

# Low-quality, low-trust and low-adoption: Agriculture in Sub-Saharan Africa

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# This talk

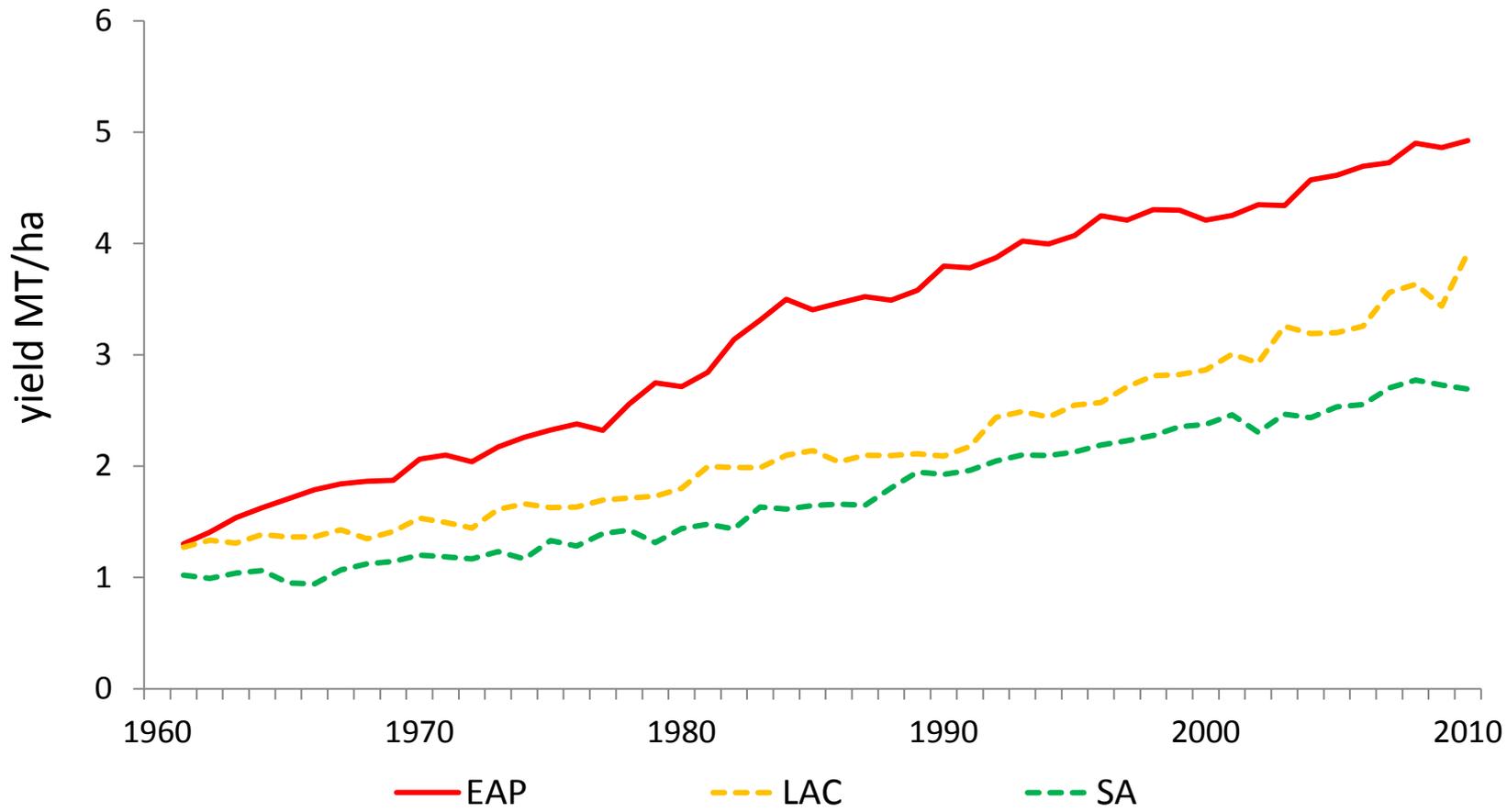
- Technology adoption in agriculture
- Use (or rather none-use) of fertilizer and hybrid seed by smallholder farmers in Africa
- Not a new subject
- Active research field: mixed evidence about what explains low adoption and the best way forward

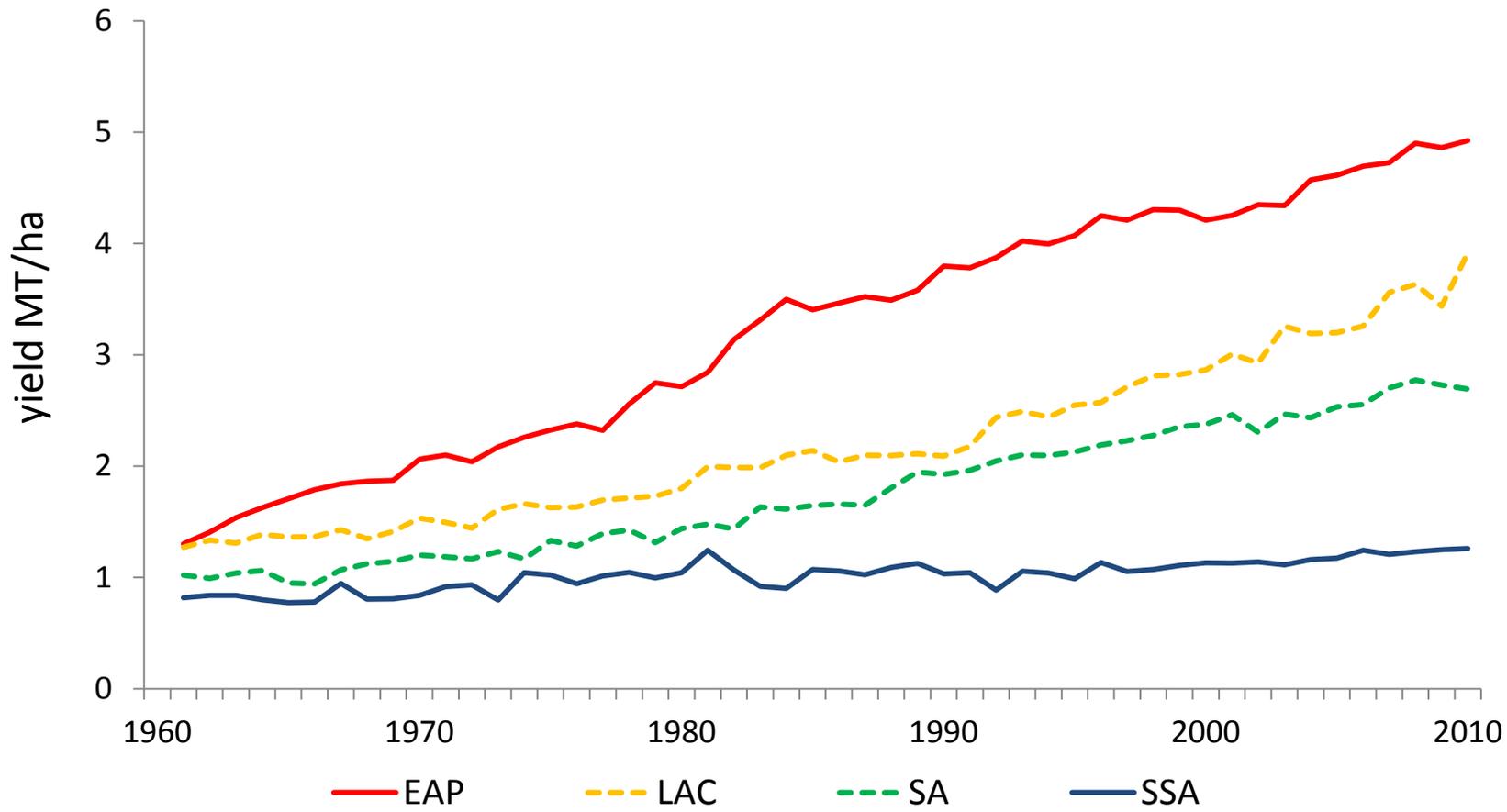
# Input market failures

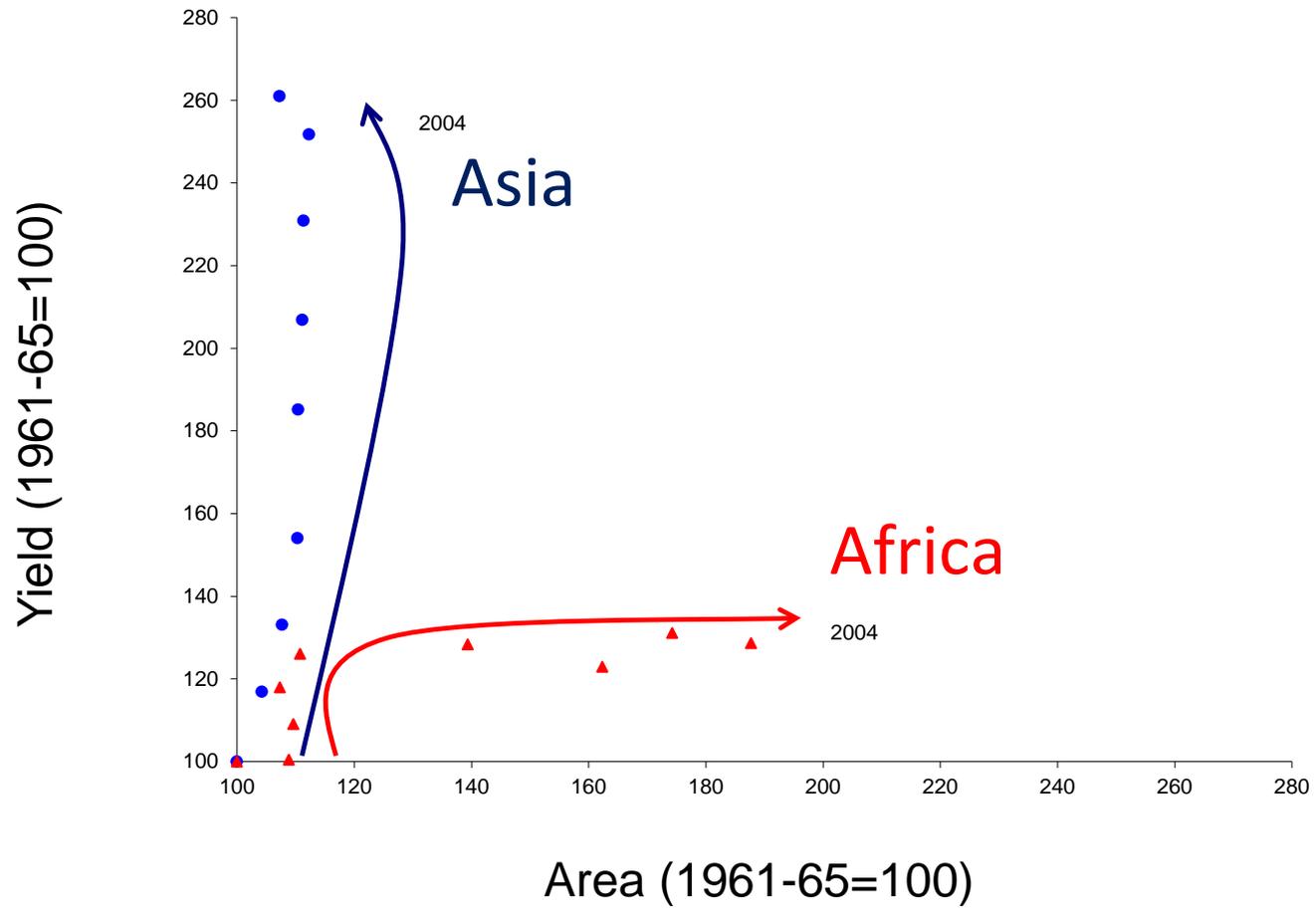
- Focus on the quality of the technology as provided in the markets available for smallholder farmers
- Start by presenting some stylized facts and a short (incomplete) review of state of the current literature

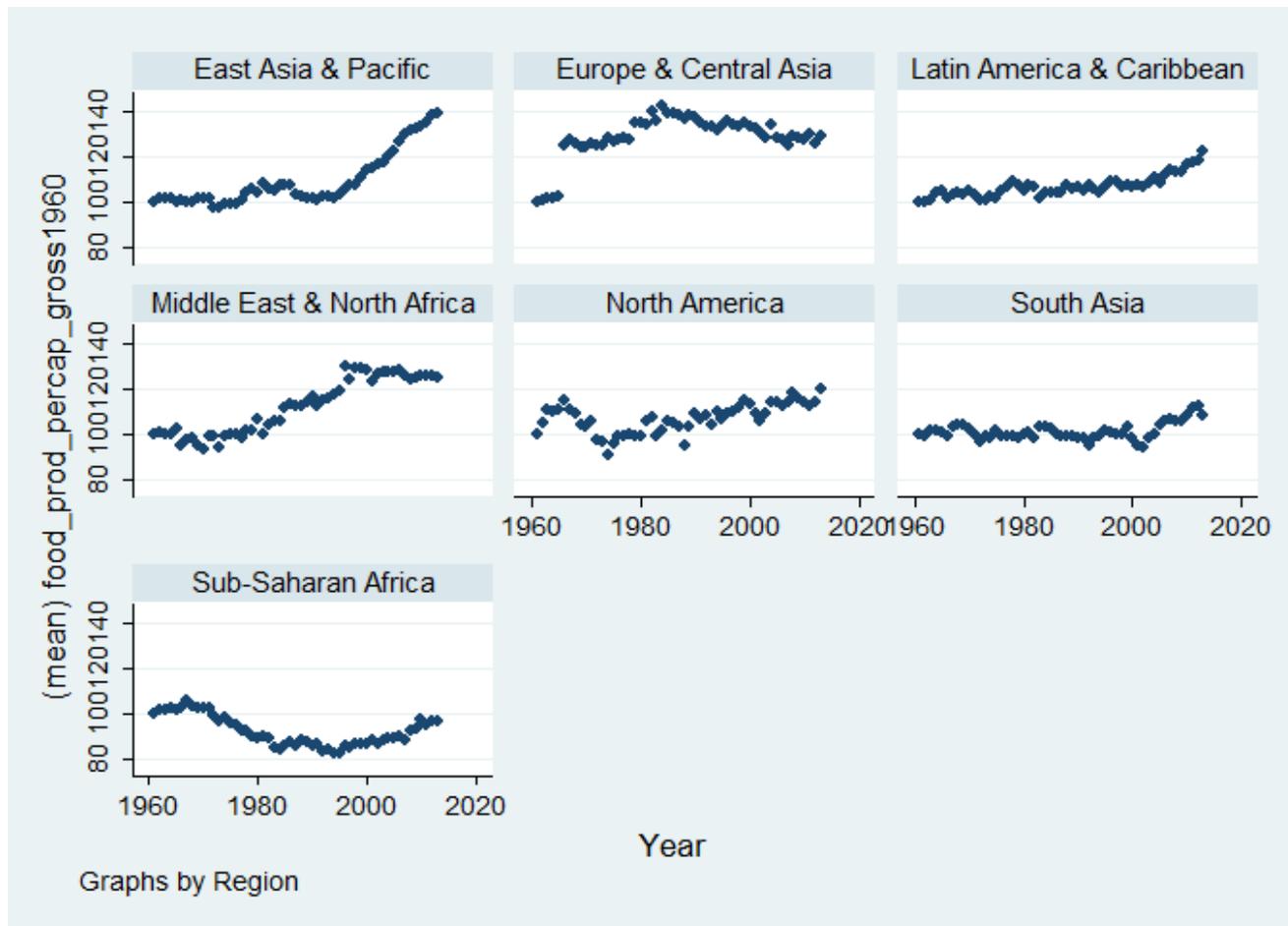
# Green Revolution: But not in Africa

- The Green Revolution, i.e., the systematic use of, e.g., high-yielding varieties of seed and fertilizer, has dramatically increased agricultural productivity across the globe









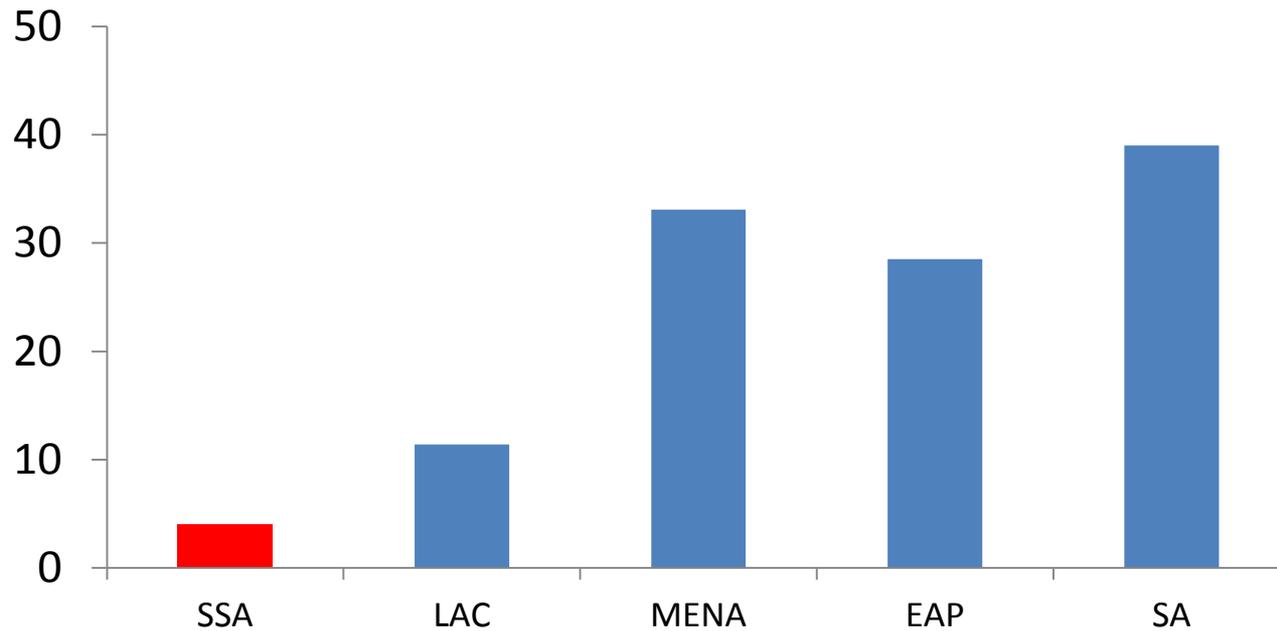
Per capita food production

# Technology

- Many agricultural experts see the use of modern inputs (e.g. fertilizers and HYV seeds), as the key to agricultural productivity.
- Is Africa lagging behind in adoption of modern technologies?

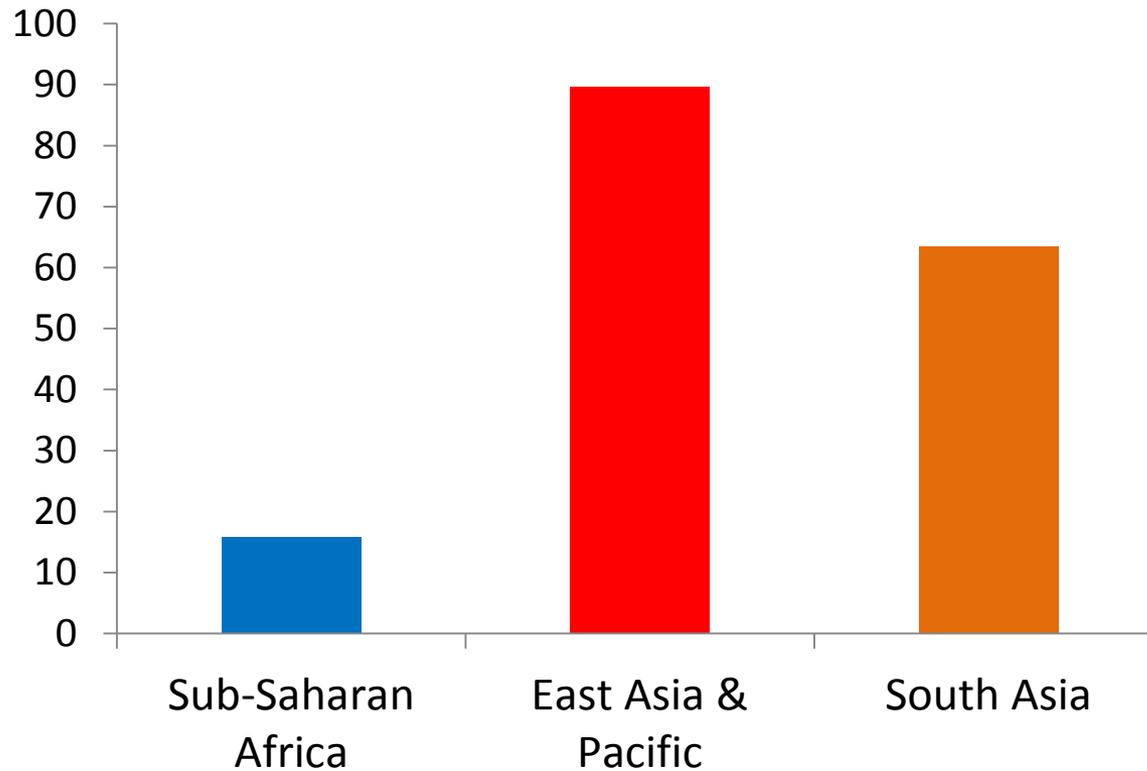
# Irrigation uncommon

**Percent of arable & permanent cropland that is irrigated**

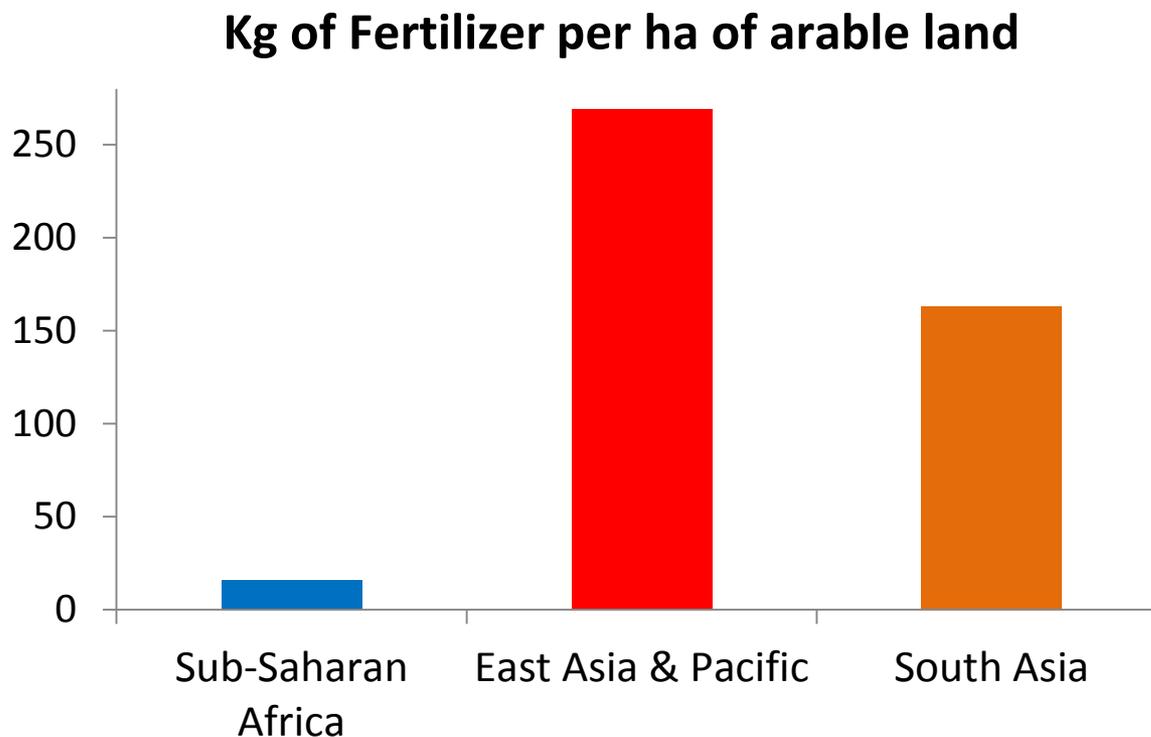


# HYV crops often not used

HYV maize as % of total crop area for maize



# Low rate of fertilizer adoption



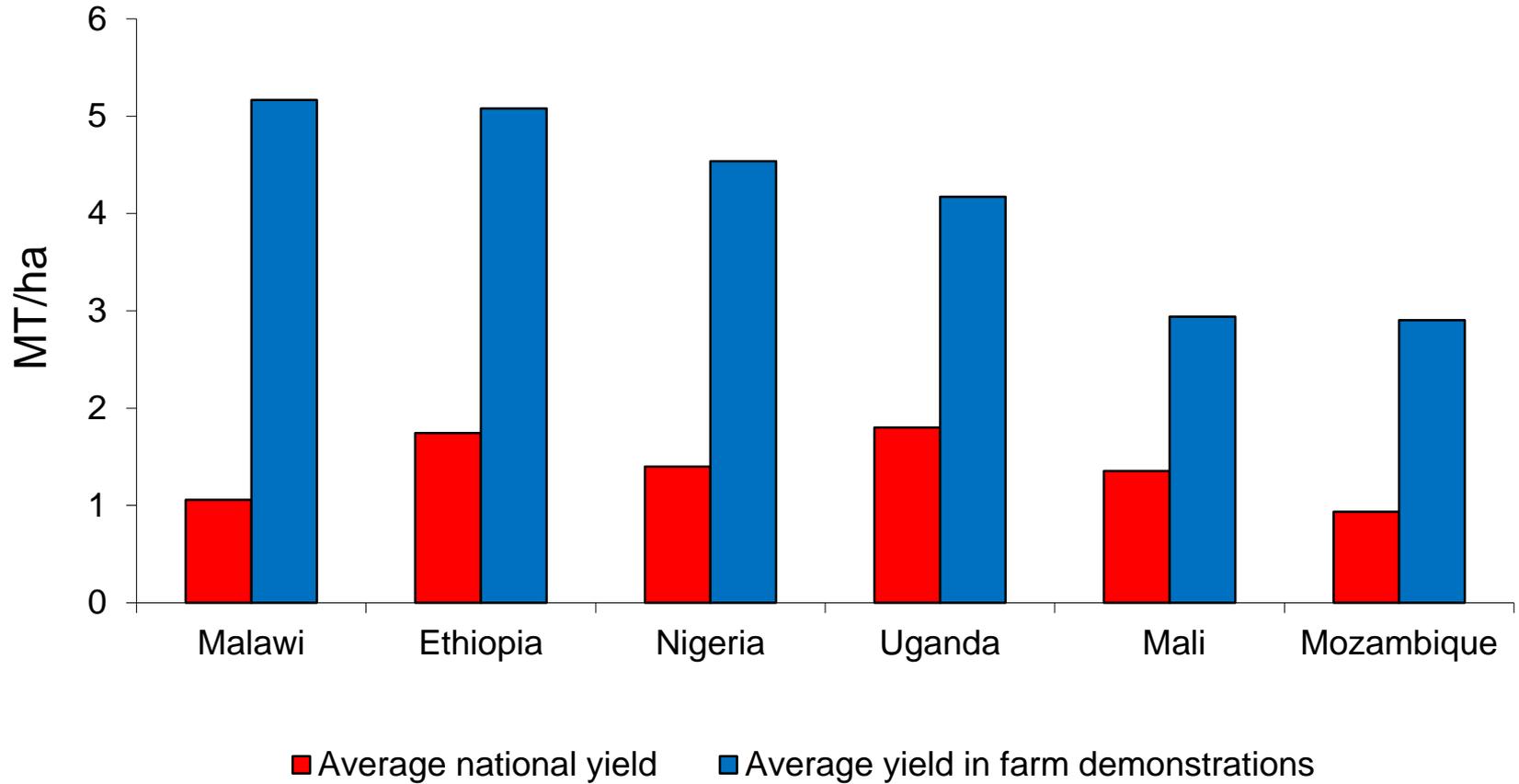
# Technology for Africa?

- African soils or agro-climatic conditions are such that high yields are not attainable given available technologies?
- Technologies not developed for Africa?

# Technology for Africa?

- Declining soil fertility has for a long-time been highlighted as a key concern in Sub-Saharan Africa, and (in)organic fertilizers is an effective method for soil replenishment
- HYV of several crops grown in Sub-Saharan Africa (sorghum, millet, and cassava) were not bred until the 1980s.
- Even for maize and rice, few varieties were available until the 1980s for Sub-Saharan African countries.

# Exploitable yield gaps for maize



# The key question

- Why is the adoption of these technologies so low, especially for smallholder farmers ?
- Research has focused on market failures

# Existing literature: Market failures

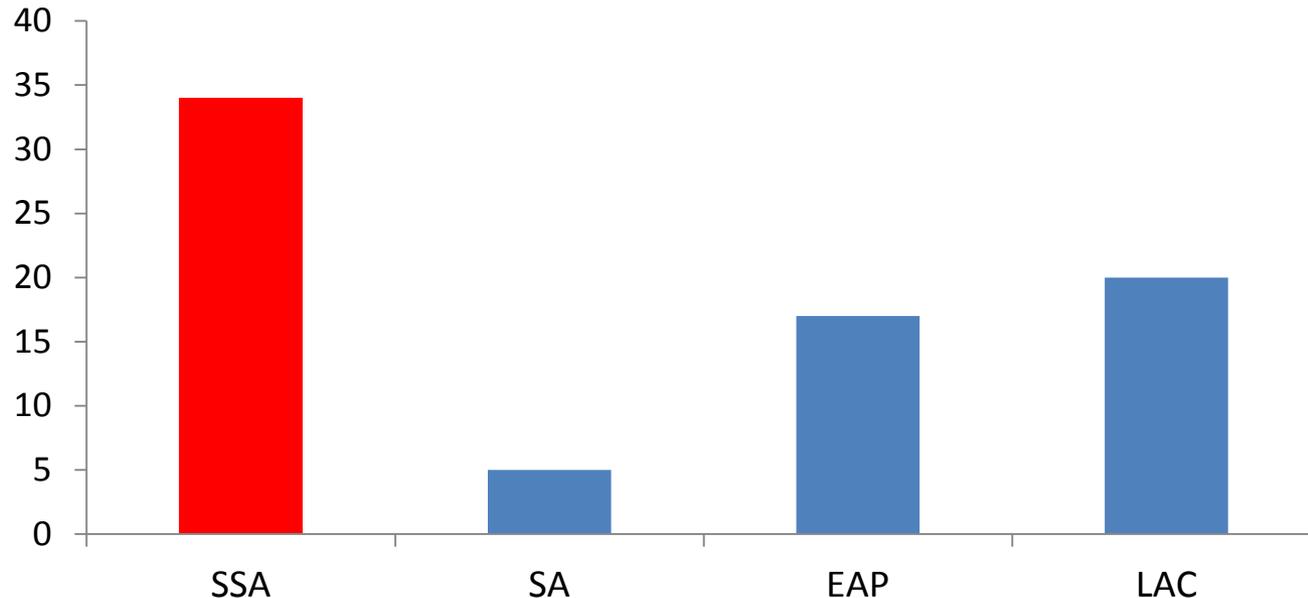
- Output market failures
- Lack of information and learning
- Credit constraints
- Lack of insurance
- Weak or imperfect property rights

# Output market inefficiencies

- Poor access to the market
  - Uncertainty about the ability to sell
  - Poor access to market price information
  - Large transaction costs
- ✓ Traders with market power claim much of the profit from adoption
- ✓ Simultaneous adoption by farmers may increase local supply and depress prices

# Market access

Percentage of rural population with poor access  
(more than 5 h) to market



- ❑ No strong evidence as of yet of how important this constraint is, or what's the best way to relax it (...but work is under way)

# Lack of information and learning

- Are farmers not using the “new” technologies because they are not aware of them?
- Or because they do not know how to use them properly?
- Affirmative answers to these questions are the underlying rationale for public agricultural extension worker programs
- Evidence here is unclear!

# Lack of information and learning

- Many smallholder farmers do have knowledge about fertilizers and HYV
- But maybe not about the optimal way to use them (complementary agricultural practices)
- Evidence on the impact of public agricultural extension worker programs - - large incentive problems

# Credit or cash constraints

- At the time of planting, farmers do not have enough money to buy fertilizers and hybrid seed
- No ability to borrow against future income
- But an argument against the credit constraint hypothesis is that farmers can start at very small scale (little money needed then)

# Imperfect insurance

- Adoption of new technologies may be risky
- A big part of this risk is driven by weather uncertainty (reliability of rainfall)
- As rainfall largely can be viewed as an aggregate risk, various informal insurance networks that are geographically close may be ill equipped to share risks
- Lacking insurance, otherwise profitable investment may not take place (Karlan et al, 2014)

# Weak or imperfect property rights

- Gross return of adopting might be high, but the privately appropriated returns may be low if the farmer's right to the plot and produce is unclear.
- But low adoption rates also for smallholder farmers owning their own land

# To sum-up

- Evidence on the importance of each of these market failures is mixed
- A complementary explanation: **Input market failures** (Bold, Kaizzi, Svensson, Yanagizawa-Drott, 2015a,b)

# Input market failures

- Anecdotal evidence suggests that the quality of that technology as provided in local markets is low
- Is it possible that smallholder farmers do not adopt basic technologies as due to some combination of adulteration, poor storage and inappropriate handling procedures, the technologies are simply not profitable?

# What we do

- First large-scale empirical assessment of the prevalence of, and economic returns to, substandard fertilizer and hybrid seed in Africa
- Investigate the quality of one of the most popular high-yield variety (HYV) maize seed in the Ugandan market, as well as a generic nitrogen-based fertilizer (urea).
- To measure the quality of the technologies in the market, we combine data on the nitrogen content of fertilizer (measured in a laboratory) from retail shops and experimental yield data from our own agricultural trials.

# Data

- Randomly sampled local retail shops in two of the main maize-growing regions of Uganda and using a covert shopper approach purchased
  - 300+ samples of urea fertilizer (“**retail fertilizer**”)
  - 30+ samples of branded hybrid seed (“**retail hybrid seed**”),
- Purchased urea and hybrid seed in bulk
  - From main wholesalers for urea (“**authentic fertilizer**”)
  - seed company producing the branded seed (“**authentic hybrid seed**”)
- Purchased traditional farmer seed from a random sample of smallholder farmers

# Measuring quality of fertilizers

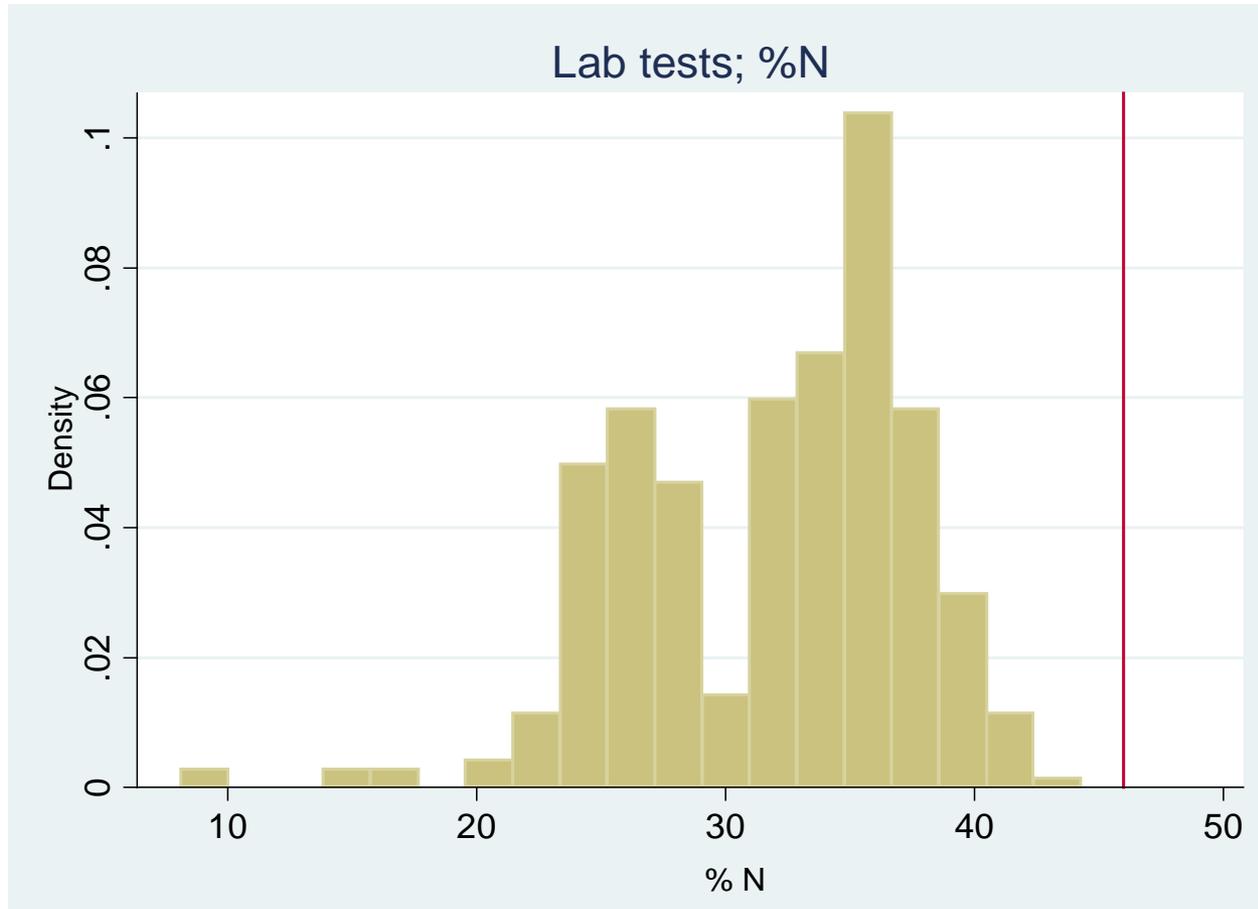
- Each retail fertilizer sample was tested three times for the content of nitrogen (N) in the lab and we use the mean of these tests to determine the quality of a sample.
- Authentic urea should contain 46 percent nitrogen (%N) and we confirmed this to be the case in our “authentic” sample.

# Measuring yield

- Researcher-managed agricultural trials
- Treatment:
  - Fertilizers with %N= {0, 12, 23, 34, 46}
  - Seed = {"farmer", "authentic", "retailer"}
- 15 possible seed-fertilizer quality combinations randomized into six 30m<sup>2</sup> plots each at each of the five experimental sites

# Findings

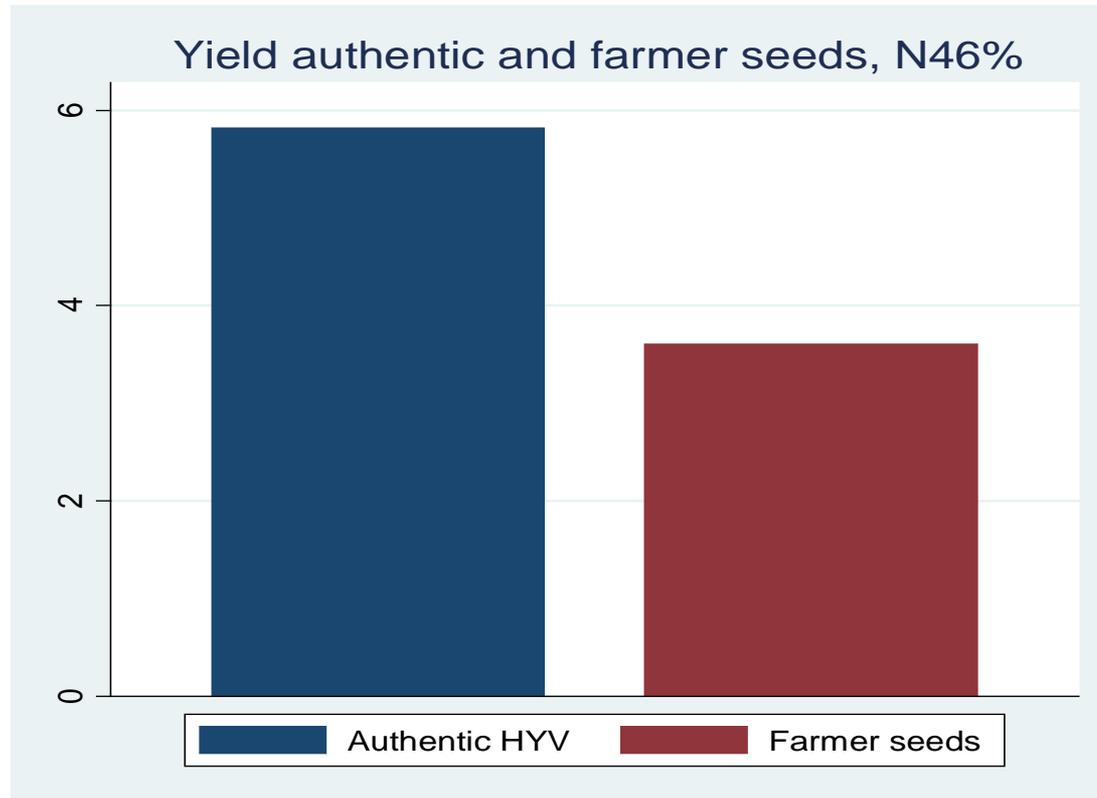
# Market based fertilizers (UREA) contain 33% less nutrients (N) than authentic fertilizers



# Measuring dilution of retail seeds

- To assess the quality of retail hybrid seed, we focus on their yield response (since this is what ultimately matters to farmers).
- Intuitively, we infer quality by assuming:
  - if a bag of farmer seed yields  $X$  tons of maize, a bag of authentic hybrid seed yields  $Y$  tons of maize and a bag of retail hybrid seed yields  $\alpha X + (1 - \alpha)Y$  tons of maize, then the bag of retail hybrid seed is of the same quality as a bag of authentic hybrid seed that is diluted with  $\alpha\%$  farmer seed.

# Measuring dilution of retail seeds

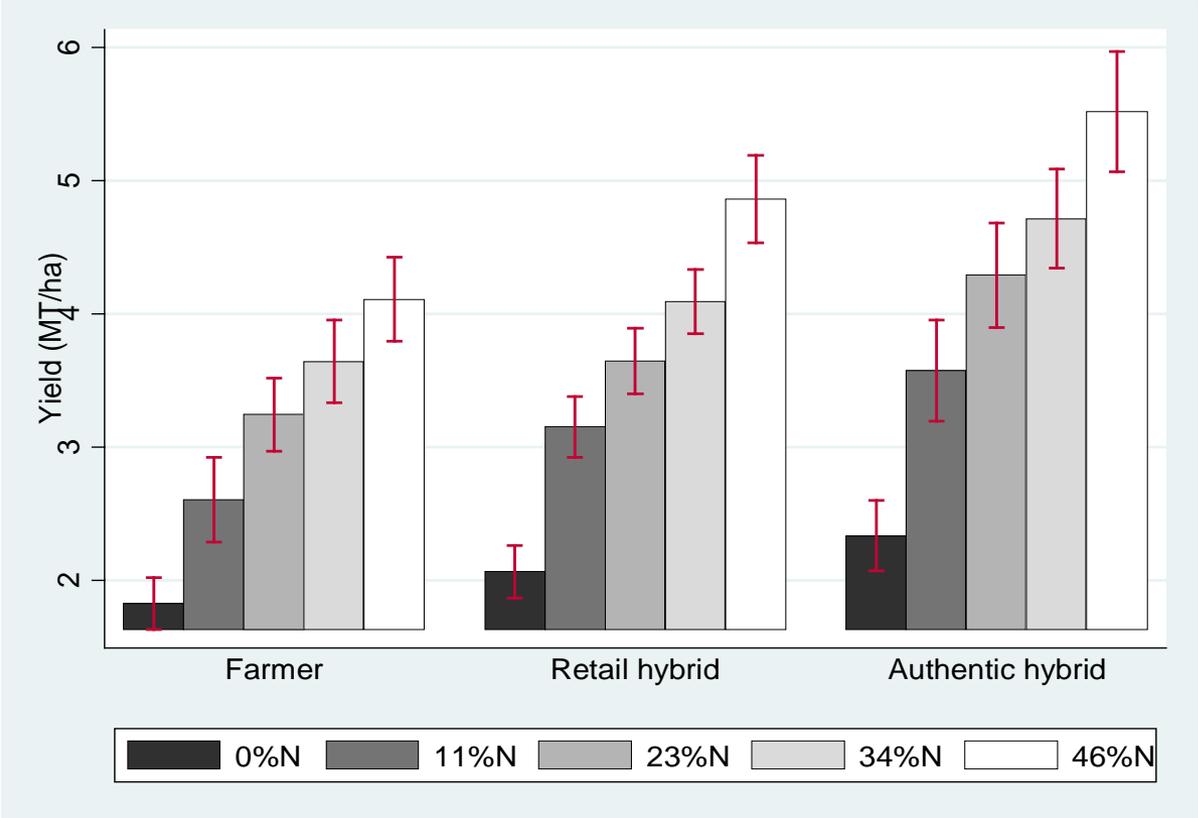


- Mix  $\alpha \times \text{farmer} + (1 - \alpha) \times \text{authentic}$  and infer the most likely level of dilution by finding  $\alpha$  that minimizes the difference between the simulated moments and the data moment

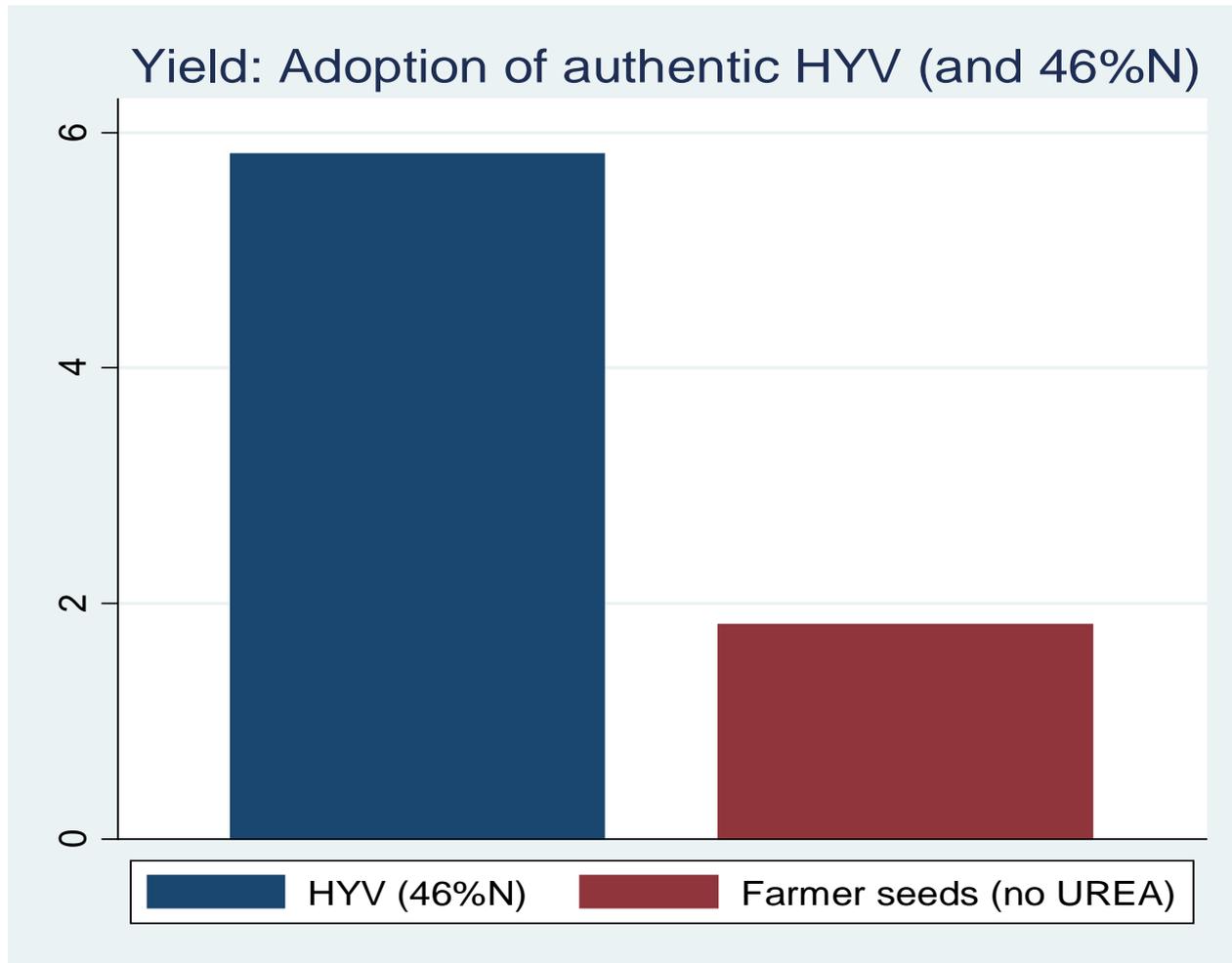
# Estimated level of dilution of hybrid seeds

	Retail hybrid seeds	Mix of authentic and farmer seeds
	(1)	(2)
$\alpha$		0.55
		(0.111)
Mean	3.563	3.566
Variance	1.172	1.264
Skewness	-0.058	-0.069
Kurtosis	2.437	2.123
Weighted sum of squared deviations		0.004

# Shortfalls in quality reduce yields substantially



# True return to quality is high



# Economic returns to adoption

- Modern technologies available in local retail markets are of poor quality
- What does this imply on the returns to adoption (of market quality inputs)?
- Unit of observation for these calculations is a retail fertilizer sample
- Approach:
  - Determine the expected yield of a fertilizer sample  $j$  with nitrogen content  $n_j$  %N, conditional on seed, by regression yield on %N
  - Predicted value of such a regression gives expected yield
  - Calculate all costs of adoption and use market prices for maize

# HYV seeds and fertilizers

Source:	Technologies available in the market	Authentic technologies
	(1)	(2)
Mean rate of return ( $r$ )	-12.2%	51.3%
Median rate of return ( $r$ )	-8.6%	51.0%
Fertilizer samples yielding positive rate of return ( $r$ )	18.4%	100.0%
Fertilizer samples yielding rate of return ( $r$ ) > 10%	1.4%	100.0%
Fertilizer samples yielding rate of return ( $r$ ) > 20%	0.0%	100.0%
Fertilizer samples yielding rate of return ( $r$ ) > 30%	0.0%	100.0%

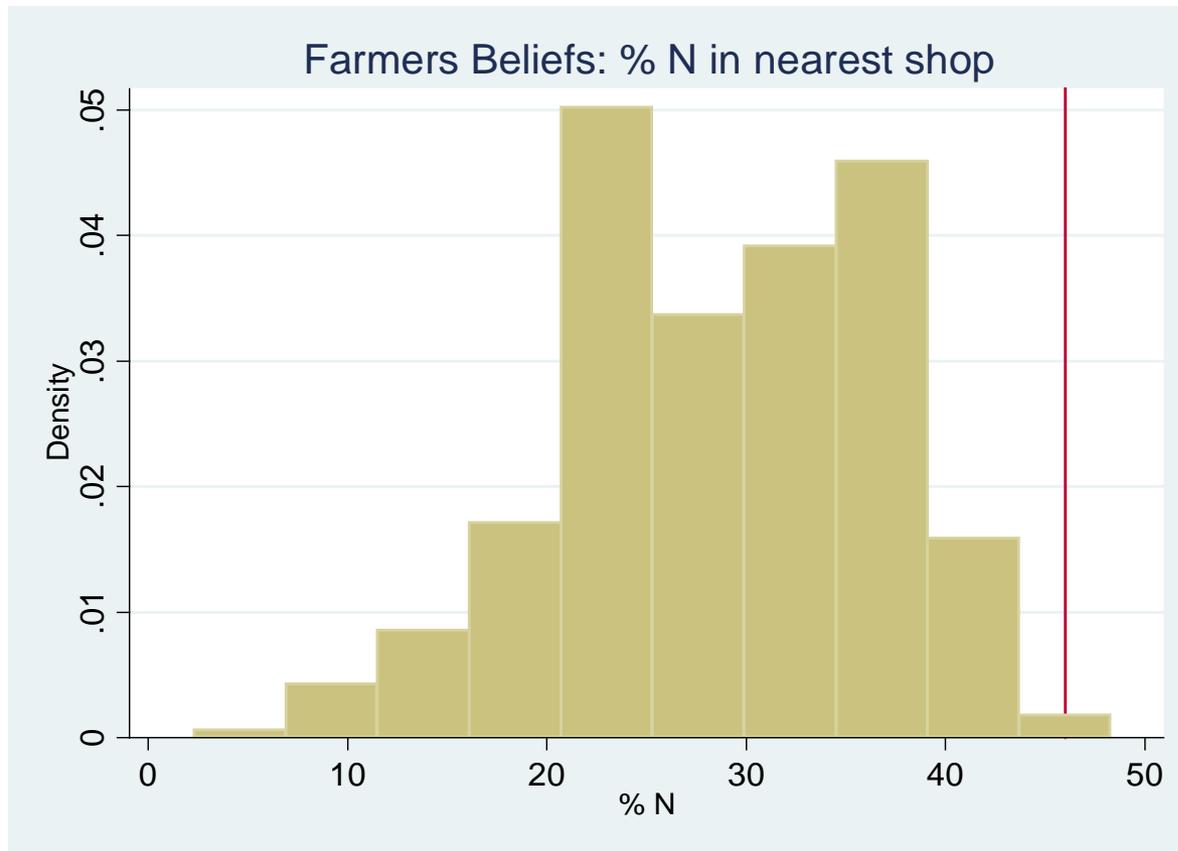
# Fertilizers only

Source:	Technologies available in the market	Authentic technologies
	(1)	(2)
Mean rate of return ( $r$ )	6.8%	54.2%
Median rate of return ( $r$ )	11.7%	53.6%
Fertilizer samples yielding positive rate of return ( $r$ )	65.3%	100.0%
Fertilizer samples yielding rate of return ( $r$ ) > 10%	52.6%	100.0%
Fertilizer samples yielding rate of return ( $r$ ) > 20%	26.3%	100.0%
Fertilizer samples yielding rate of return ( $r$ ) > 30%	7.3%	100.0%

# Farmers' expectations

- Elicit farmers' probability distribution over the quality in the market and the yield generated from using inputs from the market
- Bottom-line: Farmers' beliefs are on average largely consistent with the results from the laboratory tests and experimental yield data
  - farmers believe the quality of agricultural inputs in local markets are low (every 3<sup>rd</sup> farmer believes the content is less than half of the stated amount)
  - they do not expect adoption of such inputs to be profitable, on average.

Farmers are aware that the quality in the market is low (37% less nutrients)



# Expected economic returns to fertilizer adoption

Source:	Technologies available in the market	Authentic technologies
	(1)	(2)
Mean expected rate of return (r)	-0.2%	67.4%
Median expected rate of return (r)	-52.2%	10.5%
Farmers with expected positive net-return	26.5%	53.0%
Farmers with expected rate of return > 10%	24.4%	50.9%
Farmers with expected rate of return > 20%	22.7%	46.3%
Farmers with expected rate of return > 30%	21.3%	41.1%

# Discussion

- Poor quality inputs appear to be the norm in the local retail markets we surveyed, and that adoption of modern inputs with average retail quality is not profitable.
- The rate of return of using authentic fertilizer and hybrid seed is large, however.
- Together these results suggest that one reason smallholder farmers do not adopt fertilizer and hybrid seed is that the technologies available in local markets are simply not profitable, and this ultimately hampers agricultural productivity.

# Avenues for future research and for policy

- Low quality could be due to a multitude of factors – adulteration, poor storage and inappropriate handling procedures.
- Quality deterioration could manifest at different points in the supply chain.
- Anecdotal evidence suggest that adulteration, by bulking out fertilizer or dyeing simple grain to look like hybrid seeds, is common, but more research is needed to determine if this is indeed the case.
- Exact reasons may be irrelevant for a farmer's decision to adopt, but important for policy.

# Future research and policy

- We do not explain why the quality of agricultural inputs in local retail markets is poor, or how the problem should be tackled
- Results, however, suggest that the market is partly characterized by a low-quality, low-trust, low-adoption equilibrium.
- Specifically, the data show not only low average quality but substantial heterogeneity in quality which is not correlated with price.
- This suggests that the ability to infer quality may be severely limited, since we would otherwise expect prices to adjust.

# Discussion

- Fertilizer and hybrid seed are experience goods and in markets for such goods a seller's incentive to provide high-quality products crucially hinges on consumers' ability to learn about quality
- Our data reveal, for a given quality, large variation in yields and this uncertainty may affect farmers' ability to learn about quality.
- The difficulty in learning about quality, in turn, can help explain why retailers sell low quality inputs and why farmers' do not use them.
- In order to understand low adoption it is important to investigate this issue further.

# Policy

- Need to know more about the underlying reasons for low quality
- Need to know more about farmers' ability to learn about the technology when the quality of the technology is uncertain
- To the extent low quality is (at least partly) due to adulteration, identify policies to move to a different equilibrium?
  - Monitor and enforce existing regulations
  - Incentives to provide high quality inputs

# Incentives to provide high quality inputs

- The incentives to build up and maintain a high quality reputation in weakly regulated and unmonitored markets may not be strong enough for the small and informal drug stores that currently dominate the market
- Suggest that policies to facilitate the entry of a larger firm, or a market chain, that can tap into consumers' ability to learn about and pay for quality may be an option to improve quality

# Incentives to provide high quality inputs

- Link the seller of the technology (inputs) with the buyer of the output.
- Thereby making the seller a partial (indirect) claimant of what is being produced
- With fixed cost of buying, this provides the seller with incentives to ensure it supplies high quality inputs.

Thank you!

# Raising productivity in agriculture

- Essential to reduce poverty and food insecurity, as crop farming is the main source of livelihood for poor households in Africa
- Crucial to growth, as many of these countries are still mostly agrarian based economies

