Policy and Economic Considerations for Public Goods Provision: Agricultural R&D Funding From the Private, Public, and Philanthropic Sectors

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Overview

> Purpose & Background
> Methods
> Funders' Incentives and Capabilities for R&D Public Goods Investment
> Agricultural R&D Investments by Sector
> Discussion of Findings

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Purpose

Frame a discussion around R&D funding as a function of alternative funding objectives

- Assume purely private goods are supplied by the market and that the private sector will fund goods with some public good characteristics if profitable
- How would a global social planner allocate public and philanthropic sector spending across the residual – the remaining "underprovision" of *goods that span the spectrum of "global" and "local" and "public" and "private"…*

Agricultural R&D "Publicness"

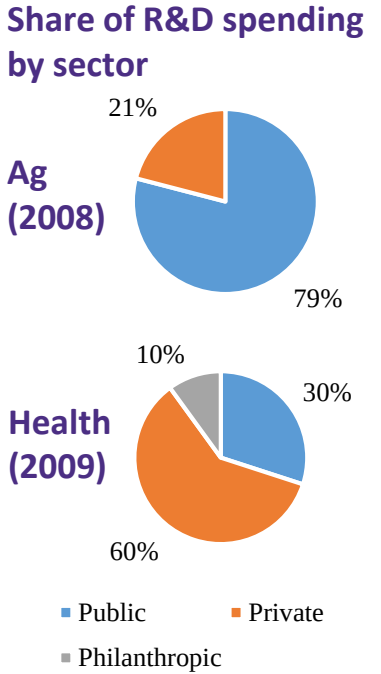
> R&D produces knowledge that can be used repeatedly – **non-rival**

> Results of R&D may fall under patent or IP protections – **some excludability** incentivizes private sector agricultural R&D investment

> Knowledge from basic R&D may have wide potential applications – **"global" public goods**

Is Agricultural R&D Undersupplied?

- Agricultural R&D largely funded by the public sector (Pardey et al., 2016; ASTI, 2012; Beintema et al., 2012)
- Research intensity ratios – for every $100 of agricultural GDP in a high-income country, roughly $3 is spent on research by public and private funders, an amount that has increased steadily over time, while in low-income countries, for every $100 of agricultural GDP only $0.54 is spent on research (Pardey et al., 2016)



Sources: Beintema et al., 2012; Røttingen et al., 2013

https://www.asti.cgiar.org/cgiar-data/cgiar#5

Research Questions

From the perspective of a global social planner, ***an efficient allocation of global R&D funding would match private, public, and philanthropic resources to R&D types consistent with each funder's objectives***

> How do characteristics of agricultural R&D and preferences of private, public, and philanthropic providers of R&D funding affect the relative advantages of alternative sectors?

> How do trends in agricultural R&D funding from public, private, and philanthropic sources for different categories of crops compare to expectations based on those hypothesized advantages?

Methods

- Draw on literature to summarize incentives for R&D public good investment by sector (private, public, philanthropic) and public good characteristics of categories of agricultural R&D

- Develop hypotheses for how a global planner would efficiently allocate funding by sector for:
  - Agriculture R&D in general
  - R&D for cash crops and commodity grains
  - R&D for “orphan” crops and subsistence crops
  - R&D outputs with higher positive social externalities (e.g., vegetative or OPV crops)

- Compare funding expectations against trends in private, public, and philanthropic investment in categories of agricultural R&D

A Model of R&D Funding Considerations

$$E(NPV) = \left[prob.to\ mrkt\left(\frac{\left[\left(Pm\ (1-\left(0\ \leq pov_j \leq 1\right)\right) * Qm\right) - Cm\right] + SOC\ (0\ \leq s_j \leq 1\ )}{(1+r)^t}\right) * (0\ \leq loc_{Rj}\ \leq 1)\right]$$
$$- \sum_i \left[prob\ (phase_i \mid phase_{i-1})\left(\frac{(C_{ij}(SC_{ij}) * Q_{ij})}{(1+\ r)^{t_{ij}}}\right) * (0\ \leq loc_{Cj}\ weight \leq 1)\right]$$

- **Financial returns:** (Pm * Qm) - Cm
  - Function of excludability, market size, market share, & consumer willingness-to-pay
- **Social benefits:** *SOC* e.g., food security
- **Location of $ flows:** *loc*, nation of consumers, employment, and investment
- **Probability of getting R&D to market**: conditional on completing all research phases
- **Estimated time to market:** *t* and *r* (discounting)
- **Costs of completing phases of R&D:** *C*, with *SC* sunk or specialized costs; conditional on completing previous research phase

Model Data & Assumptions

- We know Q* (the total desired public good or service, in this case R&D outputs)
- **By sector:** We have some reasonable assumptions behind funder preferences and priorities (e.g. importance of financial returns vs. social benefits, location of benefits/expenditures, discounting)
- **By R&D type** (e.g., genetic improvement, in-trust plant GRs, ecosystem preservation, enabling policies):
  - We can make some reasonable estimates for the probability, time, and costs of successfully moving from basic science to market
  - We can rank the R&D output by its expected financial returns and its contribution to livelihood, nutritional, environmental or other goals

Hypothesized Funder Weighting

Preferences	Private	Philanthropic	Public (National)	Public (Multilateral)
Financial Returns	Necessary	Not necessary	Valued to large degree	Valued to some degree
Social Benefits	Not accounted for	Necessary	Valued to some degree	Valued to large degree
Location of Returns	Indifferent	Some preference but below social benefits	Prefer domestic returns	Some preference but below social returns
Location of Expenditures	Indifferent	Indifferent	Prefer domestic expenditures	Indifferent *(may depend on funding restrictions)*
Probability of Success (Risk)	Very important	Less important	Important	Important
Time to Market & Cost of Capital	Very Important	Less Important	Important	Important
Subsidized Price (Poverty Goals)	No price subsidies provided	Willing to subsidize to large degree	Willing to subsidize to some degree	Willing to subsidize to some degree
Sunk Costs	Prefer to minimize	Tolerable	Tolerable to some degree	Tolerable

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Example: Assigning Weights to Research Areas

Trade-offs for Crop Genetic Advances

	Trade-offs in SSA	Maize	Rice	Sorghum	Millet	Wheat	Cassava	Forests/NRM
Importance assumed to vary by sector weighting (e.g. CGIAR goals) and public good or service	Poverty among target population	50% in SSA	58% of poor	insurance crop	insurance crop	higher income		
	Market size/ Importance to livelihoods (> 300kcal/day	46%	15%	30%	7.5%	13%		
	Nutrition benefits - iron (calories, fat, protein & micronutrients)	4	5	1	2	3		
	Resilience to climate change (temp/precip/CO2)	3	4	2	1	3		
	Minimal impact on environment: Land degradation	3	1	2	2		**2**	
	Water depletion	2	3	1	1		**3**	
	Water depletion: SA	**1**	**3**	**2**	**2**		**1**	
Importance varies by sector	Scientific & market risk, price, time and costs to market							

Sources: FAOSTAT, USDA, Reynolds et al. (2015),
1=least often mentioned as concern

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Example: Allocating Funding for New Crop Genetic Code

Solve for Sector Shares of the Public Good

- Theory suggests that compared to the private sector, the *public and philanthropic sectors* direct a greater proportion of their agricultural R&D funding toward subsistence and orphan crops
- But, given the large share that remains to be allocated among the other sectors, how do the philanthropic, national, and multilateral public investors align on priorities & divide the rest?
- **Begin by looking at current allocations**

Current Allocations

ASTI led by IFPRI

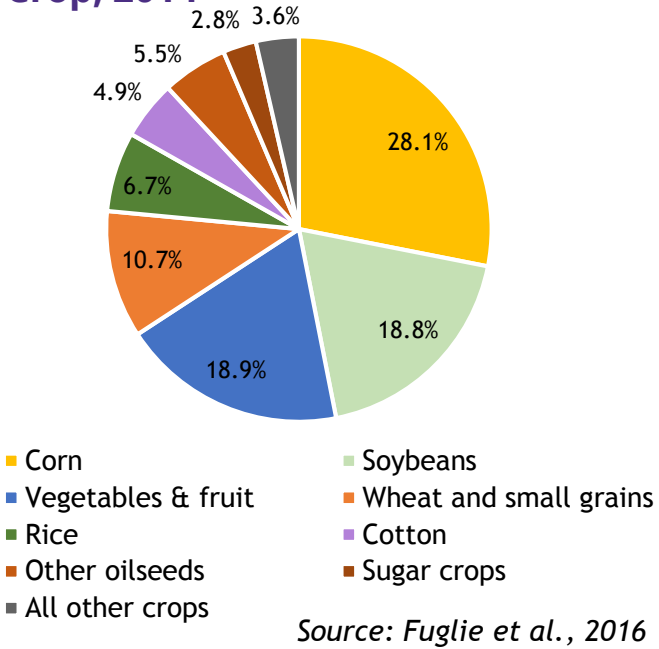
Data for agricultural R&D funding:

- CGIAR Agricultural Science and Technology Indicators **(ASTI)** – multiple years
- United States Department of Agriculture **(USDA)** Economic Research Service
- Reviews and estimates from the literature (e.g., Fuglie et al., 2016; Pardey et al., 2016)
- Publicly-traded company financial statements from U.S. SEC 10-K filings

Private Agricultural R&D Funding

- Focus on large-acre market-oriented crops, in particular corn, soybeans, and wheat, in addition to small-acre cash crops like fruit and vegetables (Fuglie et al., 2016)
- Subsistence crops like cassava, pearl millet, and sorghum are characterized by substantially lower levels of private research intensity (CGIAR, 2011; Naseem et al., 2001)

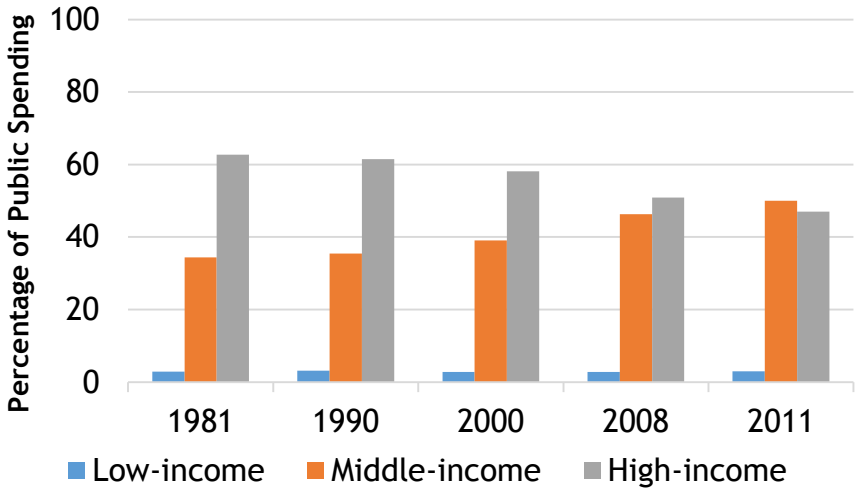
Private Sector R&D Spending by Crop, 2014

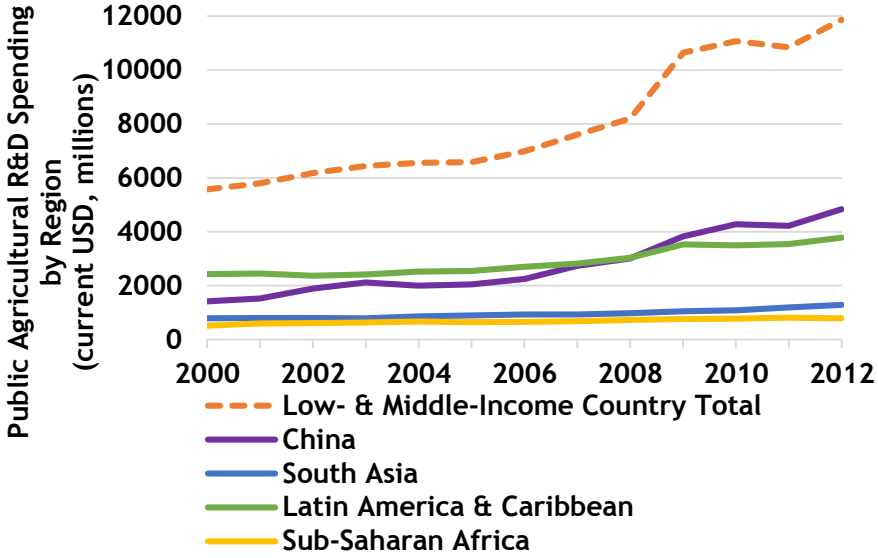


Source: Fuglie et al., 2016

Public Agricultural R&D Funding

Share of spending by country income group





Total spending by country/region

Source: ASTI, 2017

Pardey et al., 2016

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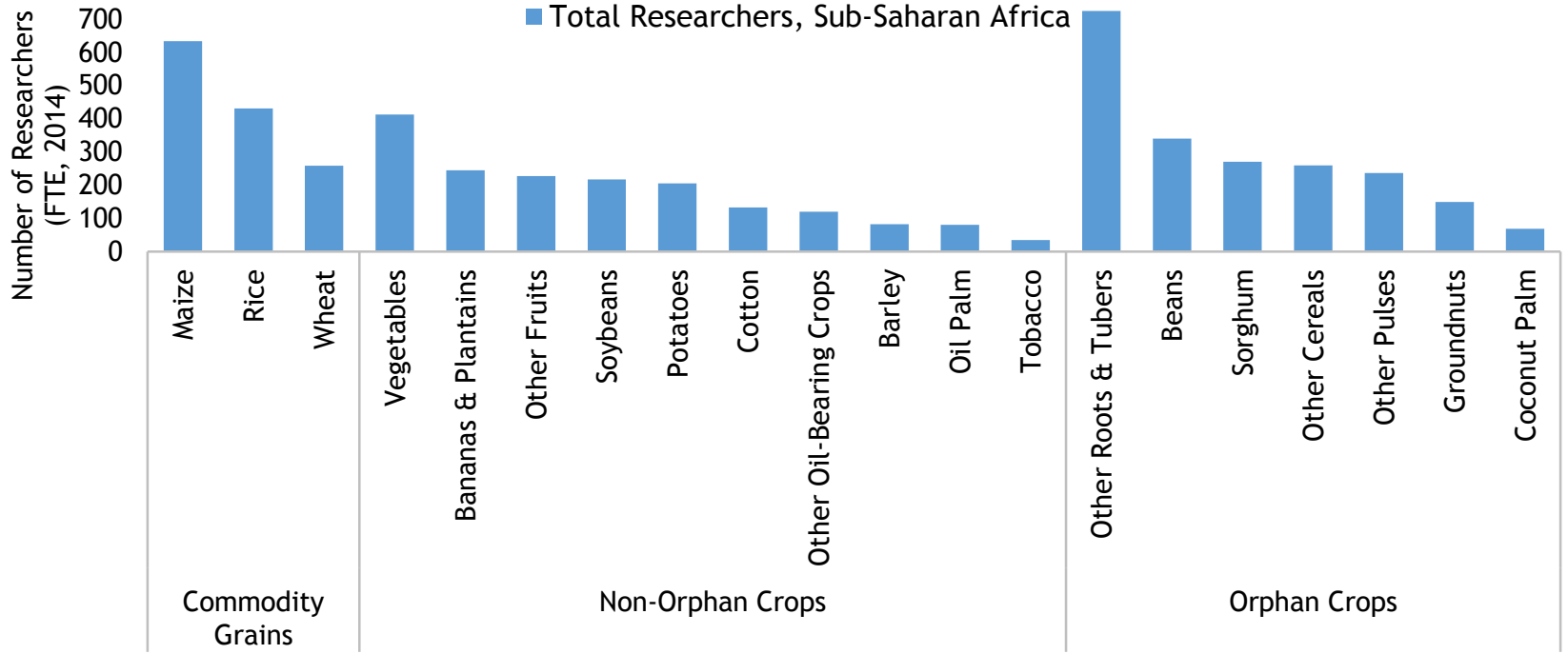
Public R&D Researchers by Crop Category



Source: ASTI Database, 2017 (2014 data)

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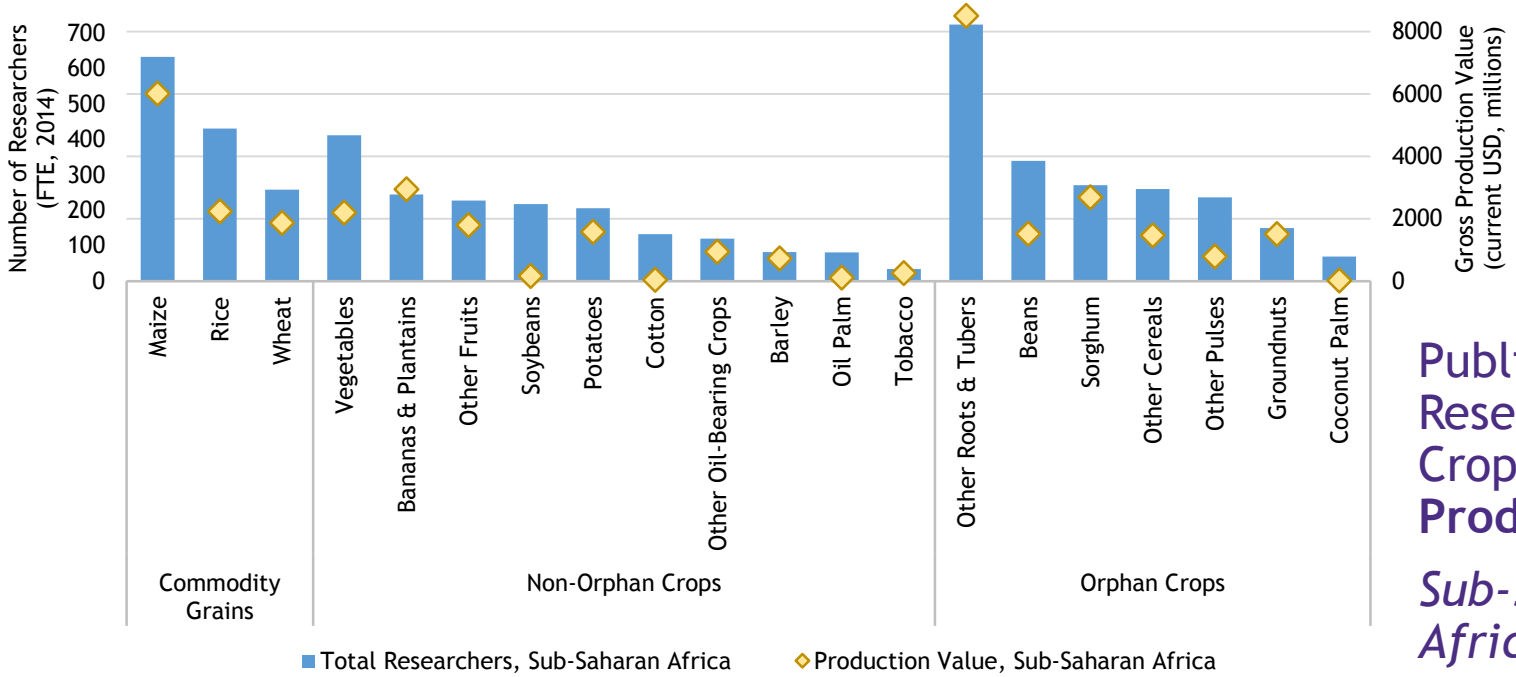
Philanthropic Agricultural R&D Funding

- Data on philanthropic investments are limited
- Estimates for total philanthropic funding in 2008 range from $245.6 million (Coppard, 2010) to $450 million (Morton, 2010)
- Top five Gates Foundation agricultural R&D grant recipients received $244.2 million from 2003 to 2010 for breeding and delivery of improved seed varieties (Gates Foundation, 2011)
  - Three of these five grants, totaling $99.2 million, focus on R&D for maize and wheat
  - One grant totaling $45 million targets development and delivery of staple crops, including commodity grains and crops that are generally for subsistence only (e.g., sweet potato, beans, millet, and cassava)
  - Largest grant, totaling $100 million, targets capacity building for both public and private breeding programs in 13 Sub-Saharan African countries.

Model Applications:
Public Research FTE and Production Value



Public R&D Researchers by Crop and **Gross Production Value**

Sub-Saharan Africa, 2014

Source: ASTI Database, 2017

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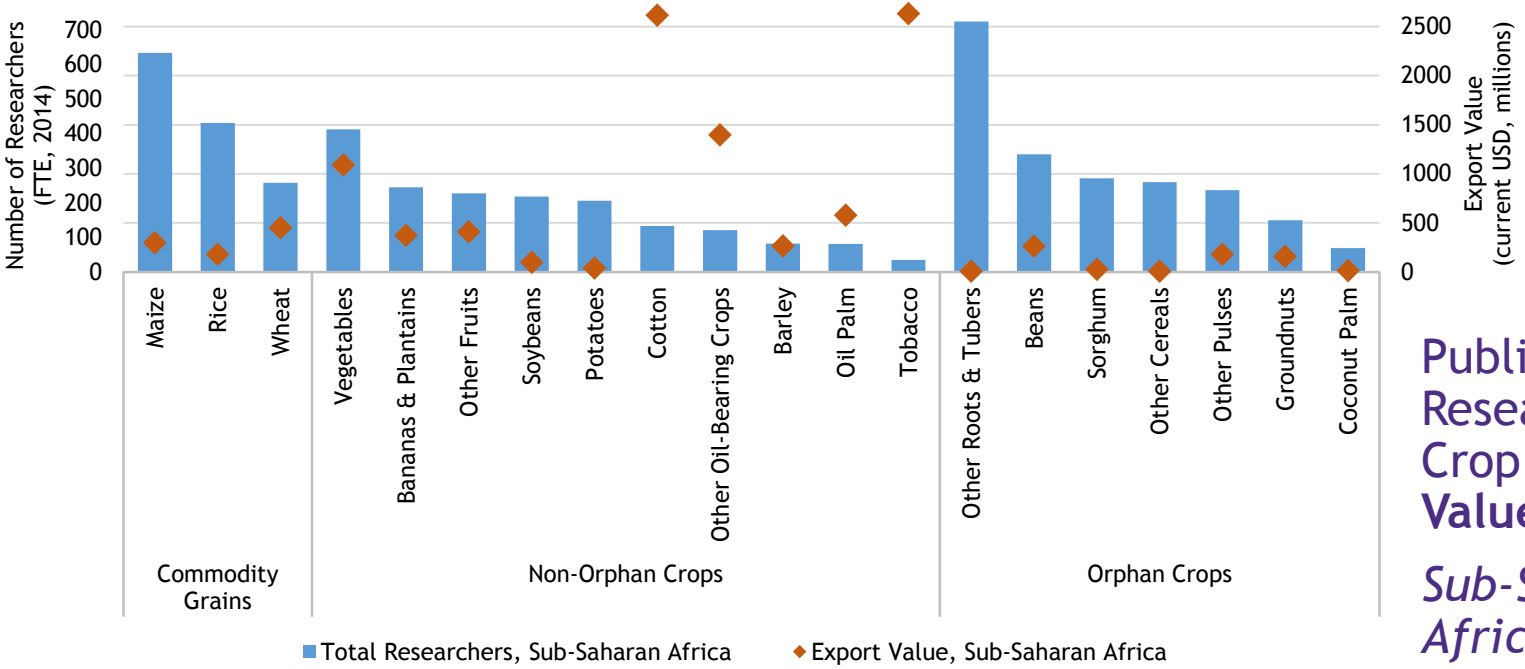
Model Applications:
Research FTE and Export Value



Public R&D Researchers by Crop and **Export Value**

Sub-Saharan Africa, 2014

Source: ASTI Database, 2017

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Findings on Public & Philanthropic Funding

Evidence supports expectations that public R&D focuses relatively more than private sources on subsistence and "orphan" crops and "neglected diseases" with smaller potential financial returns

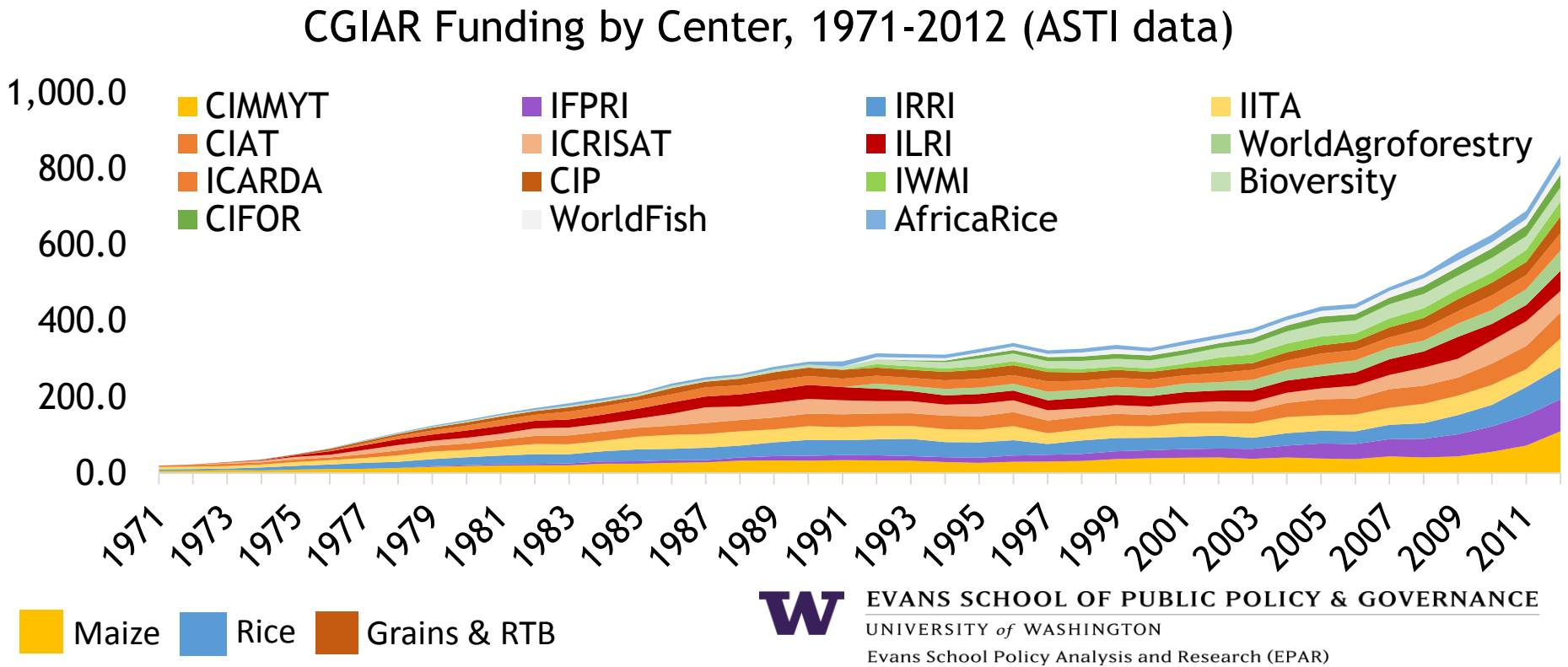
> But most public & philanthropic agricultural R&D still targets commodity grains and cash crops, similar to the private sector

Limitations in R&D spending data, inconsistent metrics and subnational variation

> Decisions likely vary by funder within each sector, and by public good or service

Model Extensions:

Changing Patterns in CG Research Funding



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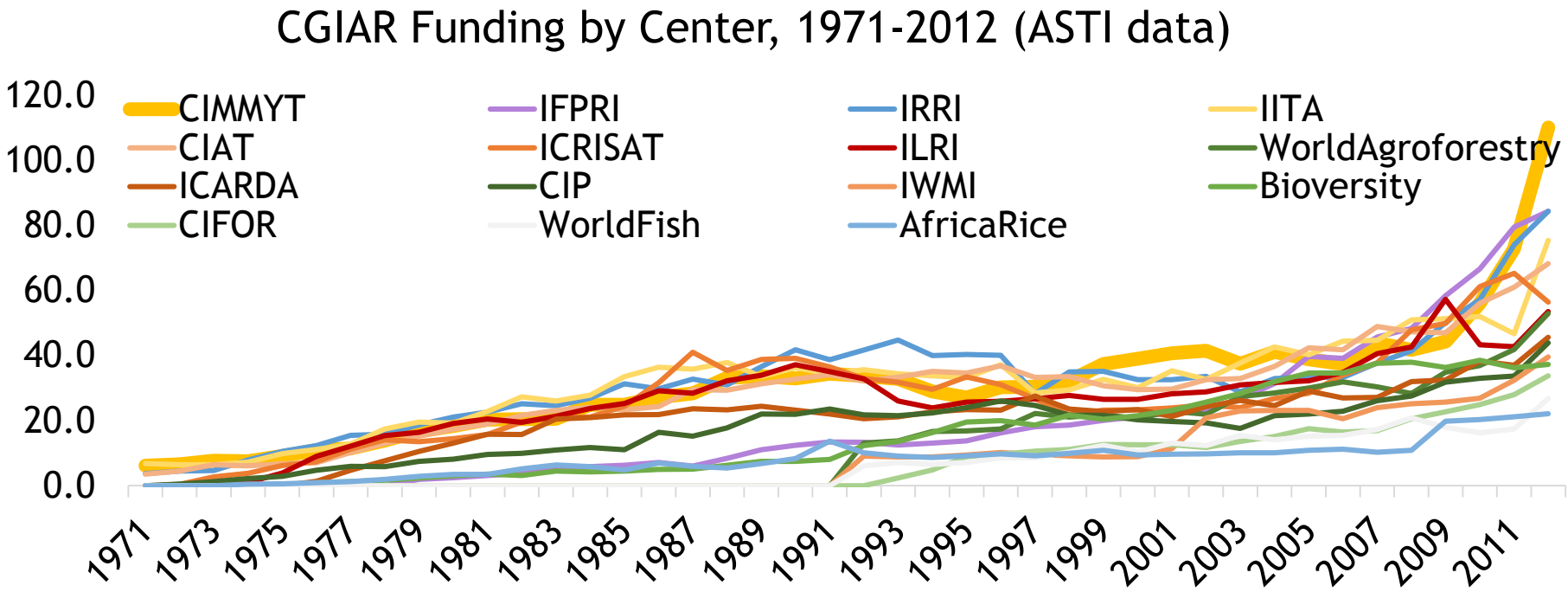

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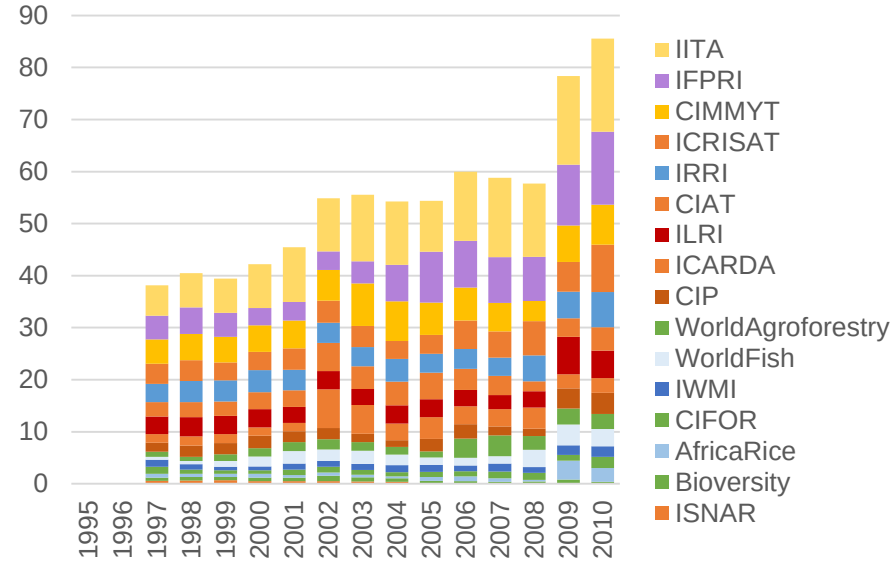
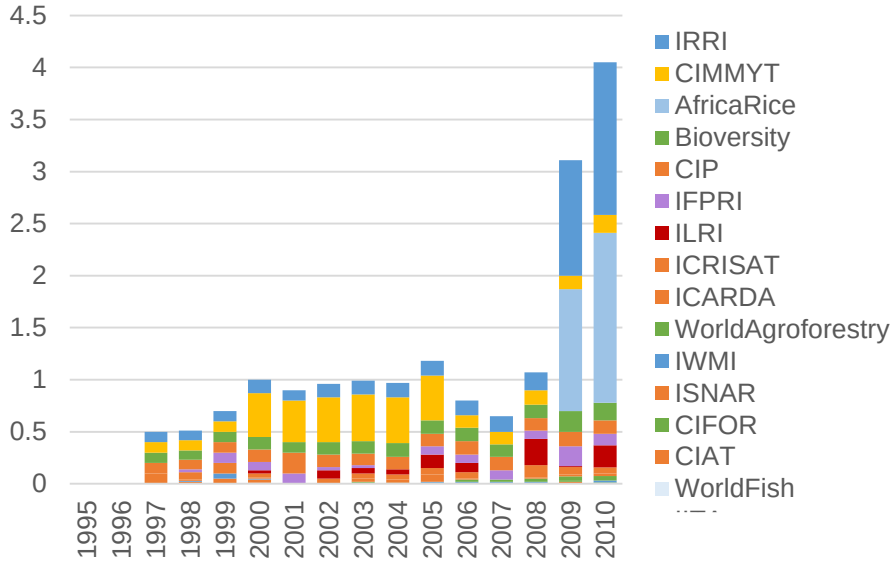
Model Extensions:
Public Funder Priorities in CG Funding?

United States



China



Maize Rice Grains & RTB

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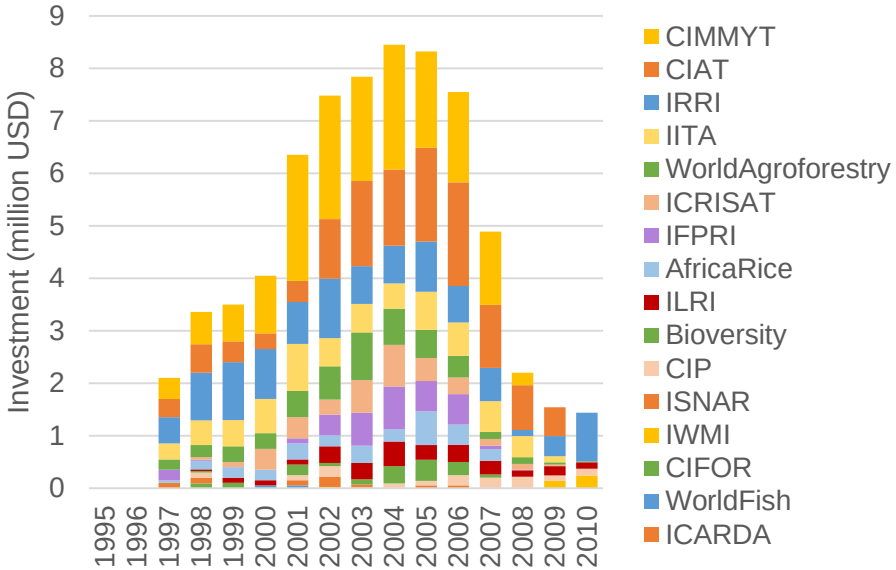
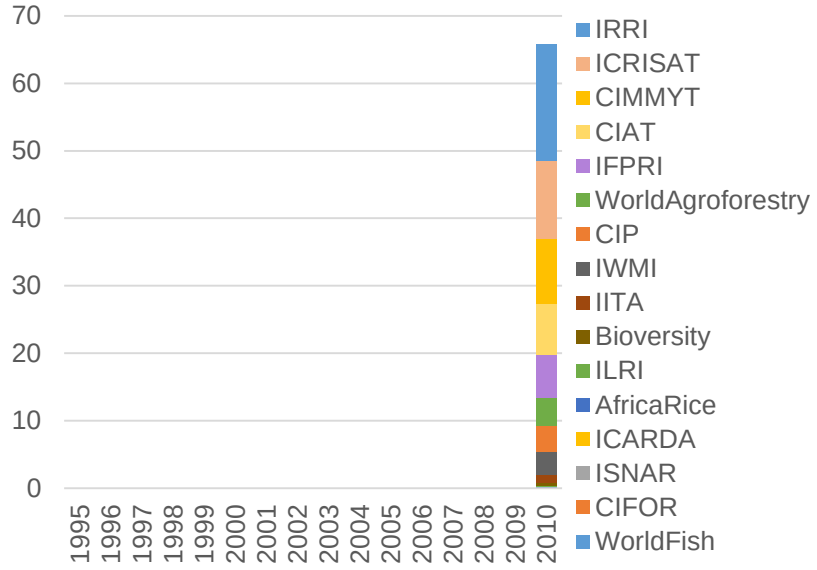
Model Extensions:
Philanthropic Priorities in CG Funding?

Rockefeller Foundation



Gates Foundation *(note y-axis)*



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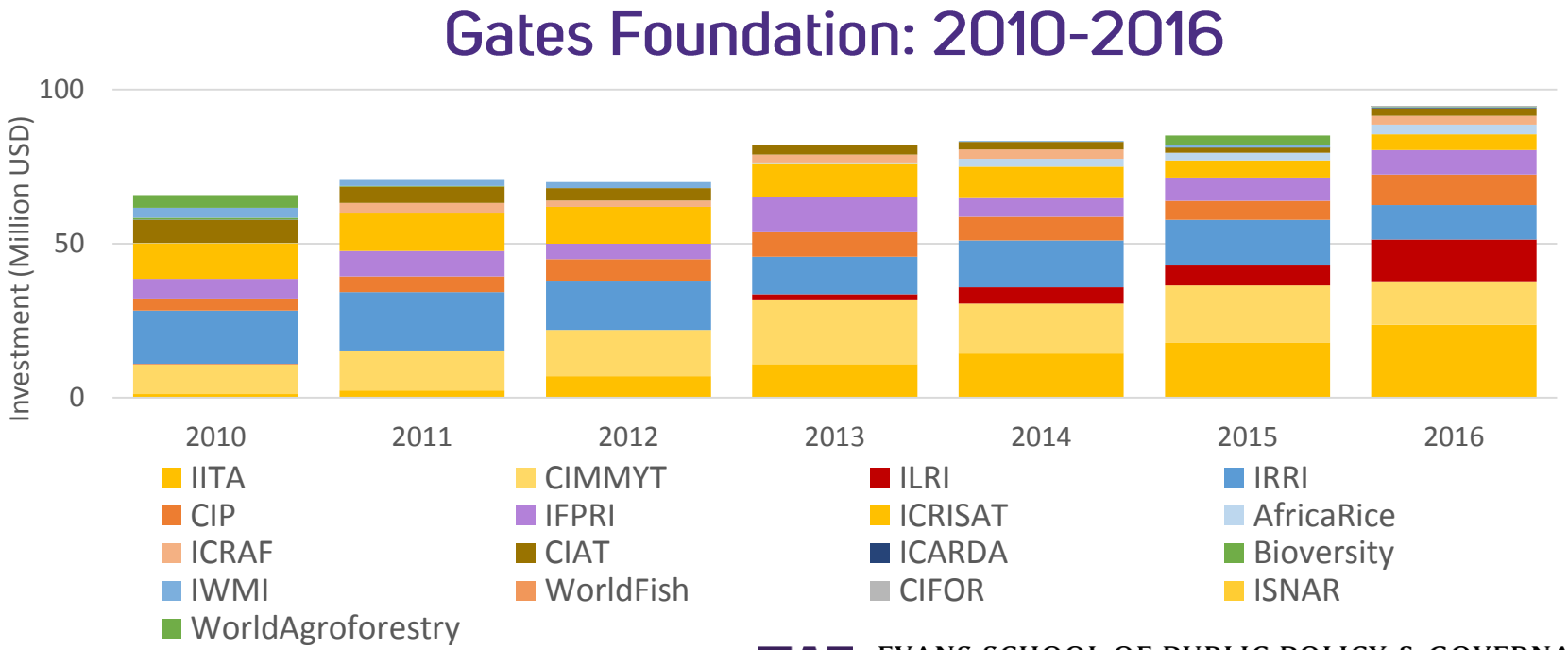

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Discussion of Findings

Both public R&D (country specific) and multilaterally funded R&D (CG centers) focus on a mix of commodity grains, cash crops, subsistence and “orphan” crops with smaller potential returns

> But both public & philanthropic multilateral support for agricultural R&D exhibits strong regional preferences / donor preferences

Limitations in comparability of R&D benefits flows further impedes recommendations surrounding the efficient allocation of new funds

> Yield gaps, hunger, malnutrition, poverty metrics, gender all invoked in justifying funding choices

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Thank you.

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Professor Travis Reynolds, co-Principal Investigator

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Please direct comments or questions about this research to Principal Investigators C. Leigh Anderson and Travis Reynolds at epar.evans.uw@gmail.com.