Too Small to be Beautiful?
Farm Size and Productivity In Bangladesh

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Agriculture Global Practice
The World Bank
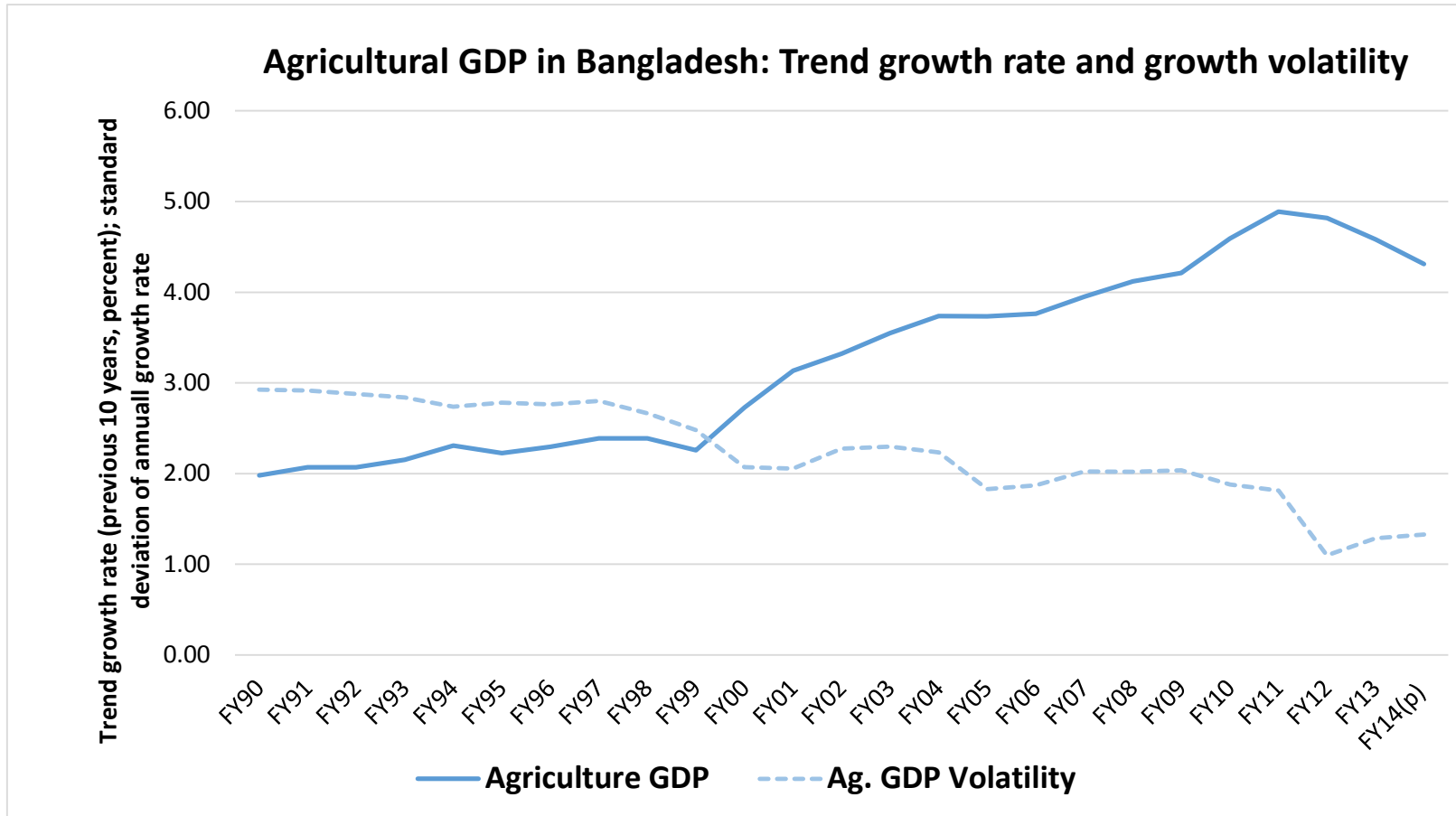
Farm size and Productivity: A Global Look

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Outline

- Setting the context: Bangladesh Agriculture
- Methodology
- Data and sample
- Results: Descriptive and SFP Analysis
- Conclusions

Agriculture has performed extremely well

Agricultural GDP in Bangladesh: Trend growth rate and growth volatility

Legend: Agriculture GDP — Ag. GDP Volatility

Driven by productivity despite falling farm sizes

Total Factor Productivity Growth 1995-2011

Legend: 1995-11 | 2005-11 | BGD 1995-11 | BGD 2005-11
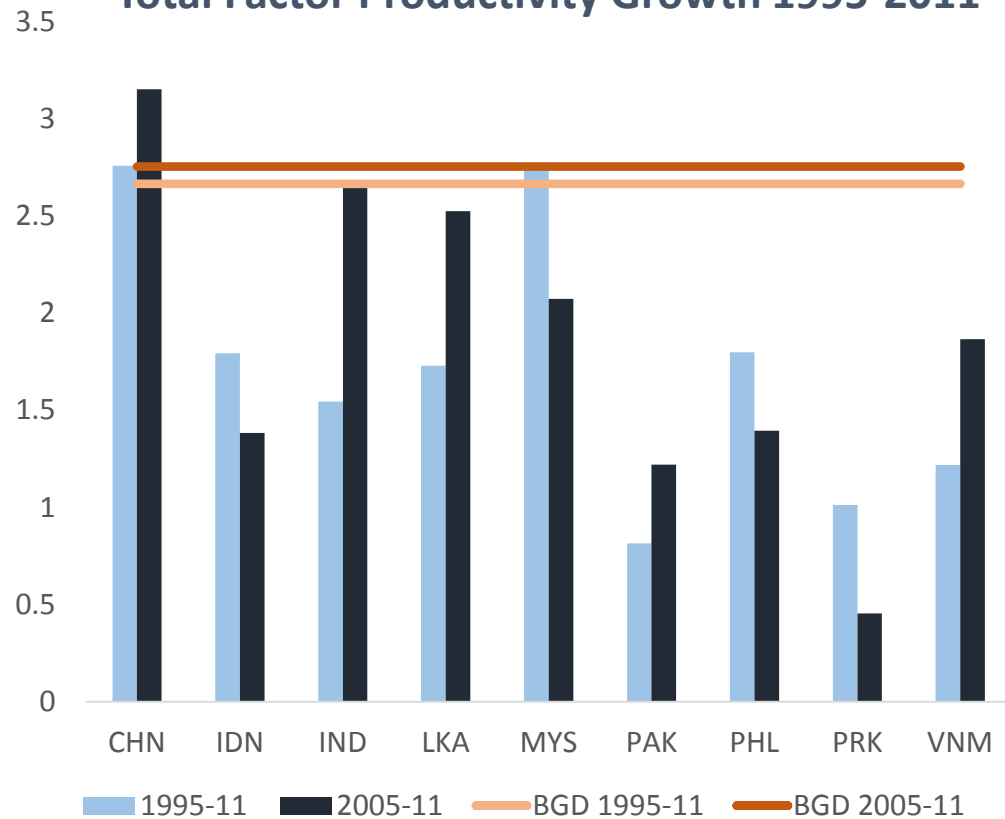
Source: based on Nin-Pratt (2015) estimates

Average Farm Size, 2000-2010.

	OPERATED LAND (HA)	OWNED LAND (HA)
2000	0.62	0.34
2005	0.53	0.32
2010	0.46	0.26

HIES (BBS) data

Interesting setting to test inverse relationship

- Land quality – panel data + soil quality, elevation, broad AEZ indicator
- Labor markets – active labor markets; high level of RNF participation
- Active land markets – over half of households leasing in land
- Credit – capital investment sub by mechanization rental services
- Adoption – new technology widely adopted
- Risk – widespread use of irrigation, relatively predictable weather
- Panel data – managerial skills/household specific effects

Falling farm sizes but *more* households turning to agriculture

	2000	2004	2008
Households with farm income (%)	79.9	80.8	87.2
Households with non-farm income (%)	83.1	89.1	77.4
HHs with both farm and non-farm income (%)	62.9	69.9	64.5
Family size	5.40	5.23	4.94
Number of earners	1.56	1.63	1.58
Number of agricultural workers	0.89	0.93	0.84
Number of non-agricultural workers	0.67	0.69	0.73
Female heads of household (%)	5.89	6.94	13.53†
Agricultural capital/agric. worker (2008 BDT)	8,158	8,434	11,758
Non-agric. capital/non-agric. worker (2008 BDT)	15,523	11,514	12,939

Shifting ground rules: technology use is widespread

	2000	2004	2008
Inputs and mechanization			
Proportion of irrigated land	66.3	77.4	80.3
Percent of cultivator HHs using fertilizer	96.8	96.4	97.7
Percent of cult. HHs using high-yield varieties	83.9	86.6	84.5
Percent of cultivator HHs mechanized	66.2	82.3	88.7
Percent of HHs with electricity	46.1	61.3	82.5

Methodology

- Stochastic Production Frontier approach
- Simultaneously estimate inefficiency function (BC 95 model)
- Conditional production function – sequential decision making
  - Given land allocation
  - Explicitly control for physical production conditions (land quality)
- Parametrize inefficiency function – land, policy variables
- Correlated Random Effects model
  - Control for time invariant unobserved household heterogeniety
- Test for endogeneity of x
  - Hausman test: χ^2 =38.24; p=0.1736
  - Instruments: output prices, wages, household size, non-agricultural capital, and standard deviation of rainfall

Empirical model

- The stochastic production function is specified as follows:

$$\ln\left(\frac{Y_{it}}{A_{it}}\right) = \alpha_0 + \beta_a \ln(A_{it}) + \beta_x \ln\left(\frac{X_{it}}{A_{it}}\right) + \beta_c C_{it} + \theta_t Year + V_{it} - U_{it}(Z_{it}, P_{it}) \quad (1)$$

$$U_{it} = \delta_0 + \delta_a A_{it} + \delta_z Z_{it} + \delta_p P_{it} + u_{it} \quad (2)$$

- Where Y_{it} is the total value of output and A_{it} is the farm size measured in hectares. The term $\left(\frac{X_{it}}{A_{it}}\right)$ denotes the (set of) inputs used per hectare. C_{it} are production conditions
- Z_{it} in (2) are demographic variables and P_{it} are policy variables

Study Sample

- 62 villages in 57 of 64 Districts

- Original survey 1988 (HHID missing)

- The repeat surveys in 2000, 2004 and 2008 – used for analysis

- Multistage random sampling
  - First stage: 64 unions selected randomly
  - Second stage: one village/unions - representative of population density, land distribution and literacy rate.

- Village census to stratify households by land ownership, tenure and literacy.

- Random sample of 20 HHs/village reflecting prob. distribution of stratum

Survey Year	No. of Farm HH	No. of Intact Farm HH	Total Sample (Inc. NF-HH)
2000	1,141	720	1880
%	60.69		
2004	1,240	720	1930
%	64.25		
2008	1,131	720	2010
%	56.27		

Descriptive Statistics: Farm Production

Production Variables (output and inputs)	2000		2004		2008	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Farm size (Ha)	0.77	0.89	0.71	0.78	0.66	0.70
Value of output (per ha) in 2008 prices	62373	40302	59579	33258	90869	72252
Fertilizer costs (per Ha) in 2008 prices	6419	4305	5489	4172	5765	3680
Labor costs (per Ha) in 2008 prices	9780	9945	9663	8821	12221	9889
Share of farm households using hired labor	0.81	0.39	0.82	0.38	0.89	0.31
Other costs (per Ha) in 2008 prices	7718	5534	7471	6239	9382	6470
Agricultural capital (per Ha) in 2008 prices	42316	64534	43988	53941	68433	88007
Number of family agric. workers (per Ha)	4.79	6.80	4.66	5.59	5.54	9.86
Share of irrigated land	0.72	0.40	0.79	0.37	0.86	0.33
Production conditions Share of sandy land	0.05	0.17	0.05	0.18	0.03	0.16
Share of loam land	0.38	0.42	0.26	0.37	0.14	0.29
Share of sandy loam land	0.30	0.40	0.41	0.43	0.50	0.45
Share of clay loam land	0.26	0.38	0.28	0.40	0.33	0.43
Share of high land	0.39	0.44	0.36	0.42	0.22	0.37
Share of medium land	0.31	0.40	0.31	0.39	0.39	0.44
Share of low land	0.14	0.27	0.16	0.31	0.16	0.32
Share of very low land	0.16	0.33	0.16	0.31	0.23	0.39
Mean monsoon rainfall (mm) in last 10 years	1528	335	1502	356	1536	344

Descriptive Statistics: Inefficiency Variables

Inefficiency Variables	2000		2004		2008	
	Mean	St. Dev.	**Mean**	St. Dev.	**Mean**	St. Dev.
Farm size (Ha)	**0.77**	0.89	**0.71**	0.78	**0.66**	0.70
Demographic/Personal Factors						
Female head (Proportion)	**0.02**	0.12	**0.02**	0.14	**0.04**	0.21
Farm HHs with non-agricultural workers (Proportion)	**0.35**	0.48	**0.32**	0.47	**0.33**	0.47
Head's schooling: primary (Proportion)	**0.31**	0.46	**0.22**	0.42	**0.23**	0.42
Head's schooling: secondary (Proportion)	**0.33**	0.47	**0.19**	0.40	**0.20**	0.40
Head's schooling: tertiary (Proportion)	**0.09**	0.29	**0.14**	0.34	**0.14**	0.35
Policy Related Factors						
Sharecropped land (Proportion)	**0.37**	0.48	**0.35**	0.48	**0.29**	0.45
Land rented? (Proportion)	**0.23**	0.42	**0.27**	0.44	**0.22**	0.41
Land fragmentation index (scale: 0-1)	**0.59**	0.28	**0.61**	0.27	**0.55**	0.28
Distance to Dhaka city (in Km)	**215**	93	**214**	93	**215**	93
Distance to Thana headquarter (in Km)	**7.21**	3.95	**7.25**	3.97	**7.22**	3.96
Living in the western region? (Proportion)	**0.54**	0.50	**0.54**	0.50	**0.54**	0.50
Observations/Households	720		720		720	

Results

Estimate four models

- Basic: $Y = A\, f(x,t|C)\, \exp\{u + v\}$ – no inefficiency function
- No soil quality: $Y = A\, f(x,t)\, \exp\{u(A,z,P) + v\}$
- Full specification: $Y = A\, f(x,t|C)\, \exp\{u(A,z,P) + v\}$
- Extended model: $Y = A.t\, f(x,t,|C)\, \exp\{u(A,z,P) + v\}$

Farm Level Stochastic Production Function Estimates

Dep. Var: Value of output (per Ha., Log)	Basic model	Without Soil Quality	Full Specification	Extended Model
Farm size (Ha)	**-0.046**	**-0.062****	**-0.050***	**-0.071****
Fertilizer/Ha	0.040***	0.039***	0.039***	0.036***
Hired labor/Ha	0.078***	0.081***	0.074***	0.073***
Other costs/Ha	0.125***	0.133***	0.126***	0.124***
Share of Irrigated Land	0.205***	0.277***	0.247***	0.248***
Adult worker in HH/Ha	-0.000	-0.001	-0.000	0.001
Agricultural capital/Ha	0.005	0.004	0.005	0.006
Use hired labor(Yes=1)?	-1.057***	-1.090***	-0.995***	-0.977***
Soil quality (share of land; base: sandy) Loamy	0.367***		0.360***	0.360***
Sandy loam	0.370***		0.364***	0.363***
Clay loam	0.370***		0.365***	0.363***
Elevation (Share of land; base: v. low land) Share of high land	0.174***		0.186***	0.188***
Share of medium land	0.083		0.081	0.087
Share of low land	0.055		0.045	0.044
Average rainfall	0.087	0.178	0.348***	0.338***
Agro-ecological zone FE	Yes	Yes	Yes	Yes
Year (base:2000) 2004	**-0.001**	**-0.021**	**0.001**	**-0.001**
2008	**0.279*****	**0.249*****	**0.257*****	**0.330*****
Land and year interactions				
2004*Farm size				**-0.001**
2008*Farm size				**0.094*****
Constant	7.503***	6.773***	5.762***	5.810***

Farm Level Inefficiency Regression Results

Dep. Var: Value of output (per Ha., Log)	Basic model	Without Soil Quality	Full Specification	Extended Model
Farm size (Ha)		**2.976***	**1.164**	**1.285**
Female head		2.363	0.953	0.934
Farm HH with non-agricultural worker		-0.726	-0.335	-0.310
HH Head's Education level (base: none)				
Primary		-2.041	-0.833	-0.858
Secondary		-0.301	0.067	0.001
Tertiary		-1.293	-0.508	-0.493
Sharecropped? (yes=1)		**-3.721**	**-1.378**	**-1.369**
Land rented? (yes=1)		-1.771	-0.528	-0.521
Fragmentation index (scale:0-1		**-10.18***	**-4.061***	**-4.219***
Log (distance from Dhaka, KM)		1.960	0.849	0.937
Log (distance from Thana, KM)		**6.588***	**3.202***	**3.146***
East-West Dummy (West=1)		-2.952	0.020	-0.169
Constant	-42.012	-32.150**	-15.169**	-15.305**
sigma_u	3.636	2.338	1.507	1.518
sigma_v	0.370	0.386	0.367	0.365
lambda	9.814	6.052	4.102	4.160
Log likelihood	-1452.340	-1497.337	-1416.213	-1408.892
chi2	1694.167	1259.024	1553.692	1585.663
p-value for chi2	0.000	0.000	0.000	0.000
Average Technical efficiency	**0.74**	**0.76**	**0.76**	**0.76**
Observations	2160	2160	2160	2160

# Estimated farm size-productivity relationship: Elasticity of output with respect to land

	Basic	**No Soil Quality**	**Full Model**	**Extended model**		
				2000	**2004**	**2008**
Frontier	-0.046	-0.062**	-0.050*	-0.071**	-0.072**	-0.023
Efficiency	-	-0.054***	-0.048**	-0.051**	-0.051**	-0.055**
Mean	-0.046	-0.116***	-0.098**	-0.122**	-0.123**	-0.078**

Farm Size and Technical Efficiency

*Table : Mean Technical Efficiency by Farm size*

Year	Land Quartile 1	Land Quartile 2	Land Quartile 3	Land Quartile 4	Full sample
2000	0.77	0.77	0.76	0.74	0.76
2004	0.78	0.79	0.76	0.74	0.77
2008	0.76	0.75	0.76	0.70	0.74

Table : Change in Technical Efficiency by Farm size

LOWESS and Scatter Plots of Technical efficiencies (Extended Specifications), 2000-2008.
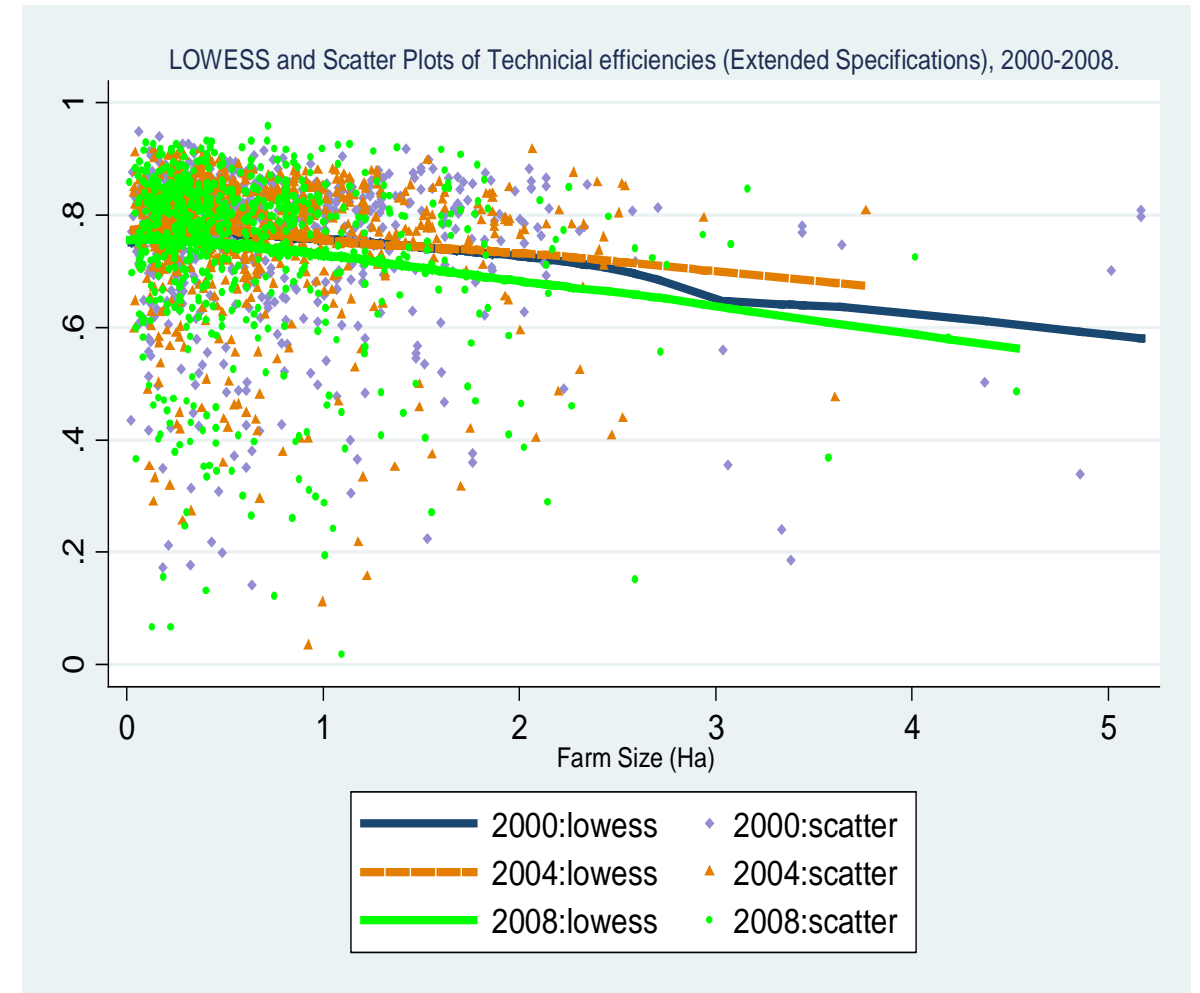
Farm Size and Total Factor Productivity (TFP)

TFP Index by Land quartile and year
(Base: LQ1, 2000=100)
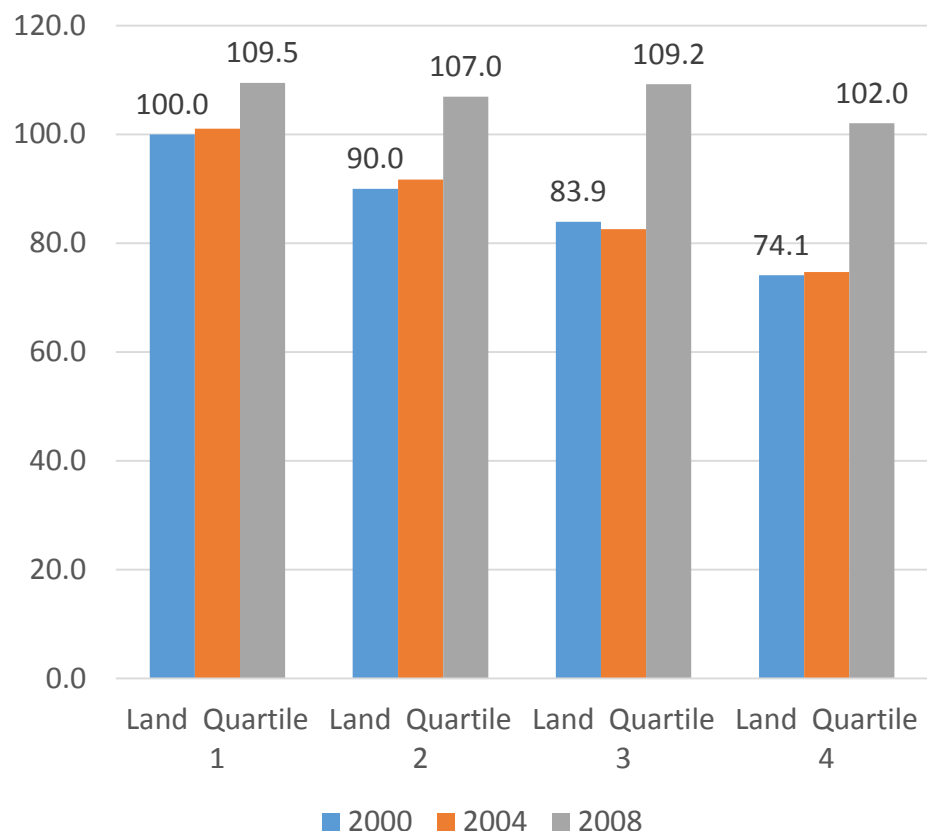
Estimated growth rates for TFP and its components: 2000-2008, using the extended model (at sample medians)

Index	Land Quartile 1	Land Quartile 2	Land Quartile 3	Land Quartile 4	Full sample
TFPG	1.14	2.18	3.34	4.08	2.86
TC	2.08	3.00	3.74	4.58	3.20
TEC	0.12	-0.21	-0.09	-0.75	-0.16
SEC	-1.05	-0.58	-0.29	0.27	-0.17

Conclusions/implications

- Farm size and productivity relationship is estimated to be negative
  - Both in terms of the output-land elasticity as well as in terms of technical inefficiency
- Bangladesh agriculture has done remarkably well, sustaining productivity growth will require strengthening the policy framework in three priority areas:
- Small farmers appear to have less access to emerging technologies – with slower observed technical change (also consistent with result on access to public services).
  - Greater attention to complete the remaining agenda on the seed sector reforms
  - Better access to public services, including perhaps last mile connectivity from the Thana HQ to villages, needs a fresh look (especially extension/advisory services)
- Sharecropping allows the flow of land to more efficient producers.
  - Remove remaining obstacles to land efficient functioning of land markets – strengthened land governance, administration and land laws (land policy works against the poor)

Thank you.

Yield by farm size and Fam. Ag. worker per ha
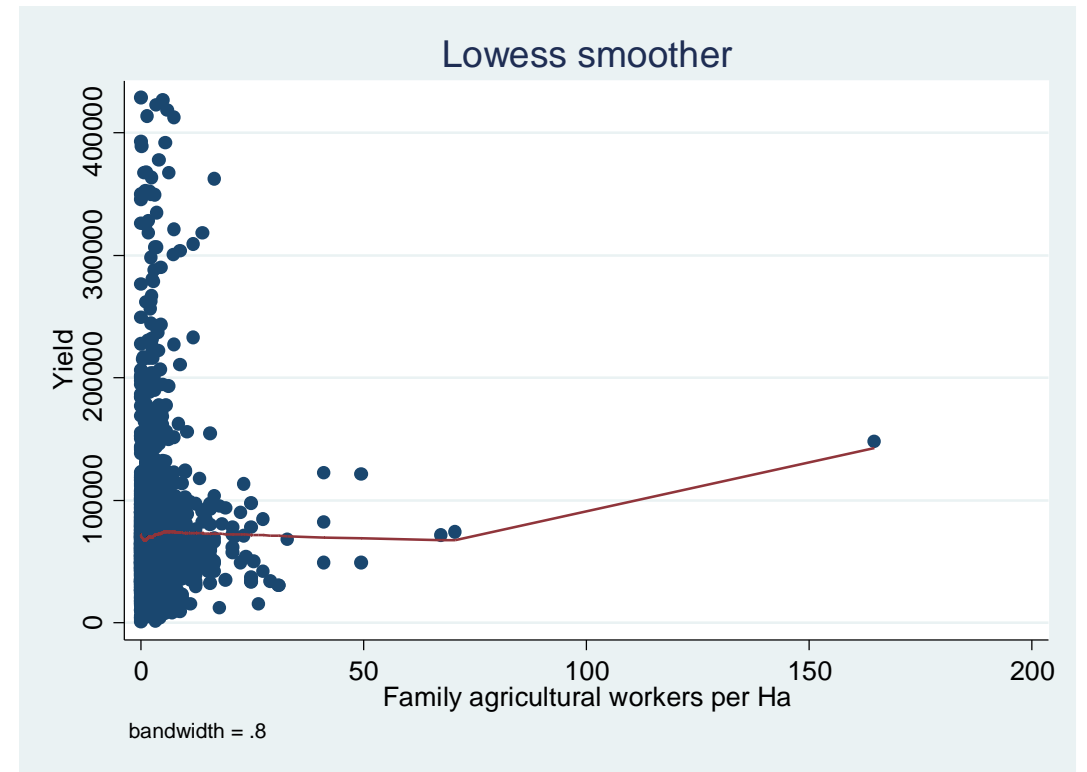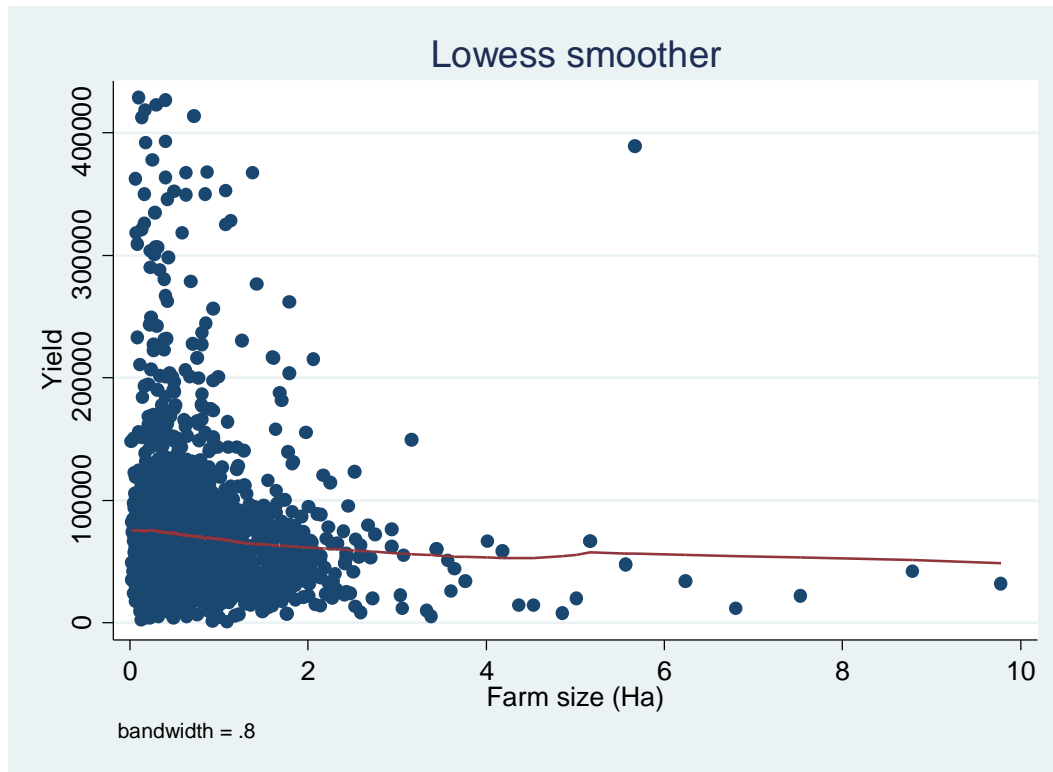
Value added per farm
by farm size and no. of Ag. family workers