

# Impacts Assessment for Agriculture In the Context of Structural Transformation

Douglas Gollin  
Tufts University

SPIA Fest  
Delhi  
2 August 2024

# Prologue

# A Tip of the Hat to SPIA

- Exciting to see SPIA flourishing!
- Congratulations to Karen Macours, Travis Lybbert, and the whole SPIA team.
- SPIA continues to set a high standard for rigorous and ambitious approaches to impact assessment.
  - ▶ Guides thinking and practice across the CGIAR and beyond.
  - ▶ Has earned credibility with funders and (more important) with scientists.
- Exciting portfolio of work and plans for future work.

# Life after SPIA

- My own life after SPIA has seen a loss in the quality of my acronyms:
  - ▶ From “SPIA” to “STEG”
- Research program on Structural Transformation and Economic Growth

# STEG

The STEG program (2019-2028?) is:

- funded by the United Kingdom's Foreign, Commonwealth, and Development Office as part of the UK aid effort.
- implemented by the Centre for Economic Policy Research (CEPR) in London/Paris
- a partnership initially (through 2024) involving
  - ▶ Oxford University
  - ▶ Groningen Growth and Development Center, University of Groningen
  - ▶ University of Notre Dame
  - ▶ African Center for Economic Transformation (ACET)
  - ▶ Yale Research Initiative on Innovation and Scale (Y-RISE)

## STEG, cont.

- Goal is to produce high-quality academic output on issues of policy relevance for low-income countries.
- Primarily focused on aggregate / macro-level changes
- Much of the work falls in a new literature of “macro dev” that links macro models to micro data.
- Funding is awarded through competitive calls (see <https://steg.cepr.org/>), almost all under £25K.

# Structural Transformation

- We define structural transformation broadly in STEG:
  - ▶ Sectoral (agriculture to non-agriculture)
  - ▶ Spatial (geographic integration of domestic markets)
  - ▶ Locus of economic activity (between home and market, with particular implications for gendered division of work)
  - ▶ Nature of work (self-employment to wage work)
  - ▶ Legal structures of production (informality to formality)
  - ▶ Structure of production units (increases in firm size and complexity of management structures)

# Central Questions

What connects agricultural impact assessment to models of structural change?

- Some agricultural innovations and interventions generate macro-scale impacts (“spillovers”, “general equilibrium effects”)
  - ▶ Can we capture these impacts adequately in our impact assessments?
  - ▶ If so, how?
- In a multi-sector world, our standard approaches to measuring agricultural impacts may be flawed.
  - ▶ If so, how do we need to change our approaches?

# Outline of This Talk

- What roles does agriculture play in structural transformation?
  - ▶ Old views and links to impact assessment
- New views of structural transformation:
  - ▶ Broader understanding of heterogeneity in agriculture's role.
  - ▶ Consider implications for impact assessment through the lens of three recent papers.
- Some concluding thoughts on methods and approaches.

# Agriculture and Growth

# What Is Agriculture's Role in Development?

Central questions:

- What do we know about the agricultural sector's role in generating aggregate growth in low-income economies?
  - ▶ How much does agricultural technology drive the growth process?
- How has our understanding changed in recent years?
- What are implications for research?

# An Old Topic

- Understanding agriculture's role in development has long been a focus in the development and growth literature.
- Much literature has posited a singular role: “agriculture's role in development”
  - ▶ Reflects a desire to articulate a coherent theoretical framing
- Often linked to something of an advocacy position:
  - ▶ “Agriculture is important, and we should prioritize it in development investments.”

## Some Examples of Literature

- B Johnston and J Mellor (1961), “The role of agriculture in economic development”

## Some Examples of Literature

- B Johnston and J Mellor (1961), “The role of agriculture in economic development”
- E Thorbecke et al. (1969), “The role of agriculture in economic development”

## Some Examples of Literature

- B Johnston and J Mellor (1961), “The role of agriculture in economic development”
- E Thorbecke et al. (1969), “The role of agriculture in economic development”
- CP Timmer (1992), “Agriculture and economic development revisited”

## Some Examples of Literature

- B Johnston and J Mellor (1961), “The role of agriculture in economic development”
- E Thorbecke et al. (1969), “The role of agriculture in economic development”
- CP Timmer (1992), “Agriculture and economic development revisited”
- D Gale Johnson (1993), “Role of agriculture in economic development revisited”

## Some Examples of Literature

- B Johnston and J Mellor (1961), “The role of agriculture in economic development”
- E Thorbecke et al. (1969), “The role of agriculture in economic development”
- CP Timmer (1992), “Agriculture and economic development revisited”
- D Gale Johnson (1993), “Role of agriculture in economic development revisited”
- N Stern (1996), “Growth theories, old and new and the role of agriculture in economic development”

## Some Examples of Literature

- B Johnston and J Mellor (1961), “The role of agriculture in economic development”
- E Thorbecke et al. (1969), “The role of agriculture in economic development”
- CP Timmer (1992), “Agriculture and economic development revisited”
- D Gale Johnson (1993), “Role of agriculture in economic development revisited”
- N Stern (1996), “Growth theories, old and new and the role of agriculture in economic development”
- GW Meijerink and P Roza Meijerink and Roza (2007), “The role of agriculture in economic development”

## Some Examples of Literature

- B Johnston and J Mellor (1961), “The role of agriculture in economic development”
- E Thorbecke et al. (1969), “The role of agriculture in economic development”
- CP Timmer (1992), “Agriculture and economic development revisited”
- D Gale Johnson (1993), “Role of agriculture in economic development revisited”
- N Stern (1996), “Growth theories, old and new and the role of agriculture in economic development”
- GW Meijerink and P Roza Meijerink and Roza (2007), “The role of agriculture in economic development”
- S Kjeldsen-Kragh (2007), “The role of agriculture in economic development: the lessons of history”

## Some Examples of Literature

- B Johnston and J Mellor (1961), “The role of agriculture in economic development”
- E Thorbecke et al. (1969), “The role of agriculture in economic development”
- CP Timmer (1992), “Agriculture and economic development revisited”
- D Gale Johnson (1993), “Role of agriculture in economic development revisited”
- N Stern (1996), “Growth theories, old and new and the role of agriculture in economic development”
- GW Meijerink and P Roza Meijerink and Roza (2007), “The role of agriculture in economic development”
- S Kjeldsen-Kragh (2007), “The role of agriculture in economic development: the lessons of history”
- I Tsakok and B Gardner (2007), “Agriculture in economic development: primary engine of growth or chicken and egg?”

## Some Examples of Literature

- B Johnston and J Mellor (1961), “The role of agriculture in economic development”
- E Thorbecke et al. (1969), “The role of agriculture in economic development”
- CP Timmer (1992), “Agriculture and economic development revisited”
- D Gale Johnson (1993), “Role of agriculture in economic development revisited”
- N Stern (1996), “Growth theories, old and new and the role of agriculture in economic development”
- GW Meijerink and P Roza Meijerink and Roza (2007), “The role of agriculture in economic development”
- S Kjeldsen-Kragh (2007), “The role of agriculture in economic development: the lessons of history”
- I Tsakok and B Gardner (2007), “Agriculture in economic development: primary engine of growth or chicken and egg?”
- D Jorgenson (2017), “The role of agriculture in economic development: Classical versus neoclassical models of growth”

## Some Examples of Literature

- B Johnston and J Mellor (1961), “The role of agriculture in economic development”
- E Thorbecke et al. (1969), “The role of agriculture in economic development”
- CP Timmer (1992), “Agriculture and economic development revisited”
- D Gale Johnson (1993), “Role of agriculture in economic development revisited”
- N Stern (1996), “Growth theories, old and new and the role of agriculture in economic development”
- GW Meijerink and P Roza Meijerink and Roza (2007), “The role of agriculture in economic development”
- S Kjeldsen-Kragh (2007), “The role of agriculture in economic development: the lessons of history”
- I Tsakok and B Gardner (2007), “Agriculture in economic development: primary engine of growth or chicken and egg?”
- D Jorgenson (2017), “The role of agriculture in economic development: Classical versus neoclassical models of growth”
- J Mellor (2017), “Agricultural development and economic transformation”

## Some Examples of Literature

- B Johnston and J Mellor (1961), “The role of agriculture in economic development”
- E Thorbecke et al. (1969), “The role of agriculture in economic development”
- CP Timmer (1992), “Agriculture and economic development revisited”
- D Gale Johnson (1993), “Role of agriculture in economic development revisited”
- N Stern (1996), “Growth theories, old and new and the role of agriculture in economic development”
- GW Meijerink and P Roza Meijerink and Roza (2007), “The role of agriculture in economic development”
- S Kjeldsen-Kragh (2007), “The role of agriculture in economic development: the lessons of history”
- I Tsakok and B Gardner (2007), “Agriculture in economic development: primary engine of growth or chicken and egg?”
- D Jorgenson (2017), “The role of agriculture in economic development: Classical versus neoclassical models of growth”
- J Mellor (2017), “Agricultural development and economic transformation”

and not excluding

## Some Examples of Literature

- B Johnston and J Mellor (1961), “The role of agriculture in economic development”
- E Thorbecke et al. (1969), “The role of agriculture in economic development”
- CP Timmer (1992), “Agriculture and economic development revisited”
- D Gale Johnson (1993), “Role of agriculture in economic development revisited”
- N Stern (1996), “Growth theories, old and new and the role of agriculture in economic development”
- GW Meijerink and P Roza Meijerink and Roza (2007), “The role of agriculture in economic development”
- S Kjeldsen-Kragh (2007), “The role of agriculture in economic development: the lessons of history”
- I Tsakok and B Gardner (2007), “Agriculture in economic development: primary engine of growth or chicken and egg?”
- D Jorgenson (2017), “The role of agriculture in economic development: Classical versus neoclassical models of growth”
- J Mellor (2017), “Agricultural development and economic transformation”

and not excluding

- D Gollin, S Parente, and R Rogerson (2002), “The role of agriculture in development”

# Canonical Views of Agricultural Development

- The canonical view of agriculture and growth is perhaps that of Johnston and Mellor (1961).
- They argue that agricultural productivity growth:
  - ▶ Increases farm income (and reduces rural poverty).
  - ▶ Drives down the price of food, helping the poor in both rural and urban areas (who disproportionately spend on food).
  - ▶ Stimulates the growth of a non-agricultural sector, by suppressing nominal wages while increasing real wages.
  - ▶ Stimulates the growth of non-agriculture by creating demand from rural households.
  - ▶ Provides export earnings that support macro balance.
  - ▶ Eventually leads to the creation of non-agricultural employment that will pull people out of agriculture.
- This stylized view remains at the core of many models of agricultural development today.

# Agriculture and Growth: Old Views

- Is this view correct?
  - ▶ Substantial literature argues for this view.
    - ★ Economic history: Allen, 1994, 1999, 2000
    - ★ 'Old school' development economics: Schultz, 1953; Johnston and Mellor, 1961; Johnston and Kilby, 1975; Mellor, 1973, 1995, 2017; Timmer, 1988, 2002
    - ★ New macro / growth literature: Gollin et al., 2002, 2007; Restuccia et al., 2008; Córdoba and Ripoll, 2009; Adamopoulos and Restuccia, 2014; Gollin et al., 2021
  - ▶ Contested view – in some sense untestable.
  - ▶ Depends on a rather specific constellation of assumptions: preferences, elasticities, factor intensities, etc.

# Implications for Impact Assessment

- In the Johnston-Mellor view, all impacts arise from a change in the price of food.
  - ▶ Essentially an outward shift in the supply curve.
- In this case, a sufficient statistic for impact is to measure the size of the shift in the supply curve:
  - ▶ So-called  $k$ -shift
- Closely related to measuring the TFP change in agriculture.

### III. Impact Assessment in General Equilibrium

# Moving Beyond a Singular Role for Agriculture

- But why should we expect that there is a single role for agriculture in development?
  - ▶ Geographic contexts matter...
  - ▶ Economic factors evolve
- Newer literature challenges us to look deeper and to recognize heterogeneity in many dimensions.
  - ▶ Not least: look at the broader economy, beyond the farm.

# Context Specificity of Agriculture's Role

- Agriculture plays different roles in driving growth in different settings:
- Many conditioning variables:
  - ▶ Openness and the role of (international) trade
  - ▶ Spatial frictions and trade – within and between countries
  - ▶ Factor mobility
  - ▶ Factor-biased technological change
  - ▶ Agriculture  $\neq$  Food
  - ▶ Dietary changes

⇒ Central argument: need to recognize that agriculture's role varies with these (and other) factors.

⇒ Not a singular role for agriculture: heterogeneity and context-specificity.

⇒ Implications for science and agricultural research

# Why Does the Growth Framework Matter?

- In a more complicated world, the benefits from research may spill across the economy.
- Measuring these benefits typically requires a model or structural approach.
  - ▶ We can't run experiments very neatly on aggregate economies, so RCTs provide limited information.
  - ▶ Causal identification is intrinsically difficult: agricultural productivity growth is not randomly assigned to different economies.
- Particularly difficult to capture long-run and large-scale impacts and those that spill across sectors and geographies.

Two Blades of Grass:  
The Impact of the Green Revolution (with Casper Worm  
Hansen and Asger Wingender)  
*Journal of Political Economy* 2021

# Two Blades of Grass

Gollin, Hansen and Wingender (2021)

- Use heterogeneity in the timing and intensity of benefits that countries received from high-yielding varieties (HYVs) in the Green Revolution.
- Variation at the country-year level across low- and middle-income countries in intensity of treatment.
  - ▶ 'Period from 1965-2010
  - ▶ Unbalanced panel of countries and years
- For identification, we construct a measure of this intensity based on the timing of initial varietal releases and the pre-Green Revolution importance of different crops in different countries.
  - ▶ For most developing countries, the date of initial HYV release in a crop was entirely exogenous.

# The Green Revolution: timing

- Define each crop as undergoing a treatment based on *the first date at which a high-yielding variety was released based on crossing that took place in an international center.*
- Some crops had precursor programs, often small.
- These developed some improved materials.
- Also selected from traditional varieties.
- Our (somewhat arbitrary) definition of treatment effect gives a sharp cut-off for each crop.

# Overview of identification strategy

- We use a Bartik-like instrument for agricultural productivity levels / growth.
  - ▶ Time variation in the initial release dates of different HYV crops
  - ▶ Spatial variation in different (initial) production shares of crops at the country level.
- Zeroth stage: ask how crop yields across all countries and years are related to crop yield growth.
- First stage: use these coefficients to construct a Bartik-like instrument:
  - ▶ Use initial production share of each HYV crop by country to predict the aggregate crop yield growth rate that each country would be expected to experience in each year.
- Second stage: use this instrument to identify the effect of crop yields on macro outcomes (income per capita, population size).

## First-stage results: various specifications

- Estimates based on constant linear trend after an HYV release.
- Columns (1) through (5): common growth effect for all 16 GR crops.
  - ▶ Column (1): country-by-crop and year FE
  - ▶ Column (2): country-by-year FE
  - ▶ Column (3): only FAO yield data (beginning in 1961)
  - ▶ Column (4): only high-quality data (starting back in 1945)
  - ▶ Column (5): excludes research-center countries
- Columns (6) and (7) report different effects by crop type.
  - ▶ Column (6): allows for different crop effects in flexible specification
  - ▶ Column (7): crop-specific linear trends
- Largest impacts of HYVs are in wheat (1.4 pp), maize (1.3 pp), rice (1.1 pp), and barley (1.0 pp)

# Difference-in-difference results

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
			Only FAO data	High quality data	No RC countries	Baseline	w. linear trends
Cereals treatment						0.0129*** (0.00139)	0.0160*** (0.00239)
Roots treatment						0.00694*** (0.00238)	0.00718** (0.00331)
Pulses treatment						0.00642*** (0.00171)	0.00568*** (0.00178)
Common treatment	0.0118*** (0.00147)	0.0126*** (0.00141)	0.0121*** (0.00145)	0.0149*** (0.00149)	0.0119*** (0.00146)		
Crop-country FE	yes	yes	yes	yes	yes	yes	yes
Year FE	yes	no	no	no	no	no	no
Year-country FE	no	yes	yes	yes	yes	yes	yes
Observations	44,906	44,630	42,768	30,174	39,868	44,630	44,630
R-squared	0.912	0.936	0.936	0.95	0.936	0.937	0.937

Robust standard errors in parentheses

\*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$

# Main Findings

## Main findings:

- A one percent increase in yields (defined as calorie output per unit of land):
  - ▶ increased GDP/capita (income) by about 1.1%
  - ▶ decreased population relative to counterfactual by 0.36%.
- Effect size is fully accounted for by a combination of:
  - ▶ direct effect on crop yields
  - ▶ factor adjustment in agriculture
  - ▶ structural transformation.
- We also find that mortality decreased; fully offset by declining fertility rates → population ↓ (so no 'Malthusian responses').

# Implications for Impact Assessment

- Direct effect on crop yields accounts for only a fraction of the economic impact of the Green Revolution.
- Impact assessment based on the value of additional production would understate the effects.
- Impacts on population growth and land use would not readily be visible.

The Long-Run Development Impacts of Agricultural  
Productivity Gains:  
Evidence from Irrigation Canals in India  
(with Sam Asher, Alison Champion, and Paul Novosad)  
*CEPR Discussion Paper DP 17414*

# Factor mobility

- What about factor mobility?
- Many closed-economy models of structural change assume that factors are perfectly mobile across sectors and across geographic space.
- In reality, important frictions not only to trade in goods but also to movement of factors.
  - ▶ Labor reallocation across space may be slow (migration frictions).
  - ▶ Labor reallocation across sectors limited by thin markets for wage labor and capital in rural areas.
- Consider two examples from current work, where factor mobility affects our interpretation of impacts of the agriculture-growth relationship.

# The Paper

This paper considers the large-scale and long-run impacts of irrigation canals in India.

- Large scale: 300k km serving 130k villages
- Long run: generate sustained differences in agricultural productivity across otherwise similar places
- Most constructed over 40 years ago
- Seasonal: mostly deliver water during dry winter (*Rabi*) growing season

# What We Do

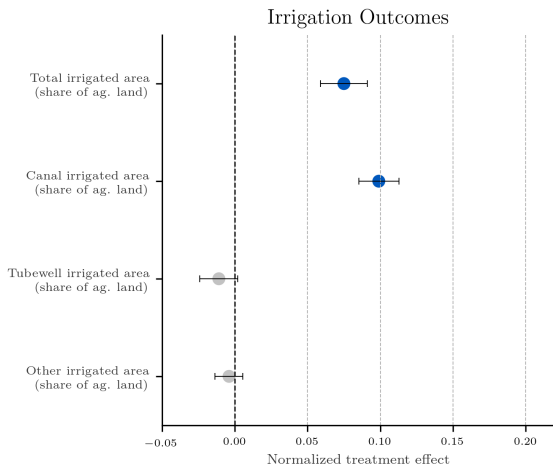
- Assemble settlement-level (village/town) data on irrigation, agricultural and non-farm activity, demographics, and living standards (N=600k)
- Three identification strategies estimate different LATEs
  - ▶ Exploit gravity-driven nature of surface irrigation in elevation-based RDD (i.e., water *mostly* flows downhill)
  - ▶ Analyze spillover effects by comparing to matched distant settlements
  - ▶ Exploit timing of canal construction to estimate effects on regional urbanization

# Main Findings

Access to canal irrigation causes:

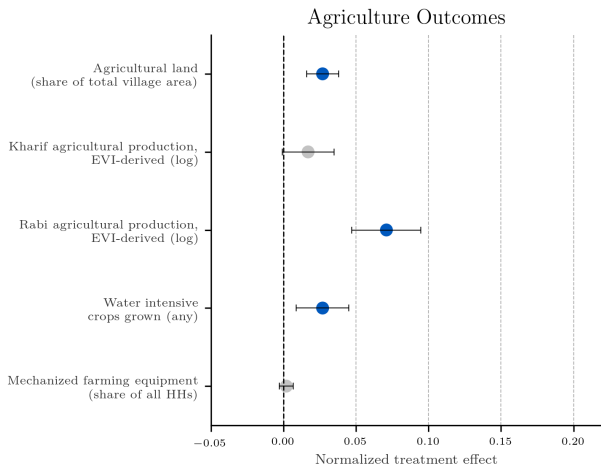
- Increase in irrigation, ag productivity, water-intensive crops
- Large increases in population density
- But...
  - ▶ No effects on rural nonfarm sector
  - ▶ No discernible impact on wage labor (i.e., no *differential* effect on wage workers in treated settlements)
  - ▶ Only consumption gains to households with land
- No spillovers to nearby non-ag sector
- Higher urban growth following canal construction

# Results: Irrigation Outcomes



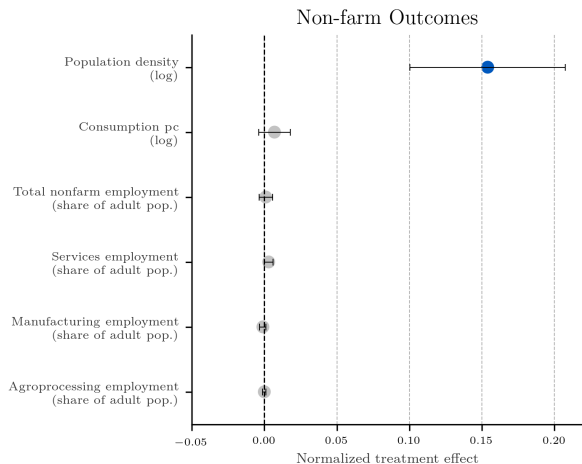
- All treatment effects normalized with control group mean and SD
- Canal settlements have more irrigated land, driven by more canals, with no changes in other methods of irrigation.

# Results: Agricultural Outcomes



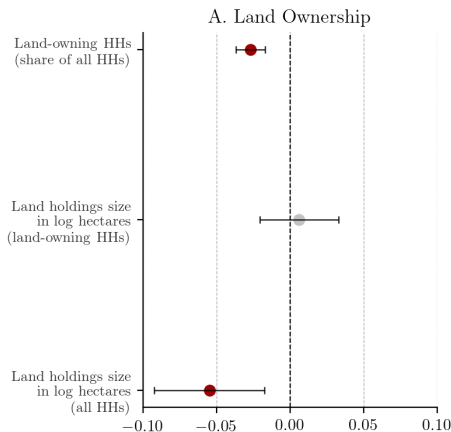
- Canal settlements have more agricultural land, greater dry season productivity, higher probability of growing water-intensive crops.

# Results: Non-Farm Outcomes



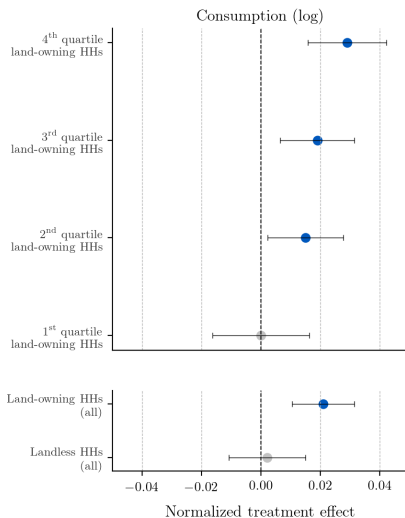
- Canal settlements have higher population density. No evidence that this comes from higher fertility or lower mortality; we interpret as net migration effect. No effects on non-farm employment of any kind.

# Results: Land Ownership



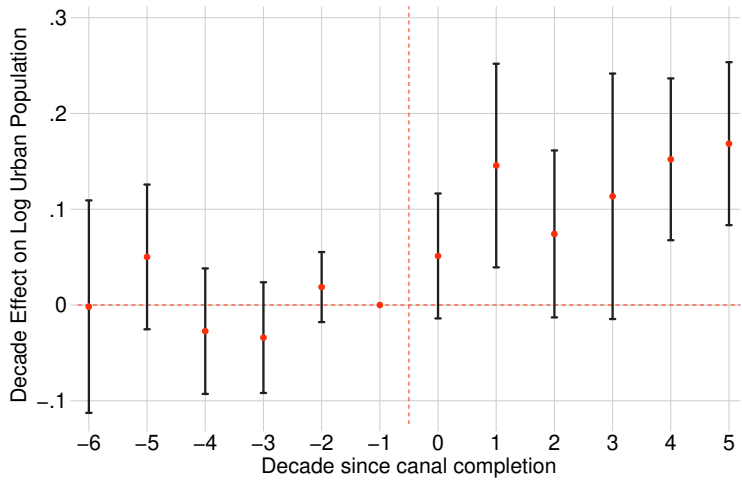
- Migration is of landless labor: existing land holdings are unchanged in size; fraction of landholding households falls, land holdings per household (for all households) falls.

# Results: Consumption



- Consumption gains are limited to land owners, increasing in landholding size.
- Productivity gains accrue to the fixed factor as land rents.

# Effects of Canals on Regional Town Growth



- Impacts felt on regional town growth, rather than immediately affected villages.

# Takeaways and Implications for Impact Assessment

- In the long run, productivity differences were equilibrated by labor flows across space, not across sectors
- Structural change occurred via concentrated urban growth
- Distributional effects (or lack thereof) on consumption are important
- Impact assessment focusing on yields would miss changes in crop mix
- No evident impact on wages or incomes except for the wealthiest  $\Rightarrow$  does not imply zero impact.
- Effects on urbanization and structural change would be missed.

# Structural Change and Declining Agricultural Productivity: Evidence from Africa

(with Thomas Bentze, Sebastian Sardon, Chris Udry, and  
Philip Wollburg)

*In Progress*

# Bentze, Gollin, Sardon, Udry, and Wollburg (202?)

## Structural Change and Declining Agricultural Productivity: Evidence from Africa

- Builds on previous *PNAS* paper (Wollburg et al., 2024)
  - ▶ Documents large (3%-4% per year) declines in crop yield in smallholder crop agriculture across six countries in Africa.
  - ▶ LSMS-ISA for Ethiopia, Malawi, Mali, Niger, Nigeria, Tanzania
    - ★ robust to specification and highly significant
    - ★ household panel data for about 30,000 smallholder farmers, covering two to five waves of surveys, roughly 2008-19.
    - ★ we omit Uganda, Burkina Faso because of data limitations
  - ▶ Weather from ERA5 and CHIRPS
    - ★ detailed, downscaled, probably not very accurate!
  - ▶ Conflict, soil suitability, flood data geolocated

## Research questions and some null answers

What accounts for these declines in yield and 'naively measured' TFP (i.e., residuals of output regressed on inputs with controls)?

- Consider and reject (mostly) explanations based on weather.
  - ▶ Using rich LASSO, we find weather variables that are individually and jointly significant in predicting ag output...
  - ▶ But they do not show secular worsening over time.
- Consider and reject (mostly) explanations based on conflict.
- Consider and reject (mostly) explanations based on land degradation or expansion on Ricardian margins.

# The story??

Evidence that the story relates to labor and structural change:

- Yield declines are attributable in a proximate sense to reductions in labor input.
  - ▶ Days of work per hectare falling
  - ▶ Hours per day falling as well
- Spatial pattern is pronounced.
  - ▶ Declines are concentrated in specific locations:
    - ★ Those experiencing rapid growth in population and economic activity
    - ★ More active labor markets
    - ★ Labor moving to non-farm enterprises (services) in towns

## Findings and interpretation

- Towns are open economies that can access food from broader national and international markets.
  - ▶ Farmers in nearby areas are price takers.
- Growth in non-farm economy creates a demand for labor that is met by people moving from nearby farms.
- Labor market imperfections prevent the replacement of family labor with hired labor.
  - ▶ Inputs such as fertilizer / mechanization are not being used to substitute for lost labor.
- Farms expand slightly into extensive margin; labor spread even more thinly.
- Selection (negative for ag productivity) in the quality of labor leaving farms.
- Result: declining crop yields... but positive story for income, transformation, and growth!

# Agriculture's role?

- An example where usual stories (going back to Boserup, 1965) are flipped.
- Processes of urbanization make surrounding areas *reduce* intensity of agriculture.
- Agriculture is still closely linked to non-agriculture.
- A useful reminder, too, that output per unit of land is a particularly poor measure of productivity in agriculture!
  - ▶ Possible that “correctly measured TFP” would show increases in productivity...
  - ▶ But this would require appropriate (and probably infeasible) adjustments for labor quality, land quality, etc.

# Implications for Impact Assessment

- If we were looking only at yield changes, this would look like a bad scenario.
- In a context of structural change, potentially positive.
  - ▶ Welfare effects would require understanding what is happening to those who exit agriculture.
  - ▶ Need richer data to assess properly.
  - ▶ Possibly need a model to understand the impacts clearly.

## VI. Discussion and Conclusion

# Some Implications

- Embrace the heterogeneity in agriculture's role in the economy.
- No universal pattern in which agriculture is the sector that drives growth.
  - ▶ True in some specific contexts
  - ▶ Not true in others
  - ▶ Sometimes agriculture leads growth; sometimes it follows.
- We should not approach the data with the idea that we will always find a particular relationship.

# Implications for Impact Assessment

- A more nuanced understanding of context is needed in looking for general equilibrium effects.
- We need to know where to look for impacts, both positive and negative!
- We also need data that allows us to measure these impacts.
  - ▶ Not straightforward in many settings.
  - ▶ Requires data collection that is distant both geographically and conceptually from the farm.
  - ▶ Increasing potential to draw on other data sources (administrative data but also big data of various kinds)

# When Are GE Effects Important?

- Not every innovation or intervention will generate these kind of effects.
- But even at the micro level, we may need to look away from yields and farm profits.

# Lessons from the Agricultural Household Model

- Singh, Squire and Strauss (1985) worked out the economics of separability of agricultural households.
  - ▶ Essentially an application of principles from trade theory to agricultural households.
- How does a household allocate resources in the context of missing markets?
- When does an agricultural household – that both produces and consumes – operate its farm as a profit-maximizing firm?
  - ▶ Answer: if multiple markets fail, separability no longer necessarily holds.
  - ▶ Households will manage their farms as part of a complex joint optimization problem with the entirety of the household decision-making process.
  - ▶ We can no longer assume that a profitable innovation will be advantageous for the household.
  - ▶ “Profit maximization” is no longer the correct objective function. (Utility is maximized instead.)
  - ▶ Household-specific shadow prices (rather than market prices) drive decision making.

# Implications for Impact Assessment

- What this implies for impact assessment is that we need to look at impacts off the farm.
- To understand whether a technology is beneficial, need to look for changes across the entire farm-household enterprise.
- A new technology might not visibly increase farm profits but might lead to substantial welfare improvements
  - ▶ (e.g., by freeing up labor of children so that they can attend school).
- Conversely, a new technology might appear highly profitable but not prove attractive to farmers.

# Implications for Policy

- Development economists have generally understood the implications of the AHM.
- Policy makers have been slower to take up this message.
  - ▶ Scientists and extension institutions also struggle to accept the point.
- Focus frequently remains on increasing yield within particular crops, rather than increasing well-being within the entire farm-household enterprise.
- The latter is a harder target for breeders; economists need to give more concrete guidance.
- Implies that priority setting needs to be based on different methods in contexts of market failure.

## VII. References

# References I

- Adamopoulos, T. and D. Restuccia (2014): “The size distribution of farms and international productivity differences,” *The American Economic Review*, 104, 1667–1697.
- Allen, R. (1994): “Agriculture During the Industrial Revolution,” in *The Economic History of Britain Since 1700*, ed. by R. Floud and D. McCloskey, Cambridge University Press, vol. 1, chap. 5, 96–122.
- (2000): “Economic structure and agricultural productivity in Europe, 1300–1800,” *European Review of Economic History*, 4, 1–25.
- Allen, R. C. (1999): “Tracking the Agricultural Revolution in England,” *The Economic History Review*, 52, 209–235.
- Boserup, E. (1965): *The Conditions of Agricultural Growth*, Earthscan Publications.
- Córdoba, J. C. and M. Ripoll (2009): “Agriculture and aggregation,” *Economics Letters*, 105, 110–112.
- Gollin, D., C. W. Hansen, and A. M. Wingender (2021): “Two blades of grass: The impact of the Green Revolution,” *Journal of Political Economy*, 129, 2344–2384.
- Gollin, D., S. L. Parente, and R. Rogerson (2002): “The Role of Agriculture in Development,” *American Economic Review Papers and Proceedings*, 92.

## References II

- (2007): “The Food Problem and the Evolution of International Income Levels,” *Journal of Monetary Economics*, 54, 1230–1255.
- Johnson, D. G. (1993): “Role of agriculture in economic development revisited,” *Agricultural economics*, 8, 421–434.
- Johnston, B. F. and P. Kilby (1975): *Agriculture and Structural Transformation: Economic Strategies in Late-Developing Countries*, New York, NY: Oxford University Press.
- Johnston, B. F. and J. W. Mellor (1961): “The Role of Agriculture in Economic Development,” *American Economic Review*, 51, 566–93.
- Jorgenson, D. W. (2017): “The role of agriculture in economic development: Classical versus neoclassical models of growth,” in *Subsistence agriculture and economic development*, Routledge, 320–347.
- Kjeldsen-Kragh, S. (2007): *The role of agriculture in economic development: the lessons of history*, Copenhagen Business School Press DK.
- Meijerink, G. W. and P. Roza (2007): *The role of agriculture in economic development*, 4, Wageningen UR.
- Mellor, J. W. (1973): “Accelerated growth in agricultural production and the intersectoral transfer of resources,” *Economic Development and Cultural Change*, 22, 1–16.

## References III

- (1995): *Agriculture on the Road to Industrialization*, Published for the International Food Policy Research Institute, Johns Hopkins University Press.
- (2017): *Agricultural Development and Economic Transformation: Promoting Growth with Poverty Reduction*, Springer.
- Restuccia, D., D. Yang, and X. Zhu (2008): "Agriculture and Aggregate Productivity," *Journal of Monetary Economics*, 55, 234–250.
- Schultz, T. (1953): *The Economic Organization of Agriculture*, McGraw Hill.
- Stern, N. (1996): *Growth theories, old and new and the role of agriculture in economic development.*, 136.
- Thorbecke, E. et al. (1969): "The role of agriculture in economic development." *The role of agriculture in economic development.*
- Timmer, C. P. (1988): "The agricultural transformation," *Handbook of Development Economics*, 1, 275–331.
- (1992): "Agriculture and economic development revisited," *Agricultural Systems*, 40, 21–58.
- (2002): "Agriculture and Economic Development," *Handbook of Agricultural Economics*, 2, 1487–1546.

## References IV

- Tsakok, I. and B. Gardner (2007): “Agriculture in economic development: primary engine of growth or chicken and egg?” *American Journal of Agricultural Economics*, 89, 1145–1151.
- Wollburg, P., T. Bentze, Y. Lu, C. Udry, and D. Gollin (2024): “Crop yields fail to rise in smallholder farming systems in sub-Saharan Africa,” *Proceedings of the National Academy of Sciences*, 121, e2312519121.