- Lots of good evidence that social learning happens in agriculture
- Key question: How to design extension services to maximize social learning?
  - Breadth versus depth of treatment with limited resources



Ben Yishay et al. 2015, Beaman et al. 2015, Tjernstrom 2015, BenYishay and Mobarak 2013

Social learning

- The messenger matters
  - A farmer is more likely to demand a new technology if a greater proportion of his/her network is demonstrating it
  - Lead farmers most closely resembling target farmers were more effective at promoting a new technology
- Designing extension systems so that some farmers will be able to observe multiple data points is critical
  - need multiple demo plots or lead farmers per village – and intensity of exposure may be more important than equity

Ben Yishay et al. 2015, Beaman et al. 2015, Tjernstrom 2015, BenYishay and Mobarak 2013

Summary: Information

- A lot of specific information is necessary for farmers to make informed decisions on technology adoption
- Information is only useful to the degree that it is profitably actionable
- Business-as-usual extension is often ineffective
- Improved extension may be critically important for new tech adoption:
  - When tech is not readily understood, and/or is complicated by heterogeneity
- Extension may be improved
  - Incentives and Feedback
  - ICT; Adapting the pedagogical model (timely, accessible, tailored info)
  - Selecting the messenger, leveraging social networks

Emerging Insights:
Input & Output Markets

Preview: input/output markets

- Price information has limited positive effects on farmers, though other members of the value chain may benefit
- Infrastructure investment can decrease transport and input costs
- Preliminary and ongoing work on:
  - Contracts
  - Market linkages
  - Crop-quality and pricing in supply chains

Input and output market inefficiencies

Farmers may be unable or unwilling to adopt new technology due to barriers within:

Input Markets

- Missing or incomplete supply chains
- Unprofitably high input prices

& OR

Output Markets

- Lack of access to additional markets
- Low prices for yields, including high quality crops

Impacts of price information

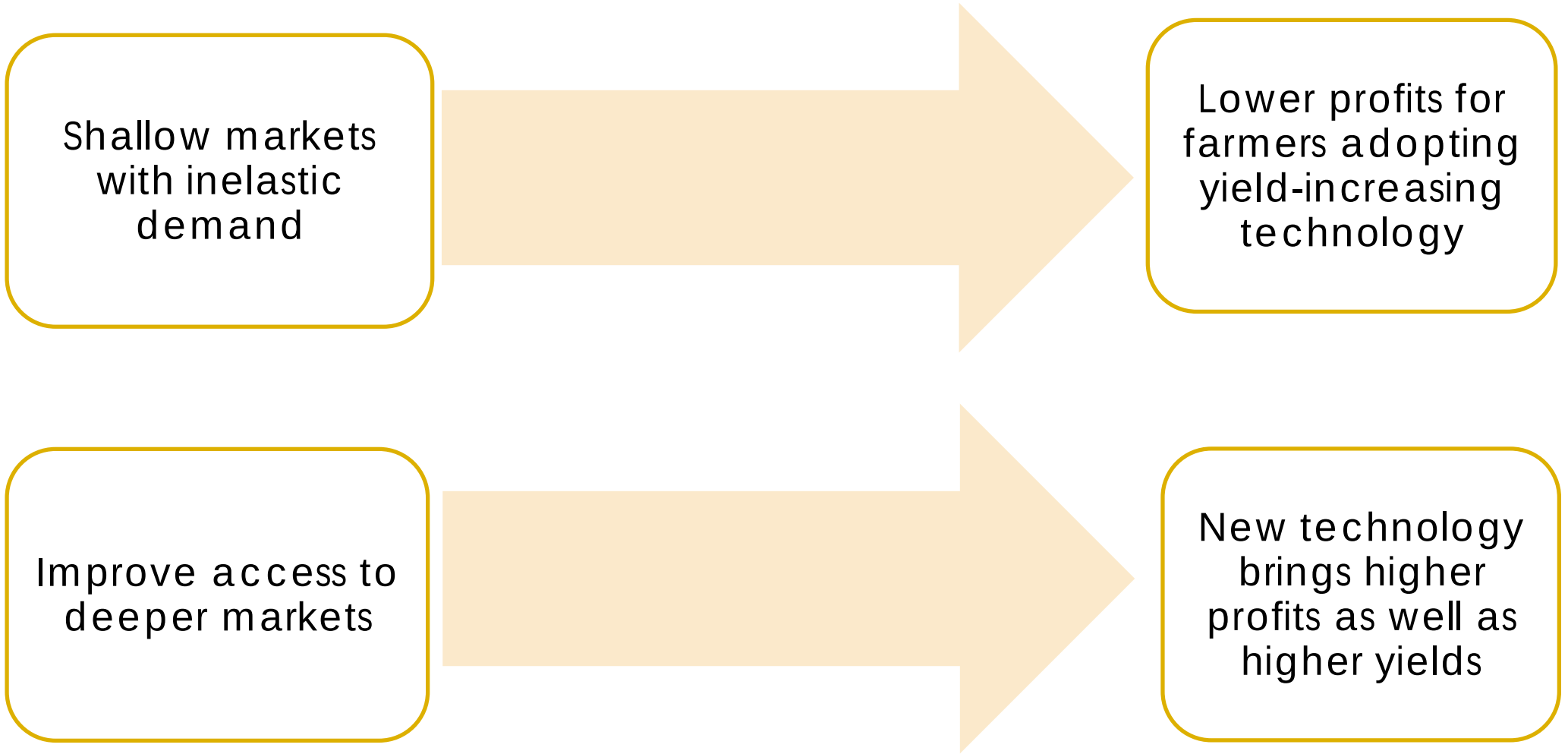
Theoretically:

Evidence shows:

- Members of value chains who can act on price information can benefit
  - Traders and fishermen saw reductions in price dispersion, potential profit improvements
- Unlikely to affect farmer incomes or price levels
  - Farmer lack bargaining power
  - Transport costs remain high
  - Farmers may change behavior, but on average no gain for farmers

Aker 2010, Jensen 2007; Goyal 2010, Fafchamps & Minten 2012, Mookherjee et al 2013

Market Linkages

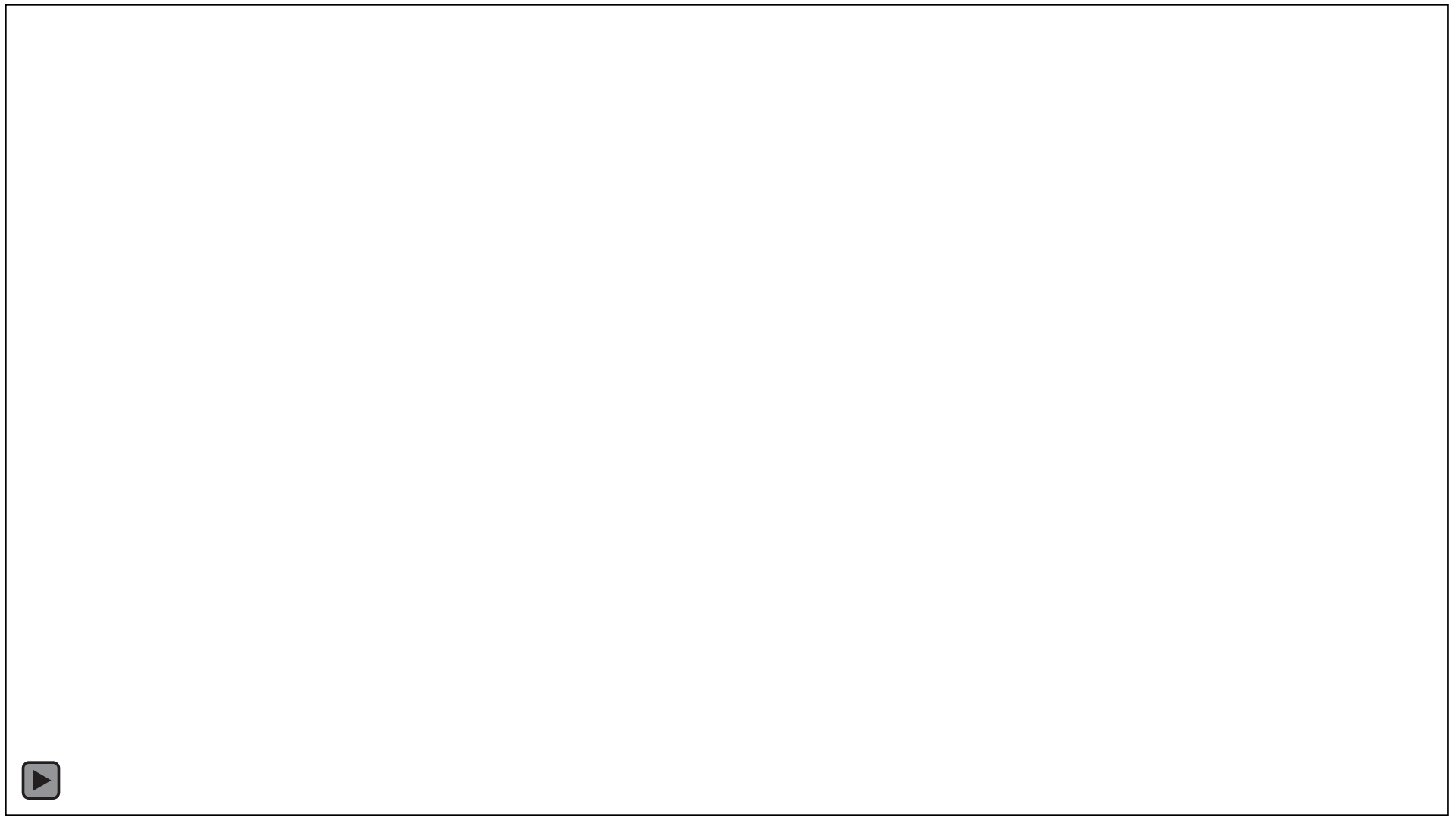


Building Market Linkages in Uganda

- Isolated, shallow markets: imbalances in food supply, limited market opportunities
- Can new contract farming services and an ICT-enabled trader alert system improve market depth in favor of smallholders?
  - Overcoming transaction mismatches through market information and “e-bulking”
  - Experimental cross-cuts with financial services, price information
- Impacts on input use, yields, market linkages, sales volumes, price dispersion, profits?
  - Impacts of contractual risk and credit in determining the probability of successful contracting?

Bergquist et al., forthcoming

Market Price Data



Integrating Value Chains to Improve Food Safety in Kenya

- Severe health consequences of Aflatoxin
- Effective preventative technologies are available, yet rarely adopted by smallholders
  - Contamination risk to own food supply
  - Also prevents smallholders' access to potentially higher-value output markets
- Rigorously evaluating adoption of preventive biocontrol Aflasafe KE01 and mobile dryers, and ex-post testing
  - When access to output markets facilitated: food safety conditional purchase commitment from a formal sector buyer
  - Whether introduction of aflatoxin testing reduces aflatoxin exposure among the poor

Hoffmann et al., forthcoming

Expected Market Reforms and Crop Quality in Senegal

- Onions would be sold based on weight (not volume), with quality certification
- Information campaign about upcoming reform and training on quality-enhancing cultivation
  - improved onion quality: more quality-enhancing fertilizers, more onion sorting
  - led to substantial income gains (10.7 percent increase)
- Despite gains, market reform not sustained given traders' resistance

Bernard et al. 2017

Understanding trader-farmer relationships is key

- These relationships can affect farmers' selling decisions
  - Sierra Leone: palm oil producers were hesitant to break relationships with traders by storing harvests rather than selling at low prices
  - India: potato farmers' ex-post bargaining relationships with traders limited the effectiveness of price information provision
- Not "just" intermediaries, traders can stand-in for financial institutions
  - Sierra Leone: cocoa market traders build committed relationships with producers through credit provision. Cocoa quality premiums aren't passed through to producers via better prices, but credit provision increases
  - Kenya: dairy farmers preferred to sell to co-ops and receive lower, bulked payments (like savings) than sell to traders and receive daily payments

Casaburi et al 2014; Mitra et al 2015; Casaburi et al 2017; Casaburi and Macchiavello 2016

Summary: input/output markets

- Price information:
  - has limited positive effects on farmgate prices, suggesting asymmetric info not a source of market power for traders
  - More evidence that info leads to convergence across markets. Still leads to welfare benefits for farmers.
- Infrastructure investment can decrease transport and input costs
- Recent, preliminary, and ongoing work on:
  - Contracts
  - Market linkages
  - Crop-quality and pricing in supply chains

Overall Summary

- Many interventions that improve yields do not subsequently see widespread adoption. Why not?
- Profitability is key.
  - There is no adoption 'puzzle' if, given input prices, output prices, and risk, a rational farmer would choose not to invest.
  - Important to think about scoping conditions: where would a new technology be likely to generate the highest farmer profit?
- RCTs are an excellent way to figure out what does *not* work, as well as what does!

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How can we work together?

- Where opportunities to randomize, team up with our research networks: ATAI can help "matchmake"
- Bi-annual research funding competitions for affiliated RCTs
- Opportune policy windows to apply existing evidence
  - e.g. Senegal onion market reform recommendations from ATAI connection since September

What else? What do these look like in practice?

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Thank you!

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