Measuring the Impact of Fertilizer Use in Burkina Faso

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Motivation

- Cereal yields significantly lower than other countries
- Rain-fed agriculture
- Low use of modern inputs
- Why is fertilizer use so low?

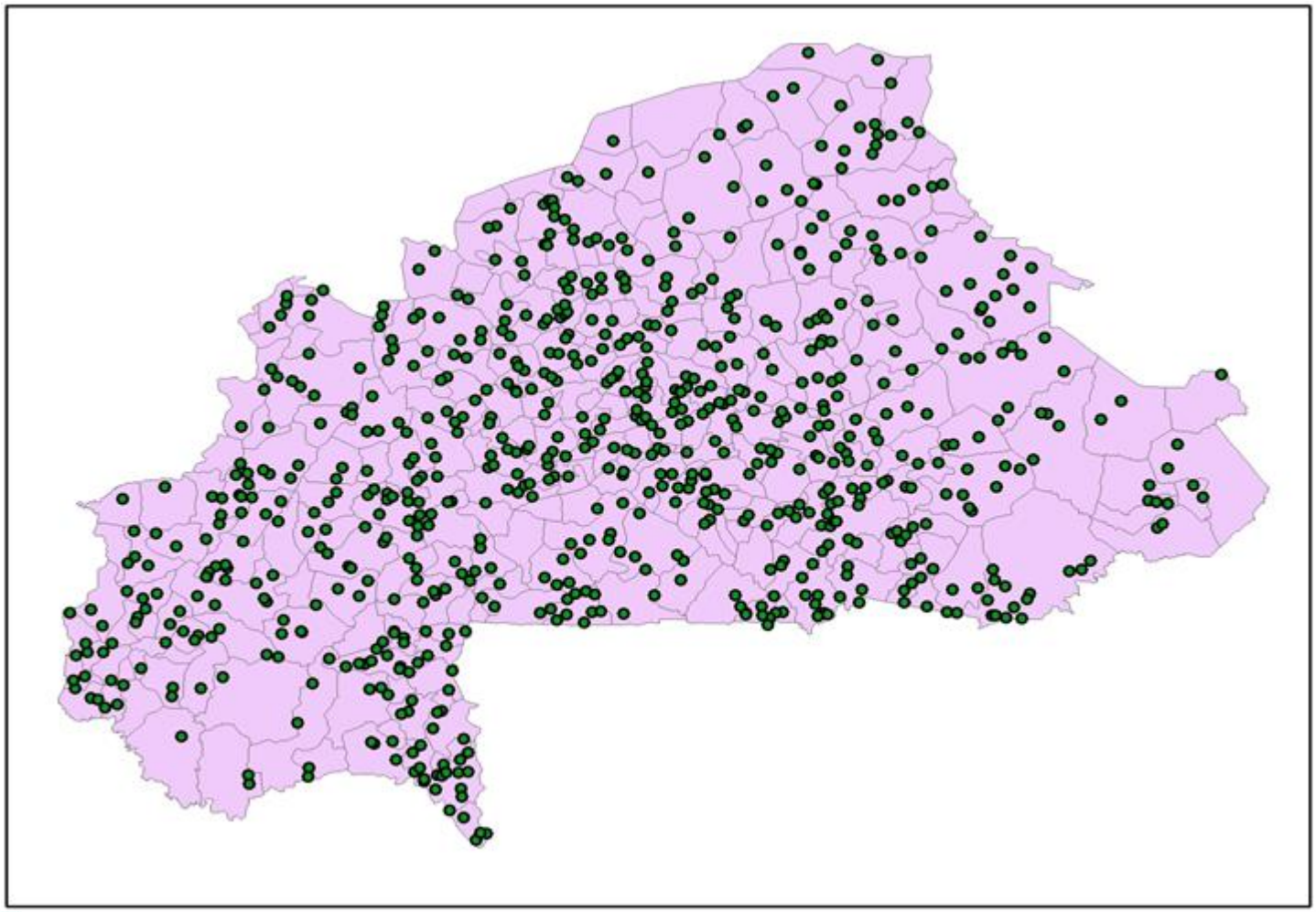
Research Question

What is the impact of fertilizer use on crop yields and household food security?

Data

- Continuous Farm Household Survey (*Enquête Permanente Agricole*)
  - Nationally representative (45 provinces, 826 villages)
  - 2009/10-2011/12
  - 2700 households growing cereals
  - Agricultural output, inputs, food security, food groups consumed, livestock, income

Sample Villages



Identification

- Fertilizer use not randomly assigned, cannot regress outcome variable on fertilizer
- Use matching techniques with DID to control for observable & time invariant differences among fertilizer users and non-users

Empirical Analysis

- Fertilizer includes urea and NPK
- Unit of analysis: plot manager
- Analyze impact on maize crop only for comparability, maize widely grown with variation in fertilizer use

Matching

- In sample, some people use fertilizer
- Try to find ‘similar’ people that didn’t use fertilizer
- Match on pre-treatment observed characteristics that predict fertilizer use
- Use largest set of covariates that allow for large region of common support & pass balance tests
- Add continuous variables to increase variability in PPS

DID

- Compare change in outcome of fertilizer users with change in outcome of those not using fertilizer
- DID estimator: $\hat{\delta} = (\bar{y}_{fert,1} - \bar{y}_{fert,0}) - (\bar{y}_{nofert,1} - \bar{y}_{nofert,0})$
- Allows farmers using fertilizer and not to be different, but requires their difference to be constant over time

DID-matching

- Dependent variable is change in outcome variable
- To test impact in year 2011, keep all untreated 2010 observations. Treated group has treatment = 1 in 2011 while comparison doesn't
- Keep largest plot per person each year
- On average 1.56 plots per person per year
- With panel data, no obvious reason to use only matching techniques and not use DID with matching

Summary Stats

Maize Yield (kg/ha)			
	2010	2011	2012
Fertilizer	1582	1443	1401
No Fertilizer	1158	1046	983

Number of Maize Plots			
	2010	2011	2012
Fertilizer	1330	1272	1439
No Fertilizer	2343	1899	1723

Matching Variables

- Characteristics:
  - Plot manager
  - HH
  - Plot
  - Geographic

Outcome Variables

- Maize yield
- Food Consumption Score (0-112 based on food groups consumed in last week, WFP)

Results 2011

	psmatch (1)	psmatch(5)	nnmatch (1)	nnmatch (5)	ipw
ΔYield	327.5* (172.9)	297.7* (152.7)	418.7*** (98.1)	327.3*** (84.5)	369.5*** (105.6)
ΔFCS	6.39* (3.41)	6.49* (3.92)	1.57 (2.23)	3.31* (1.95)	0.705 (2.65)
Mean Fert Use (N kg/ha)	16.94	16.94	17.61	17.61	16.78

Results 2012

	psmatch (1)	psmatch(5)	nnmatch (1)	nnmatch (5)	ipw
ΔYield	7.30 (142.6)	52.57 (129.1)	-69.31 (208.6)	68.79 (165.4)	-44.18 (242.0)
ΔFCS	-4.19 (4.15)	-1.90 (3.49)	-0.635 (3.02)	0.300 (2.55)	-1.99 (3.43)
Mean Fert Use (N kg/ha)	12.26	12.26	14.89	14.89	12.81

Weighted Regressions

	Full Sample	Restricted Sample	Full Sample	Restricted Sample
	Maize Yield 2011		**Maize Yield 2012**	
Fertilizer Use	347.3*** (66.6)	326.4*** (78.3)	-14.1 (77.3)	57.3 (76.9)
	FCS 2011		**FCS 2012**	
Fertilizer Use	5.68*** (1.66)	0.647 (1.89)	-3.72* (1.96)	2.61 (1.94)
Mean Fert Use (N kg/ha)	17.61	13.37	14.9	12.7
Other control variables are use of improved seed, herbicide, fungicide, pesticide, manure and SWC structures				

Discussion (1)

- Large impact on yields in 2010/11 (~25% increase, ~20 kg increase yield / N kg)
- Similar effect as seen in literature
- No impact in 2011/12, which was a drought year
- FCS improves when yield increases

Discussion (2)

- No effect of organic fertilizer on short term yields
- Includes manure, compost pit, household refuse, animal penning, indirect penning and other sources – mostly low in nitrogen content
- Anecdotal evidence insufficient labor allocated to manure application
- Other benefits of organic fertilizer: improves soil structure and ability of soil to retain water and nutrients

Conclusion

- No yield response in drought years may deter adoption
- Need complementary investments in irrigation, climate information systems
- Policies that affect fertilizer should be based on studies measuring impact over a number of years rather than single year, also consider variation in yield response

Questions/Comments?

PSM-Steps

1) Probit/logistic regression with fertilizer use as dependent variable. Use rich set of observed covariates as explanatory variables
2) Obtain predicted propensity score (PPS)
3) Define region of common support (where PPS overlaps for treatment & comparison group)
4) Choose matching estimator
5) Calculate ATT & standard errors

Nearest Neighbor Matching

- Nearest neighbor matching: define ‘close’ by weighting difference between covariates by inverse of sample covariance matrix
- Benefit is dropping functional form assumption (probit/logit)
- Use bias adjustment for consistency when matching on two or more continuous covariates (Abadie & Imbens 2006, 2011)

Inverse Probability Weighting

- IPW: Compare with everyone, weights account for ‘similarity’
- Estimation unreliable when large number of observations have very low/high PPS since their importance in weighted regression approaches infinite/zero
- Re-estimate after dropping observations with PPS<0.1 & PPS>0.9

Other ‘Matching’ Techniques

- Weighted regression: Control for other inputs changing. Weights are 1/PPS & 1/(1-PPS) for treatment & comparison group respectively

Assumptions

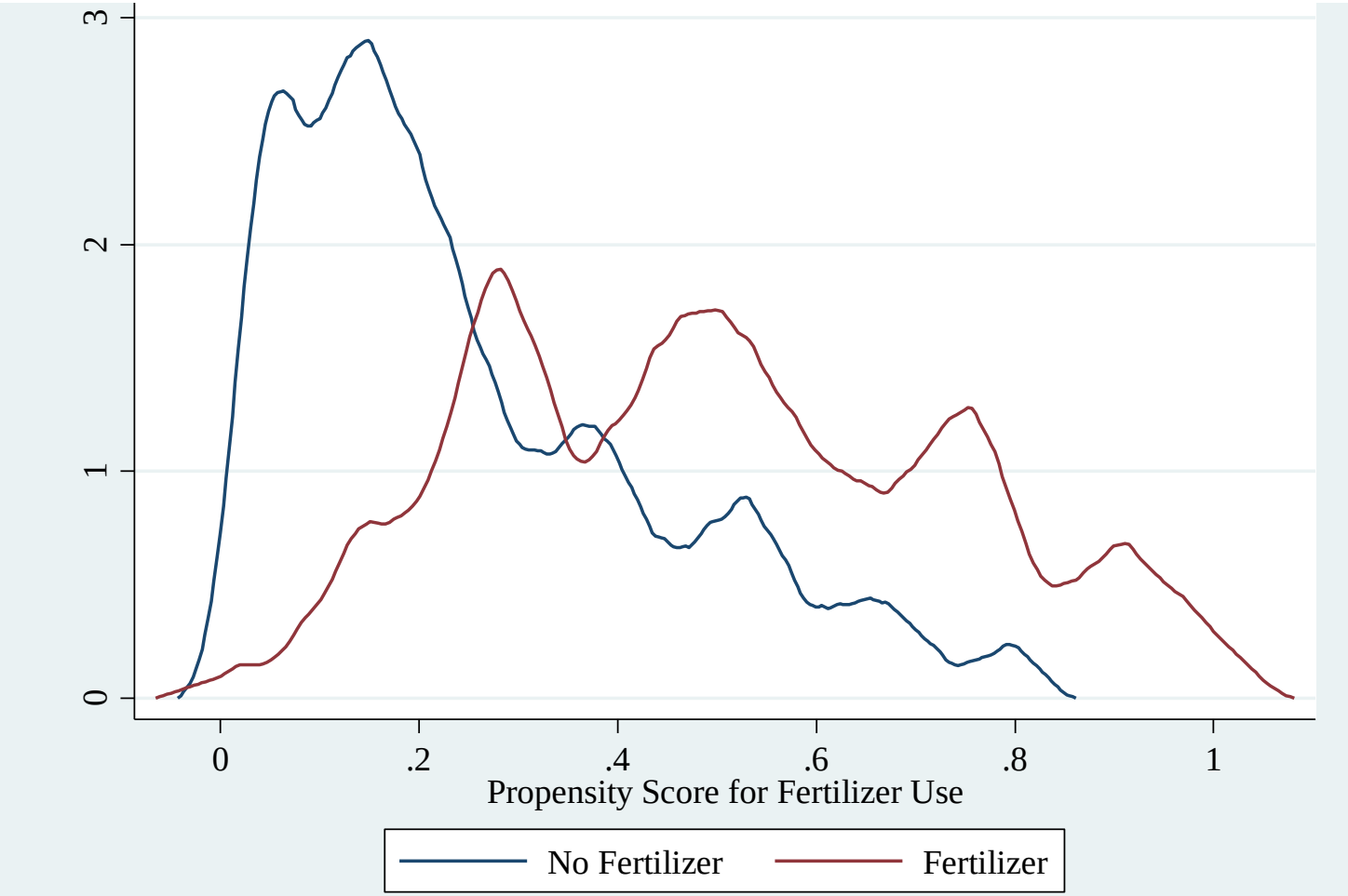
PSM:

1) Conditional mean independence – matching on observables creates appropriate comparison group
2) Common support

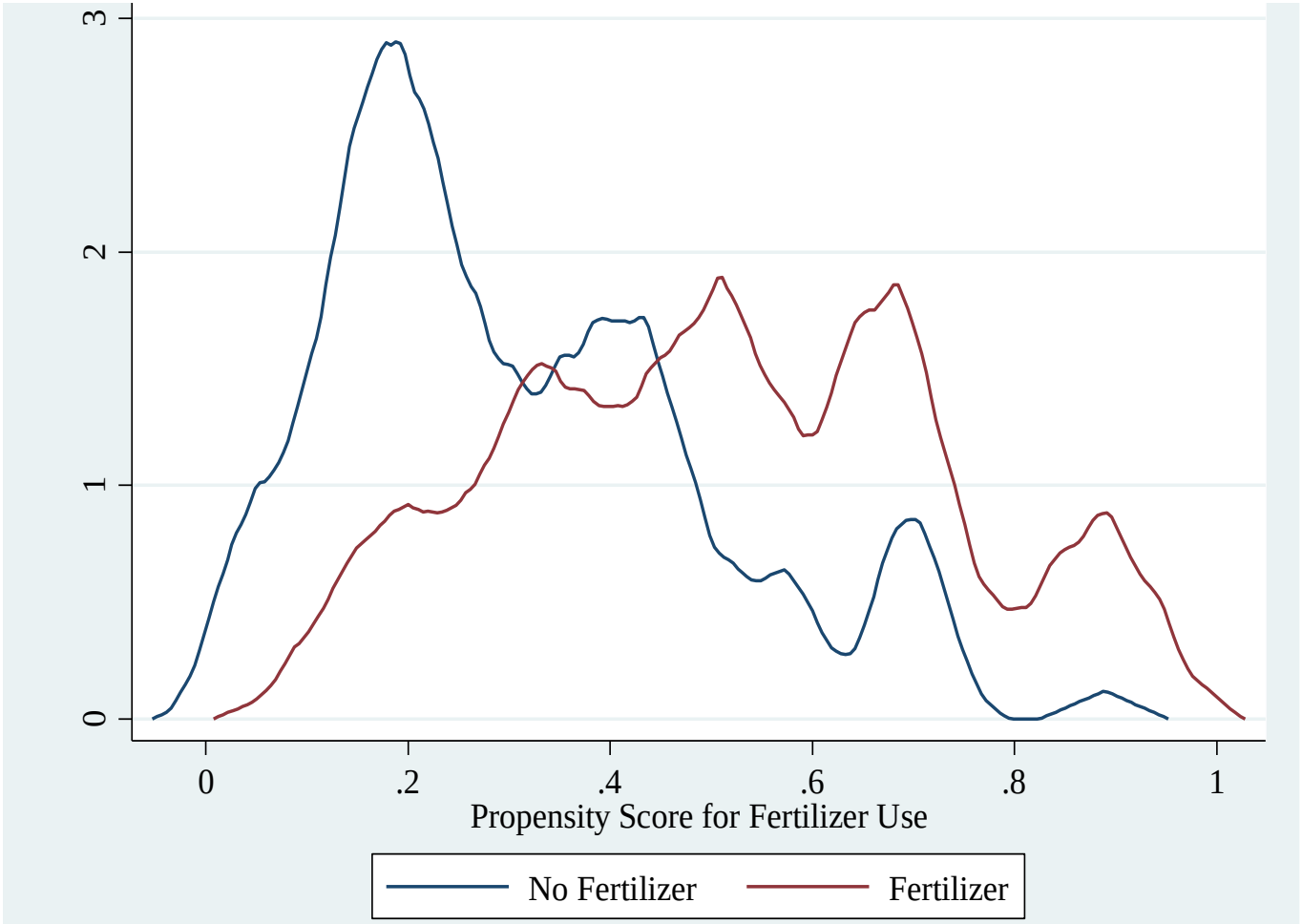
DID:

1) Parallel trend between treatment & comparison groups

Common Support (2011)



Common Support (2012)



Balance Test 2011 (1)

	Unmatched	Mean		t-test	
Variable	**Matched**	**Treated**	**Control**	**t**	**p>|t|**
Household head	U	0.98	0.98	-0.31	0.759
	M	0.98	0.99	-0.58	0.563
Age	U	48.42	50.96	-1.49	0.138
	M	48.42	44.40	2.15	0.033
Primary educated	U	0.17	0.08	2.5	0.013
	M	0.17	0.35	-2.95	0.004
Female	U	0.05	0.05	-0.02	0.985
	M	0.05	0.04	0.34	0.735
Collectively managed	U	0.91	0.95	-1.32	0.189
	M	0.91	0.96	-1.43	0.153
Far from home	U	0.36	0.22	2.66	0.008
	M	0.36	0.28	1.21	0.227
Lowland	U	0.06	0.05	0.54	0.589
	M	0.06	0.01	1.93	0.055
Slope	U	0.06	0.07	-0.19	0.851
	M	0.06	0.08	-0.55	0.582
Tenure own	U	0.68	0.70	-0.39	0.698
	M	0.68	0.63	0.74	0.46

Balance Test 2011 (2)

	Unmatched	Mean		t-test	
Variable	**Matched**	**Treated**	**Control**	**t**	**p>|t|**
HH size	U	11.3	9.11	2.8	0.005
	M	11.3	9.37	2.01	0.046
HH farming area (ha)	U	3.74	2.48	3.43	0.001
	M	3.74	3.14	1.2	0.23
HH livestock (TLU)	U	10.09	8.16	0.67	0.506
	M	10.09	6.21	1.22	0.225
HH head female	U	0.03	0.04	-0.24	0.809
	M	0.03	0.03	0	1
HH head age	U	48.01	50.53	-1.44	0.152
	M	48.01	44.42	1.87	0.063
HH head education	U	0.25	0.17	1.72	0.087
	M	0.25	0.42	-2.58	0.011
No of plots	U	5.34	5.39	-0.14	0.89
	M	5.34	4.50	2.4	0.017
ln value of ag assets	U	9.34	8.92	1.98	0.049
	M	9.34	9.04	1.17	0.242
Extension	U	4.8	4.86	-0.71	0.478
	M	4.8	4.88	-0.83	0.409
HH area corn	U	1.03	0.59	2.73	0.007
	M	1.03	0.95	0.33	0.742

Balance Test 2012 (1)

	Unmatched	Mean		t-test	
Variable	**Matched**	**Treated**	**Control**	**t**	**p>|t|**
Household head	U	0.96	0.96	-0.12	0.901
	M	0.96	1.00	-2.03	0.043
Age	U	49.88	53.61	-2.08	0.039
	M	49.88	50.95	-0.52	0.601
Primary educated	U	0.08	0.10	-0.64	0.526
	M	0.08	0.12	-0.99	0.324
Female	U	0.03	0.03	-0.04	0.971
	M	0.03	0.00	1.75	0.082
Collectively managed	U	0.94	0.87	1.53	0.126
	M	0.94	0.88	1.27	0.205
Far from home	U	0.28	0.17	2.14	0.033
	M	0.28	0.24	0.67	0.505
Lowland	U	0.05	0.07	-0.39	0.695
	M	0.05	0.04	0.34	0.734
Slope	U	0.05	0.09	-1.10	0.272
	M	0.05	0.01	1.66	0.098
Tenure own	U	0.66	0.68	-0.42	0.673
	M	0.66	0.71	-0.78	0.434

Balance Test 2012 (2)

	Unmatched	Mean		t-test	
Variable	**Matched**	**Treated**	**Control**	**t**	**p>|t|**
HH size	U	9.72	9.25	0.71	0.476
	M	9.72	10.71	-1.28	0.201
HH farming area (ha)	U	2.32	2.26	0.29	0.772
	M	2.32	2.76	-1.59	0.113
HH livestock (TLU)	U	4.61	6.34	-1.42	0.158
	M	4.61	5.42	-0.95	0.345
HH head female	U	0.02	0.02	0.09	0.93
	M	0.02	0.00	1.42	0.157
HH head age	U	49.66	53.87	-2.29	0.023
	M	49.66	50.95	-0.61	0.545
HH head education	U	0.17	0.15	0.41	0.685
	M	0.17	0.23	-0.92	0.361
No of plots	U	4.95	5.21	-0.70	0.486
	M	4.95	5.44	-1.28	0.204
ln value of ag assets	U	9.09	8.91	0.85	0.394
	M	9.09	9.62	-2.06	0.041
Extension	U	4.81	4.85	-0.45	0.652
	M	4.81	4.76	0.38	0.704
HH area corn	U	0.61	0.60	0.06	0.956

FCS Chart

	FOOD ITEMS (*examples*)	Food groups (definitive)	Weight (definitive)
1	Maize , maize porridge, rice, sorghum, millet pasta, bread and other cereals	Main staples	2
	Cassava, potatoes and sweet potatoes, other tubers, plantains		
2	Beans. Peas, groundnuts and cashew nuts	Pulses	3
3	Vegetables, leaves	Vegetables	1
4	Fruits	Fruit	1
5	Beef, goat, poultry, pork, eggs and fish	Meat and fish	4
6	Milk yogurt and other diary	Milk	4
7	Sugar and sugar products, honey	Sugar	0.5
8	Oils, fats and butter	Oil	0.5
9	spices, tea, coffee, salt, fish power, small amounts of milk for tea.	Condiments	0