The Macroeconomic Impact of Agricultural Input Subsidies

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Agricultural productivity in developing countries

Motivation:

- Agriculture is at the heart of government policy:
    - e.g. over half of EU budget spent on subsidies and development of agriculture.
- Differences in agricultural productivity could explain differences in economic development.
- 1960s, rapid industrialization in Asia was led by a "Green Revolution".
- 2003 Maputo Declaration: SSA's attempt at catching-up.
- Implementation of Input Subsidy Programs (ISPs) primarily targeting staples production:
    - (+) improve food security, redistribute resources to poor farmers, relax credit constraints.
    - (−) may divert resources from exportable cash crops, slow down structural change

Goal:

- Evaluate the trade-offs of ISPs both empirically and structurally in GE.

This project

Empirically, we show that staple-targeting Input Subsidy Programs (ISPs):

- stimulate use of modern inputs and therefore productivity of staples,
- improve food security,
- cash crops: higher land share and price but no change in yields
- *increase* urbanization

We build a dynamic, occupational choice GE model with heterogeneous households:

- Food security is represented by Stone-Geary preferences and transaction cost for staples
- Match empirical evidence for land, cash crops & urbanization: GE overturns PE effects
- **ISPs can generate welfare improvement, but only with high transaction cost**

Data employed

Cross-country panel from FAOStat (1961-2020):

- 46 countries in SSA used for diff-in-diff analysis, 10 countries with ISPs
- assignment to treatment based on signing Maputo declaration/introduction of ISP.

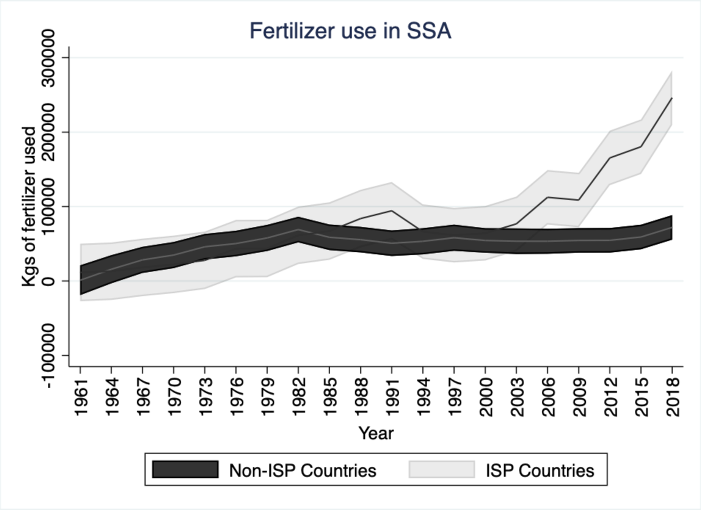
Cross-sectional LSMS data from Malawi 2010:

- country with **largest ISP in SSA**, costs 3-6% GDP annually.
- one of **poorest countries**: $367 per capita, 47% of children stunted, 80% pop in rural areas,
- **high transaction costs**: avg agricultural output $100 "at gate," worth $490 "in shops."
- **fragmented and subsistence-based farming**.

▸ Data details

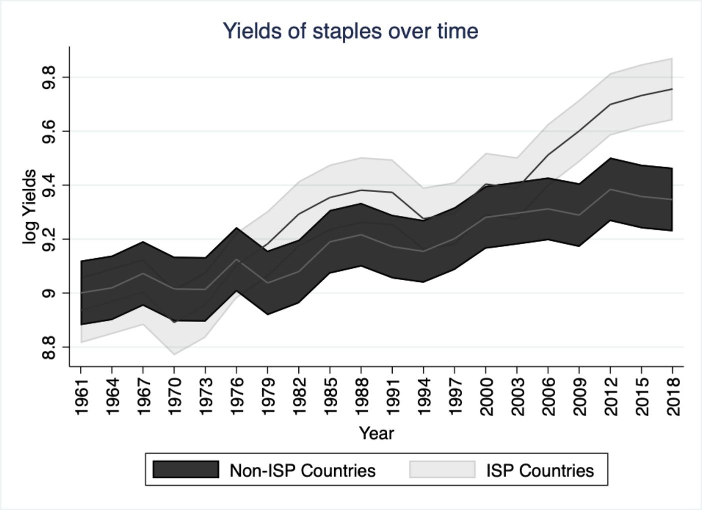
Macro diff-in-diff on FAOStat data: fertilizer use

Fertilizer use increases by 96 tonnes. ▸ Regression



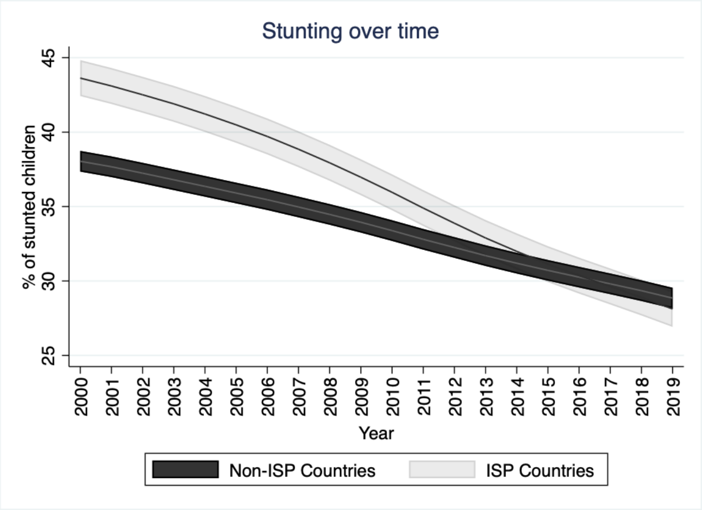
Macro diff-in-diff on FAOStat data: staple productivity

Yields of staples increase by 323 kg per ha. ▸ Regression



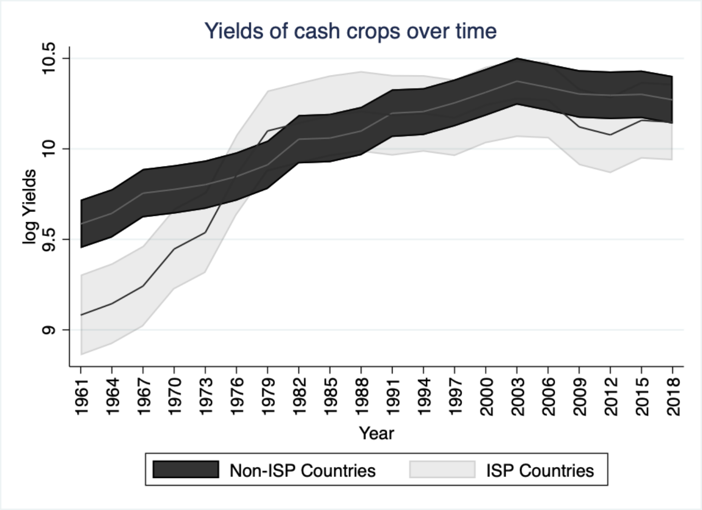
Macro diff-in-diff on FAOStat data: food security

Share of children stunted drops by 11%. ▸ Regression



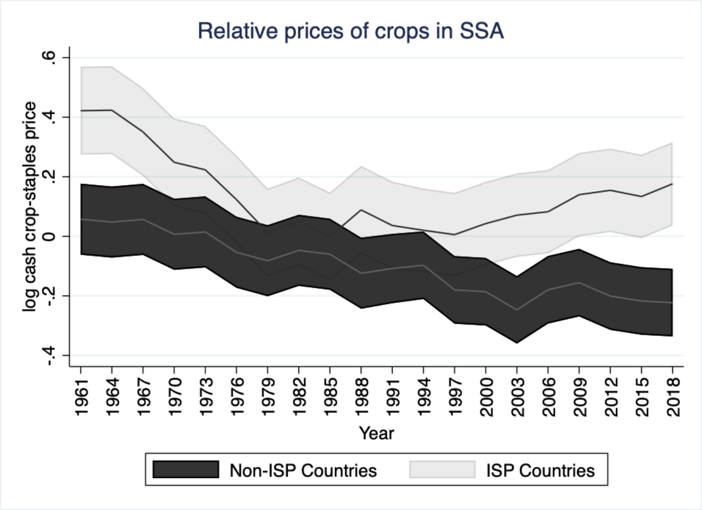
Macro diff-in-diff on FAOStat data: cash crop productivity

Yields of cash crops are not affected. ▸ Regression



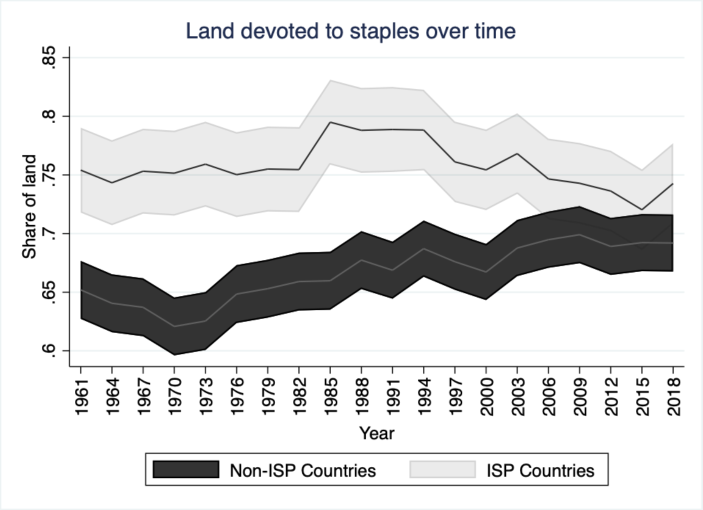
Macro diff-in-diff on FAOStat data: relative prices

Relative price of cash crops to staples increases by 15%. ▸ Regression



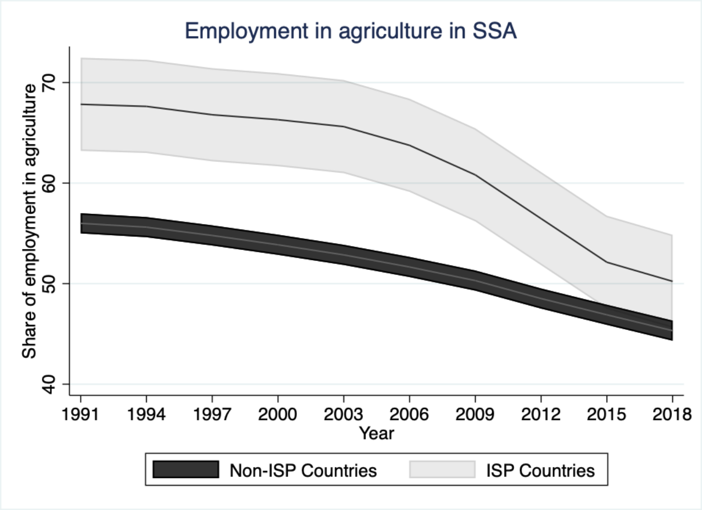
Macro diff-in-diff on FAOStat data: land allocation

Share of land devoted to staples decreases by 9%. ▸ Regression



Macro diff-in-diff on FAOStat data: structural change

Share of population employed in agriculture decreases by 10%. ▸ Regression ▸ Cross-Sectional Evidence



Quantitative model: overview

Dynamic stochastic general equilibrium model with heterogenous agents and financial frictions:

- Households are subject to idiosyncratic **agricultural-** and **labor-productivity shocks**.
- Decide about **wealth accumulation, occupation, agr production**. ▸ HH problem
- **Occupational choice** with frictional reallocations due to entry/maintenance costs:
  - **urban:** wage income from representative manufacturing firm with Cobb Douglas technology,
  - (two) **rural:** individual farms producing (i) staple- or (ii) cash-crops,
  - all goods consumed; cash-crop also **exported according to a demand function**.
- **Food security:**
  - **Subsistence food constraint:** Stone Geary utility in staples
  - **Transaction costs:** 1 unit of staples purchased requires $1 + Q_S$ transported
  - $\Rightarrow$ Profit maximization is not always optimal, HHs minimize expenditures.
- **Financial frictions:**
  - no intertemporal borrowing
  - limited intratemporal borrowing for input purchases due to **working capital** constraint.
- **Government** running the ISP financed from foreign aid.
- **General equilibrium** through prices of staples, cash crops, manufacturing, labor & capital.
- Calibrated to Malawi micro and macro data

Quantitative effect of abolishing subsidy

	Subsidy	No Subsidy
Consumption equivalent welfare	-	-4
Staple production	100	89
Staple productivity	100	89
Cash crop price	100	94
Cash crop production	100	103
Cash crop productivity	100	95
Share of financially constrained farmers	16	31
Share of staple-only farmers	7	2
Urbanization rate	18	16
Marketable staples surplus, % of GDP	17	16
Output	100	93
Consumption	100	90
Transaction cost	100	102
Trade Balance % of GDP	14	20

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Conclusion

We evaluated ISPs:

- Empirically important to look at GE
- Quantitatively possible to generate welfare benefits*

We also want to:

- compare micro/PE and macro/GE effects of ISPs in detail,
- analyze changes to ISP design, compare with cash transfers,
- analyze the transition path
- analyze costly infrastructural investment that simultaneously reduces:
  - costs of entry into urban
  - agricultural transaction costs

Thank you!

Any feedback will be highly appreciated:

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Data employed

Cross-country panel from FAOStat (1961-2020):

Variable	Control group	Treatment group
Number of countries	36	10
Log yields of staples	9.18	9.32
Log yields of cash crops	10.07	9.97
Share of population stunting	33.56%	36.20%
Share of rural population	69%	75%

Cross-sectional LSMS data from Malawi 2010:

Variable	Average
Number of households	12,015
Household size in rural/urban areas	4.59/4.46
Cons. in rural/urban areas	1,318/2,951
Income in rural/urban areas	1,142/2,795
Wealth in rural/urban areas	1,309/3,976
% of population in rural areas	82%
Size of total household land	1.97
% of HHs cultivating only maize	41%
% of staple harvest self-consumed	84%

Macro diff-in-diff on FAOStat data: regression evidence

Regression: $Outcome_{i,t} = \alpha + \beta ISPCountry_i \times ISPIntroduction_{i,t} + \gamma_i + \gamma_t + \epsilon_{i,t}$ Back

- ISPs increase staple yields by 323kg per ha.
- ISPs decrease cash crop yields by 46kg per ha (not-sign.).
- ISPs decrease share of land devoted to staples by 9%.
- ISPs increase ratio of "cash crop to staple" prices by 18%.
- ISPs decrease share of stunted children by 11 %.
- ISPs increase urbanization rate by 10 %.

	log Staple yields	log Cash Crop yields	Share of land with staples	Relative prices	Stunting	Urbanization rate
ISP-treatment	0.26***	-0.02	-0.06***	0.18***	-3.67***	-4.11***
	(0.04)	(0.04)	(0.01)	(0.03)	(0.37)	(0.58)
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.17	0.33	0.09	0.16	0.74	0.48
N	2490	2490	2490	1972	900	1421

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Appendix: cross-sectional evidence from Malawi

Being a HH devoting 10 p.p. (18%) less of land to maize:

- increases the *value* by 5%
- 2.4 kg less of fertilizer used
- 24 p.p. lower share of self consumed crops

	(1)	(2)	(3)	(4)
	$share\ maize_i$	$\log(value_i)$	$fertilizer_i$	$\%self\ consumed_i$
$FISP\ recipient_i$	-0.06***	0.08***	70.96***	-4.05***
$share\ maize_i$		-0.52***	24.27**	24.30***
Controls&Village FEs	Yes	Yes	Yes	Yes
R^2	0.34	0.34	0.16	0.35
N	8,544	8,544	8,544	8,544

Note: Value is in per capita & per land area unit terms. Controls include household head's sex, age, marital status, religion, language, education, household size, and land controls (avg soil quality, total area, total kgs of fertilizer used).

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Appendix: Household's problem

$$V(z,a,e) = \max_{C,a',e'} u(C) + \beta \mathbb{E} V(z',a',e') \tag{1}$$

$$st.: Y + a' = (1+r)a \tag{2}$$

$$Y = \min_{e' \in \{S,CC,M\}} \{Y_S(C), Y_{CC}(C), Y_M(C)\} \tag{3}$$

- z: productivity vector of $\{\theta, l_Z\}$, a: wealth, e: occupation, Y: net expenditure
- $u(C) = \frac{1}{1-\sigma} \left(\psi_S \left(c_S - \bar{c}_S \right)^{1-1/\epsilon} + \psi_C c_C^{1-1/\epsilon} + \left(1 - \psi_S - \psi_C\right) c_M^{1-1/\epsilon} \right)^{\frac{1-\sigma}{1-1/\epsilon}}$
- Example for workers:
  - Net expenditure: $Y_M \equiv P_M C - w l_Z = (1+Q_S) c_S + p_C c_C + p_M c_M - w l_Z$
  - Price index: $P_M = (\lambda^{1-\epsilon} \psi_S^{\epsilon} + p_C^{1-\epsilon} \psi_C^{\epsilon} + p_M^{1-\epsilon} \psi_M^{\epsilon})^{\frac{1}{1-\epsilon}}$, where $\lambda = (1+Q_S)$
- But for farmers, the price index depends on consumption chosen $\implies$ C & e' are linked

Staple producer's problem

- Staple producers profits: $\pi_S = p_S \phi_S \theta x_S^\zeta - (1 - \tau_S)\, p_x x_S$
  - θ: productivity of farm, p_x, x_S: price & quantity of fertilizer applied, τ_S: subsidy
- Collateral constraint: finance $(1 - \tau_S)\, p_x x_S$ from household's wealth$\cdot\kappa$ before production takes place
- Objective: minimize expenditure to obtain optimal consumption bundle.

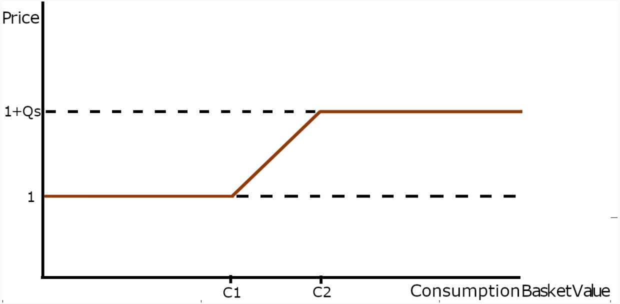


Figure 1: Staple consumption price conditional on consumption chosen (output held fixed)

Cash crop producer's problem

- Cash crop producers profits:

$$\pi_B = p_B \phi_B \theta l^\rho x_B^\zeta + p_S \phi_S \theta (1-l)^\rho x_S^\zeta - (1-\tau_S)\, p_x x_S - (1-\tau_B)\, p_x x_B$$

  - θ: productivity of farm, p_x, x_S: price & quantity of fertilizer applied, τ_S: subsidy
  - l is land-split choice
  - $\rho \in (0,1)$ is aimed at capturing variety of motives for mixing (insurance, timing of operations).

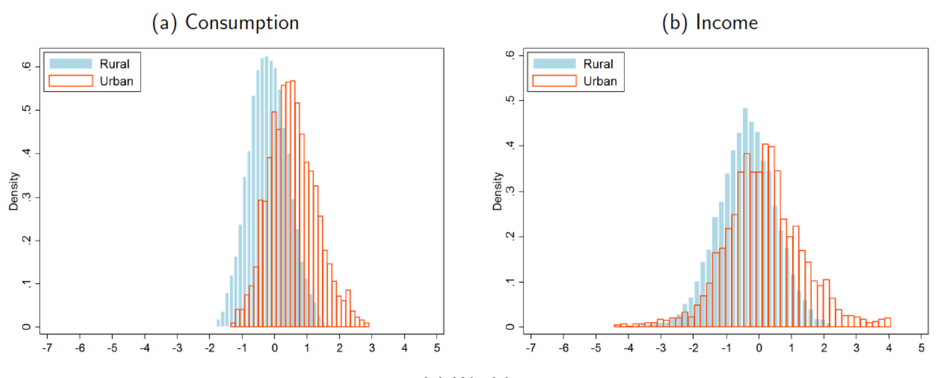
- Collateral constraint: finance $(1-\tau_S)\, p_x x_S + (1-\tau_B)\, p_x x_B$ from household's wealth$\cdot\kappa$ before production takes place

- Objective: minimize expenditure to obtain optimal consumption bundle.

- **Comparative statics:** land optimally allocated to cash crops l:
  - declines in subsidy rate τ_S,
  - increases in relative price $\frac{p_B}{p_S}$. ▸ Back

Appendix: Calibration strategy

- Calibrate to Malawi: preferences, production technology & shocks, market frictions
- $Q_S = 0.5$: compare consumer to producer prices, and relative to US
- Productivity to match: $log(harvest_{i,t}) = \beta_0 + \beta_1 \cdot log(harvest_{i,t-1}) + \beta_2 X_i + \gamma_v + \epsilon_{i,t}$
- Follow an RCT of capital injection by Amber et al.(2020) for working capital constraint



Calibration to Malawi in 2010

Parameter	Moment
Discount factor β	0.927
Consumption share of staples ψ_S	0.51
Consumption share of staples ψ_M	0.23
Foreign demand shifter a_D	0.1
Staple productivity ϕ_S	1.1
Cashcrop productivity ϕ_B	0.56
Home production when unemployed in cities $l_z =$ unemployed.	0.03
Stone Geary preference $\bar{c}$	0.0
Price of fertilizer p_x	0.98
Collateral constraint κ	1.62
Entry cost to cashcrop sector F_B	0.27
Entry cost to urban sector F_W	1.57
Maintenance cost to cashcrop sector FM_B	0.001
Duration of employment ρ_W	0.5
Autoregressive agricultural productivity ρ_S	0.925
Volatility of agricultural productivity σ_S	0.925
Rates of return on land ρ	0.76
Depreciation δ	0.044

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