Agricultural technology adoption and impact: Explaining the puzzle of low adoption

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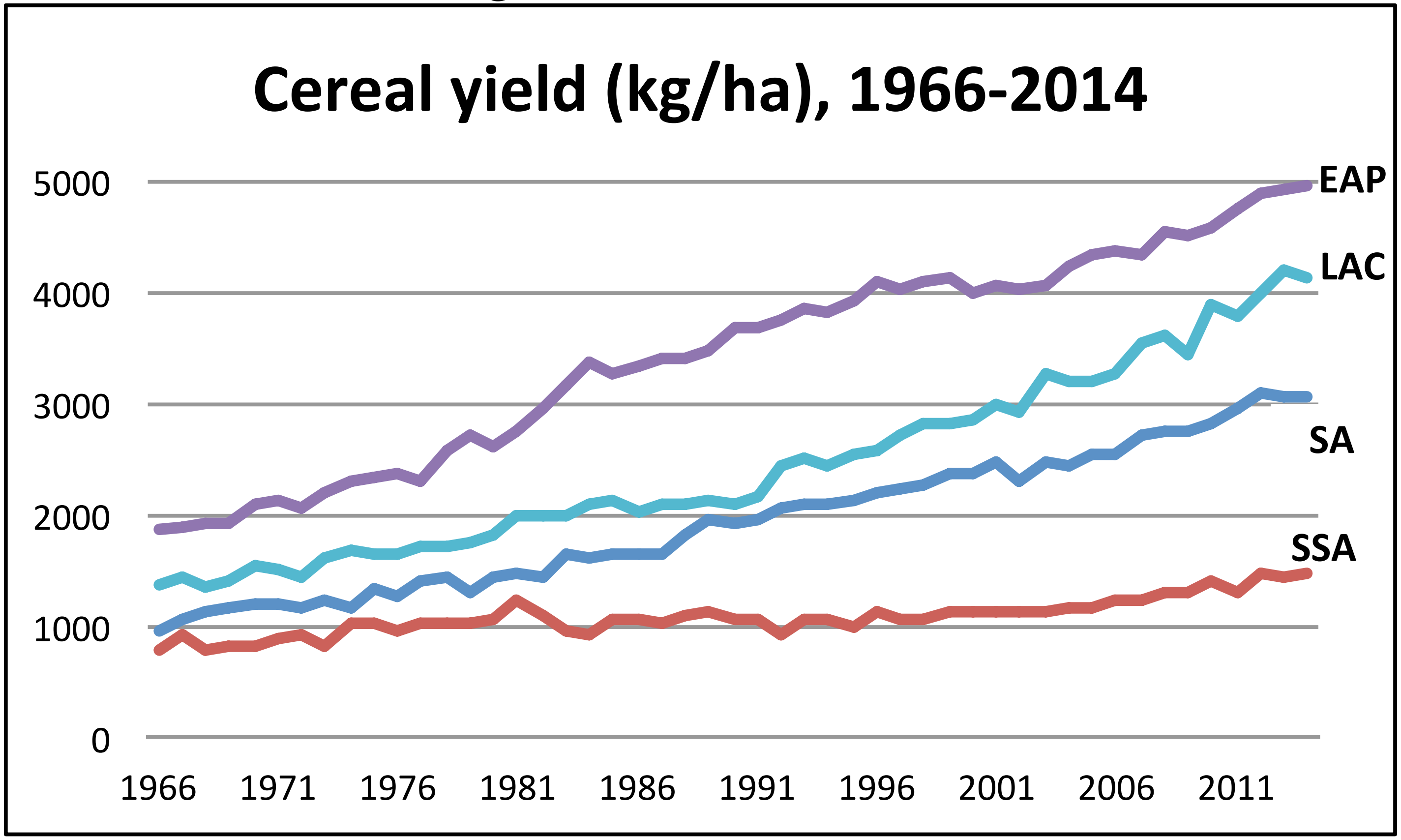
The role of agriculture for development: The puzzle of neglect

- Currently, only 2 SSA countries meet the CAADEP goal of spending 10% of public budget on ag, down from 10 in 2009
- Widening gaps between SSA and other regions for cereal yield, fertilizer use, and irrigation



Objective of this presentation:

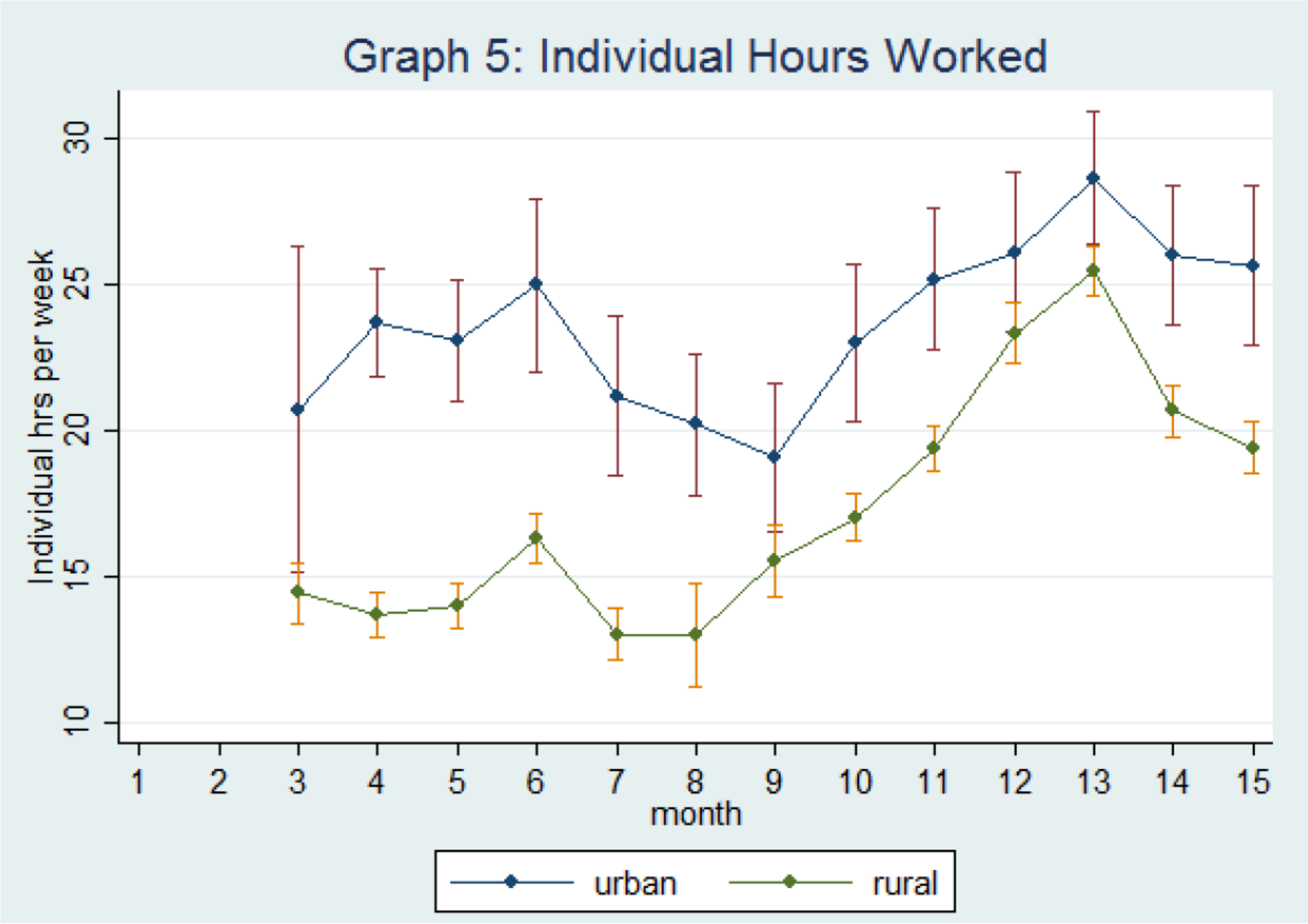
- Growing yield gap for SSA suggests the need to overcome a low-level equilibrium trap for **technology upgrading**
- Neglect of agriculture not due to ignorance, but to policy choice justified by **adoption failures**
- Observe limitations to the dominant **Supply-driven** approach to technology adoption that starts from existing (presumed adoptable) technologies and seeks ways of removing constraints to adoption
- Suggest implementing a more **Demand-driven** approach that seeks to offer technologies desired by farmers, customized to their heterogeneous circumstances
- Key however is to make a D-driven approach **cost effective**
- We develop this argument in **7 steps**, followed by a **conclusion**

Step 1: Agriculture has a key role to play for development, yet has failed to deliver in many countries

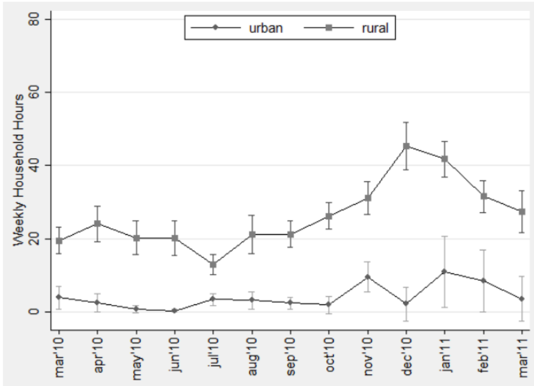
- **Role of agriculture** for growth (WDR 2008) and for poverty reduction (SDG1) well recognized:
  - WDR 2008: agriculture and linked sectors key for **growth** in the "agriculture-dependent" countries
  - SDG1: most of the world **poor** are in SSA, rural, dependent on agriculture directly or indirectly for their livelihoods
- **Technology adoption** is key for agriculture to fulfill these development functions due to rural population growth and land constraints
- Yet, the **growing yield gap** shows that technology is failing to increase **land productivity** to support growth
- **Labor productivity** in smallholder farming is also low and failing to increase to support rising farm incomes

Step 2. Why are rural households poor? The question of labor calendars

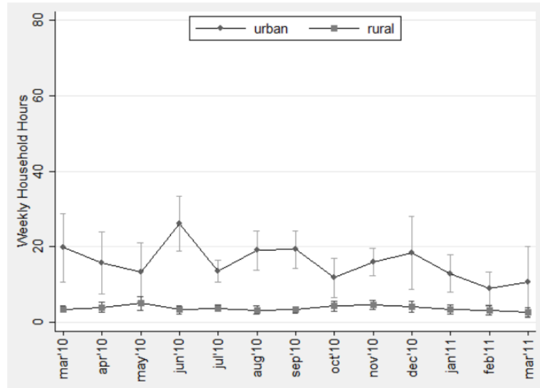
- **Labor productivity** in agriculture a key determinant of income for smallholder farmers and wage workers
- Observe average urban/rural labor productivity per working-age adult (Malawi, LSMS-ISA)
  - Annual = 2.2
  - Per hour worked = 1.5
- In general:
  - Large urban/rural gaps in labor productivity **per person per year**
  - But rather low gaps in labor productivity **per hour worked**
- Hence raises the issue of rural vs. urban **labor calendars:**



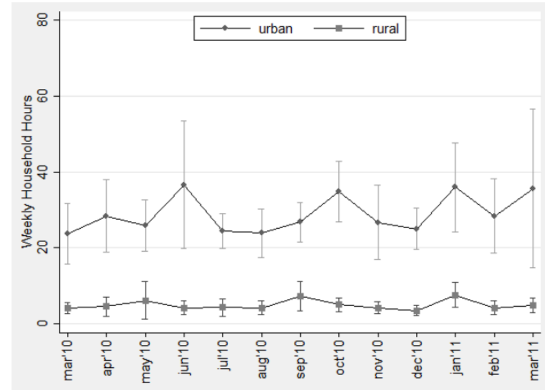
Labor calendars for rural and urban households in Malawi (LSMS-ISA): rural individuals work less and more seasonally



(a) Hours Supplied to Agriculture



(b) Hours Supplied to Household Businesses



(d) Hours Supplied to Wage Labor

Agriculture is the highly seasonal activity for rural households. Other rural activities (household business, wage labor) are non-seasonal, but not counter-cyclical to agriculture

Conclude

- The LSMS-ISA data show that rural households have nearly **equal hours worked at peak agricultural time** (planting), **with rather similar labor productivity per hour worked**, but much **lower hours worked** beyond peak times and lower annual labor productivity
- Thus, rural poverty is importantly due to high seasonality of **rural labor calendars**
- Hence, to reduce poverty, there is a key role for development strategies (**agricultural and rural transformations)** that increase **annual** labor productivity by filling and smoothing out rural labor calendars

Step 3: Technology adoption is for more than yields. It is to fill in labor calendars with Ag and Rural Transformations

The function of technology adoption is to support **four transformations**:

A **Green Revolution** (GR) to increase yields of staple foods

An **Agricultural Transformation** (AT) to diversify farming systems toward high value crops

A **Rural Transformation** (RT) to diversify rural households' sources of income toward the rural non-farm economy (RNFE)

A **Structural Transformation** (ST) with labor migration toward urban environments and a decline of the share of ag in employment and GDP

A pre-requisite to **inclusive transformations** is **access to Assets** (land, animals, human capital) as in BRAC ultra-poor.

The desirable policy sequence in using Ag-for-Development is consequently: **Assets/GR/AT/RT/ST**

Step 4. Supply- vs. Demand-driven approaches to technology adoption

The theory of change used to promote technology adoption in SSA has typically followed a **Supply-driven business strategy**

- The **S-driven strategy** starts from the perspective of **the supply side**: there exist technologies (fertilizers, seeds, agronomy) that increase yields and are available for adoption but are not being adopted
- It then **works on the demand side**:
    - What are the effective **constraints** to the adoption of available technologies?
    - What can be done to remove these constraints?
- This was the initial **ATAI whitepaper** approach

An alternative theory of change: a **Demand-driven business strategy** (INSEAD Blue Ocean Strategy)

- The **D-driven strategy** starts from the perspective of the **demand side**:
  - Who are the "**extreme non-adopters**" (most likely to adopt given their circumstances) and why do they **not adopt**?
  - What are the **technology specifications** for which they have a WTP given their **particular** circumstances?
- It then **works on the supply side**:
  - How to **adapt/customize** agricultural technology to what farmers would like to adopt (innovation, assembly)?
  - How to make this particular technology **locally available** for adoption?
  - How to provide **information** on this technology to farmers so they can understand it and eventually decide to adopt?

Step 5. Why a GR is difficult to achieve in rainfed SSA: Heterogeneity and complexity limit adoption

- **Heterogeneity** in rain-fed agroecological conditions limits adoption to farmers with the necessary **complementary factors**
- **Lack of complementary factors** typically limit adoption to **some 30-40%** (say) of the farm population in rain-fed farming:
  - **Credit** vouchers: only 28% able to use (Carter)
  - **Index insurance**: only 6 to 8% uptake at market price (ATAI)
  - **Fertilizer**:
    - Only 37% benefit due to lack of complementary factor: lime for soil acidity in Zambia (Jayne)
    - Only 55% benefit due to lack of complementary factor: organic fertilizer for soil carbon content in Madagascar (Barrett)

- **Complexity**: Rain-fed agriculture makes **learning** about the production function particularly difficult. Heterogeneous conditions across farmers limit social learning (Tjernström). Short time series available to understand stochastic events
- **Dynamics: Climate change** makes learning a moving target
- **Limited technological options**: Little hope of raising yield ceiling. Focus on yield gains via dealing with heterogeneity (**customization**) and with extreme events (**resilience** to drought, flood, temperature)
- Example of a **S-side approach failure**: NERICA raises yields but rejected by consumers, resulting in dis-adoption

→**Proposition:** Success with a GR for rain-fed agriculture beyond the **40%** adopters under a **S-driven Strategy** requires designing a **D-driven Strategy** for the **remaining** non-adopters

Step 6. S-driven Strategy: Progress made using RCTs to understand constraints to adoption of existing technologies

Many institutional innovations in support of the **40% adopters**:

- **Addressing demand-side constraints**
  - **Nudges to behavior** to overcome time inconsistency in fertilizer purchase (Duflo)
  - **Help farmers notice** what matters in available information (Hanna)
- **Addressing contextual constraints**
  - **Market access**: Enhanced by information (Aker), contracts (Ashraf; Casaburi), trading platforms (McIntosh), competitiveness of traders (Falcao), market transparency (Bernard et al.)
  - **Access to credit**: customization of microfinance schemes (Field and Pande), limited liability (McIntosh), post-harvest loans (Burke)

- **Access to insurance**: Take-up of **index insurance** can be increased by better contract design (basis risk), better data and measurement, better marketing, better delivery (Carter)

But effective S-side constraints remain

- Secure the **existence** and **local availability of D-driven technology** given **heterogeneity** of technological needs
- Also need more effective **information** and diffusion methods: **extension** services to correspond to learning, choice of entry points for **social learning** (Magruder), use **motivated agents** in value chains (Mobarak; Emerick)

→**Conclusion**: Permanence of supply-side constraints associated with heterogeneity of conditions, of farmer objective functions, and of farmer capacities suggest that a **D-driven Strategy** is needed for the **non-adopting 60%**

Step 7. Efforts at D-driven strategies to technology adoption exist but need improvement

- **Participatory breeding** (ICARDA, Ceccarelli): good for variety selection and feedback, but narrow focus on traits
- **Participatory research** (CIAL, Ashby): good for farming systems, but too agronomy focused and weak feedbacks
- **Farmer Field Schools** (FAO, Feder): good for beneficiary farmers, but too expensive and lacks feedbacks
- **Science and Technology Backyard (STB) Platforms** (China Ag University): place scientists in villages for participatory diagnostics of yield gaps. Address agronomic, infrastructural, and socio-economic needs for change. Need evaluation
- **Major problems to be addressed in customizing:**
    - Cost effectiveness: Address economies of scale in external validity of local customization
    - Lack of rigorous evaluations and experimentation

Conclusion: Unlocking technology adoption in rain-fed agriculture

- A **GR** for good quality rain-fed SSA is necessary, but hard to achieve due to heterogeneity of conditions, and insufficient per-se to take rural households out of poverty
- An **AT/RT** is important to fill in labor calendars, increase the annual productivity of labor, and reduce rural poverty
- **Review of evidence** from **S-driven** RCTs shows that important progress with **constraint removal** (40% adoption ceiling) often ends up facing limitations on the supply side of technology (existence, local availability, and information), indicating the importance of a complementary **D-driven Strategy** (60% others)
- A **D-driven Strategy** is needed to address heterogeneity of circumstances (complementary factors), of objectives, and of capacities

- **D-driven approaches** include: (1) participatory breeding, (2) participatory research (CIAL), (3) Farmer Field Schools, (4) STB platforms, but lack rigorous evaluations
- **Implementation** of a **D-driven Strategy** requires prior comprehensive multi-disciplinary **diagnostics** to identify demand (user-need assessment) and **experimentation** with alternative institutional options for delivery.
- In **conclusion**, the current review of the role of technology adoption for development (growth and poverty reduction) suggests:

(1) Pursuing a **D-driven Strategy** (customized supply of technology) as an important complement to a **S-driven Strategy** (constraint removal on demand for technology)

(2) **Experimenting** with **D-driven** approaches to achieve cost effectiveness of innovation and local assembly

End