Ethiopia Yield Gap Analysis

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What's new since last time

- A more flexible translog function allowing for interactions between inputs
- Control function approach to incorporate a feedback loop between nitrogen and yield
- Numerical methods to find optimum nitrogen use
- GYGA variables

Yield gap framework

@michiel insert picture

LSMS-ISA and GYGA

@ Michiel add in the GYGA map

Data

- Two (now three) LSMS-ISA surveys 2011 and 2013 (and as of last week 2015)
- But due to a mistake in recording production in 2011 we only analyse 2013
- Yield defined as production/plot size $=>$ different from FAOSTAT/GYGA

Summary statistics

Table 1: Summary statistics

Statistic	N	Mean	St. Dev.	Min	Max
N	2,420	26.62	54.51	1.00	692.30
lab	2,420	173.90	306.90	1.00	2,763.00
area	2,420	0.19	0.35	0.0004	8.12
slope	2,413	12.64	10.32	1.00	84.70
elevation	2,413	1,799.00	405.70	371	2,909
SOC	2,420	7.90	2.21	1.87	17.10
rain_wq	2,420	762.40	97.66	704	1,135
GGD	2,420	7,179.00	827.30	4,922.00	10,392.00
AI	2,420	7,169.00	2,398.00	2,041.00	12,854.00
TS	2,420	1,097.00	340.90	538	2,279
yesN	2,420	0.37	0.48	0	1
impr	2,404	0.24	0.42	0	1
extension	2,406	0.34	0.47	0	1
title	2,219	0.50	0.50	0	1

Methodology

- Three stages in the estimation of the production function
- First stage Tobit model to avoid feedback loop/confounding
- Second stage stochastic frontiers estimation
  - bootstrapping SEs due to nonlinear first stage function function
  - Numeric solution to find the economically optimal Nitrogen use
- Third stage policy variables

Cobb Douglass function

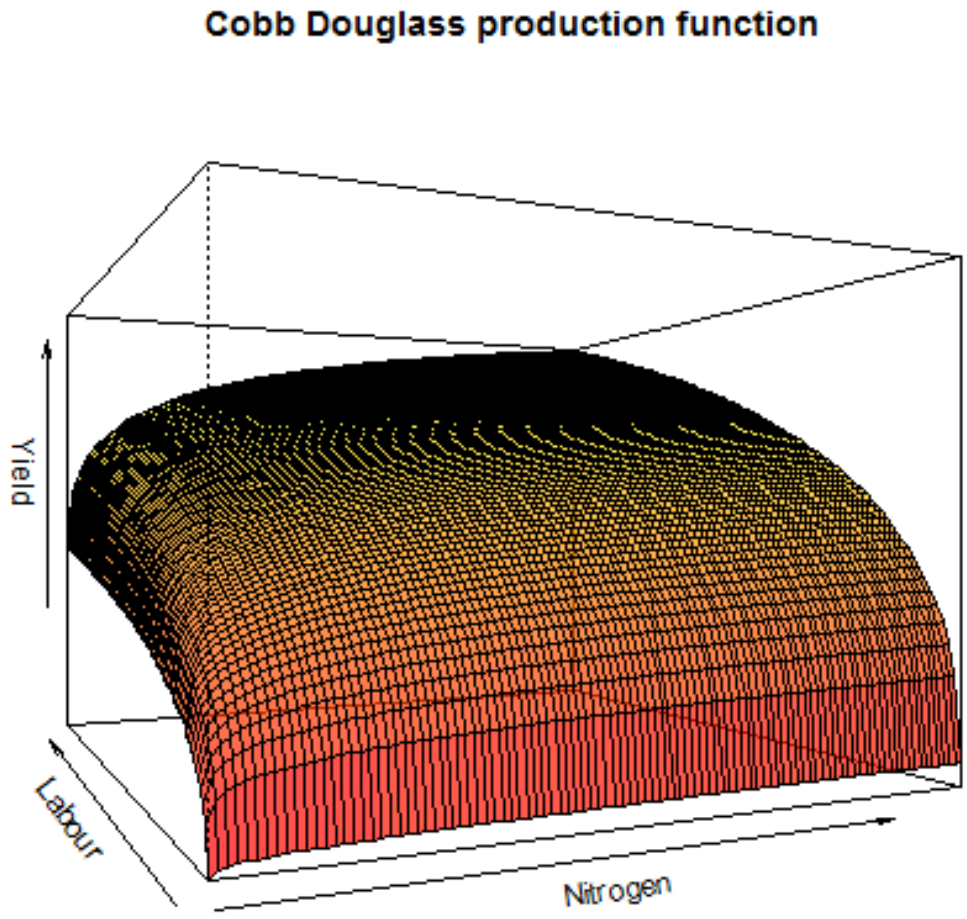


Figure 1

Translog production function

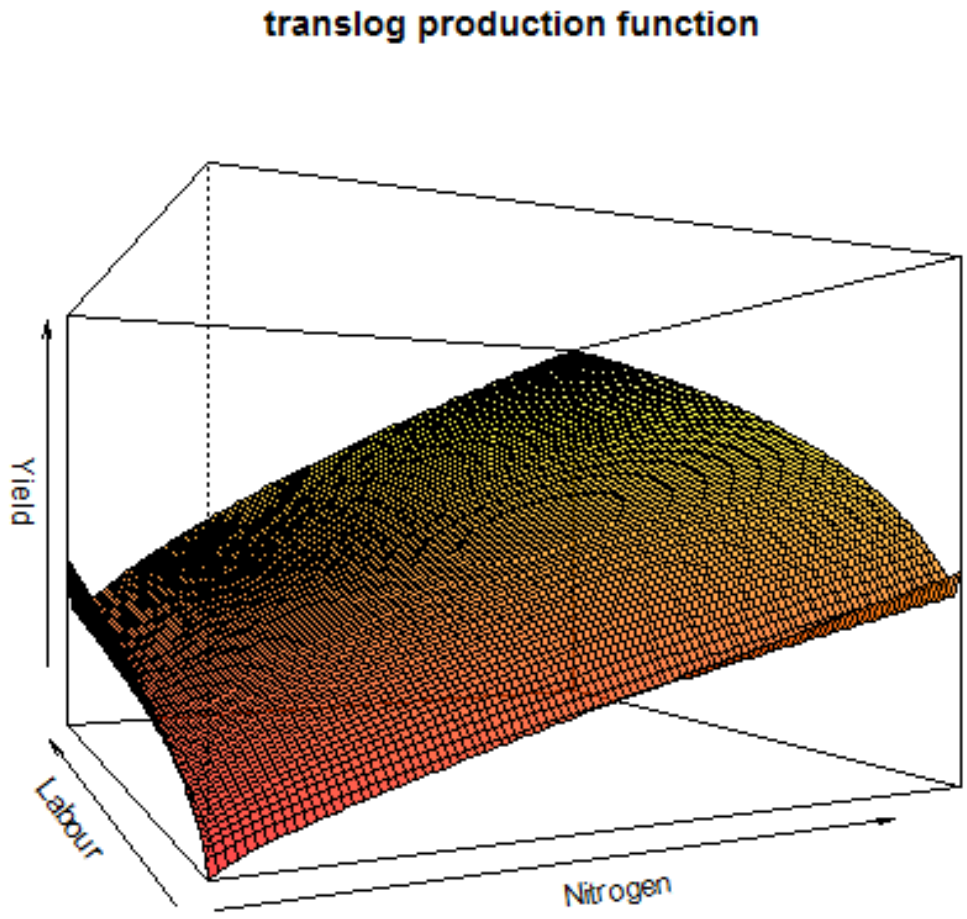


Figure 2

Endogeneity

- Idea of a feedback loop between the level of nitrogen applied and the yield
- In econometrics speak: the residuals from the estimation are correlated with the explanatory variable (Nitrogen)
- Agronomic interpretation: Higher yield in good soils, but Nitrogen also works better in good soil confounding
- Policy interpretation: Farmers listen to extension agents and see improvements spurring on more improvements
- Solution: Instrumental variables style approach, called a control function for a nonlinear first stage regression
    - This requires find suitable instruments - distance, age, social capital, politics, soil quality??

Stochastic frontier analysis

parameter	Basic	GYGA	Basic + r	GYGA + r
(Intercept)	7.06 (1.29)**	6.84 (1.42)**	7.67 (1.28)**	7.47 (1.41)**
log(N)	0.16 (0.17)	0.15 (0.17)	0.08 (0.06)	0.08 (0.06)
log(lab)	0.16 (0.05)**	0.16 (0.05)**	0.15 (0.06)**	0.14 (0.06)**
I(log(N)^2)	0.02 (0.02)	0.02 (0.02)	0.03 (0.01)**	0.03 (0.01)**
I(log(lab)^2)	0.01 (0.01)	0.01 (0.01)	0.01 (0.01)*	0.01 (0.01)*
log(slope)	-0.22 (0.03)**	-0.23 (0.03)**	-0.20 (0.03)**	-0.21 (0.03)**
elevation	-0.00 (0.00)**	-0.00 (0.00)	-0.00 (0.00)**	-0.00 (0.00)
log(area)	-0.22 (0.02)**	-0.22 (0.02)**	-0.22 (0.02)**	-0.22 (0.02)**
SOC	0.04 (0.01)**	0.04 (0.01)**	0.04 (0.01)**	0.03 (0.01)**
log(rain_wq)	-0.10 (0.19)	-0.22 (0.21)	-0.15 (0.19)	-0.27 (0.21)
noN	0.27 (0.31)	0.24 (0.31)	NA	NA
impr	0.36 (0.06)**	0.37 (0.06)**	0.34 (0.06)**	0.35 (0.06)**
crop_count2	0.47 (0.04)**	0.48 (0.04)**	0.48 (0.04)**	0.49 (0.04)**
phdum_gt70	-0.24 (0.09)**	-0.26 (0.10)**	-0.26 (0.09)**	-0.27 (0.10)**
phdum55_2_70	-0.04 (0.07)	-0.06 (0.07)	-0.07 (0.07)	-0.08 (0.07)
log(N):log(lab)	-0.03 (0.01)**	-0.03 (0.01)**	-0.03 (0.01)**	-0.02 (0.01)**
GGD	NA	0.00 (0.00)**	NA	0.00 (0.00)**
AI	NA	0.00 (0.00)	NA	0.00 (0.00)
TS	NA	-0.00 (0.00)	NA	-0.00 (0.00)
rd	NA	NA	-0.09 (0.03)**	-0.09 (0.03)**
sigmaSq	1.95 (0.10)**	1.94 (0.10)**	1.91 (0.10)**	1.90 (0.10)**
gamma	0.81 (0.02)**	0.81 (0.02)**	0.80 (0.03)**	0.80 (0.03)**

Stochastic frontier analysis

- Residuals (rd) are significant implying endogeneity indeed exists
- GDD is significant and including GYGA variables controls for climate conditions
- Nitrogen coefficients: level is not significant, square is positive, interaction is negative

Optimal Nitrogen level and MPP values

ZONE	n	N plots	N	Nopt	MPP
AMHARA	450	254	92	132	13
BG	145	12	27	53	31
DIRE DAWA	39	3	26	85	14
GAMBELLA	18	0	NA	169	NA
HARARI	166	97	53	68	9
OROMIYA	747	235	68	63	15
SNNP	580	215	65	116	18
SOMALI	80	2	9	59	16
TIGRAY	135	53	59	383	14

Data issues

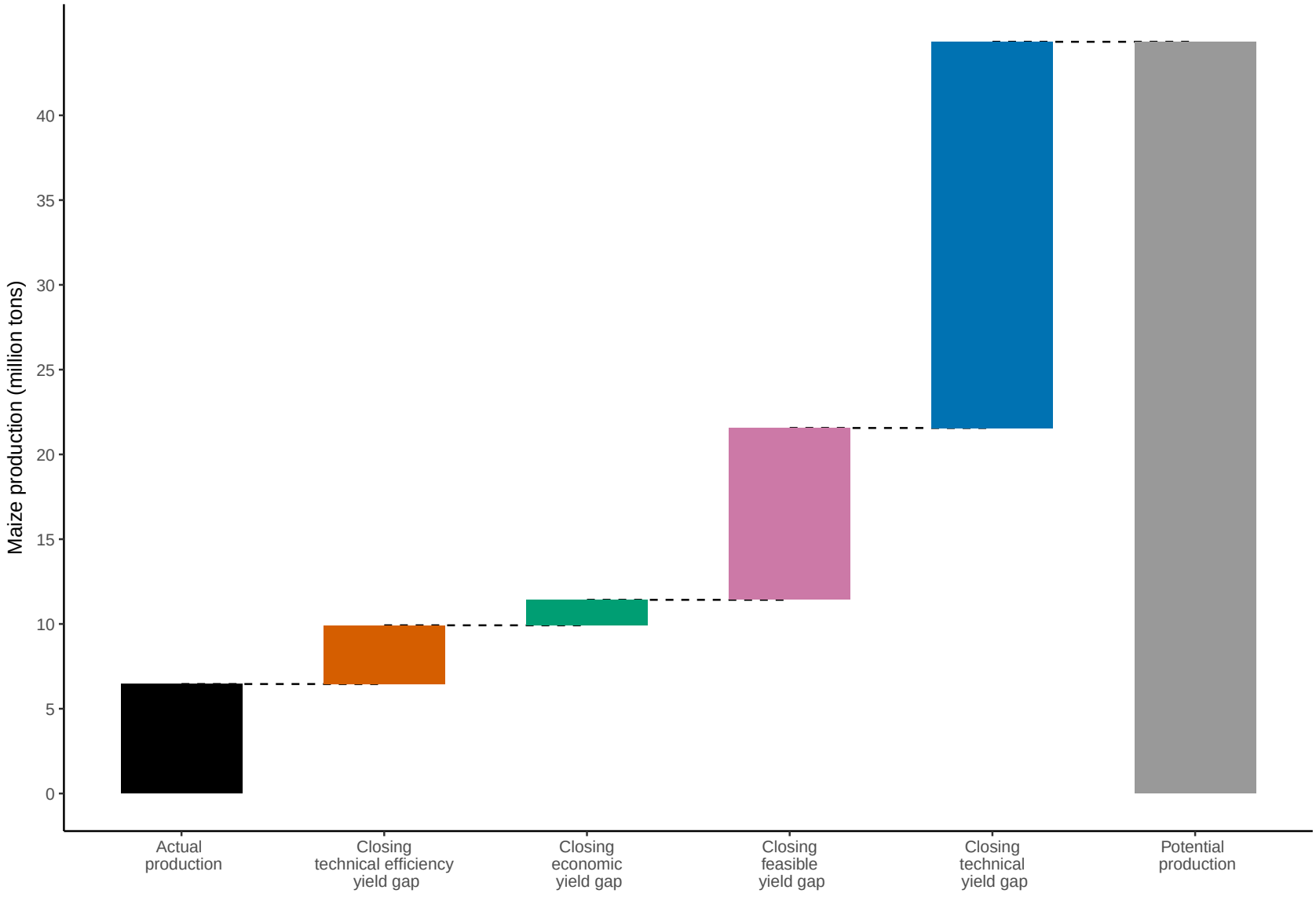
- How to solve missing yield potential data?
  - Average values are too low, maximum is too high.
- To calculate feasible yield gap information is needed on the use of inputs when costs are zero:
  - Level of nitrogen when yield diminishes (per region)
  - Use of labour and capital at this point
- Information on nitrogen/fertilizer use can be taken from experimental plot data $=>$ literature survey.
- Use of labour and capital demands assumptions (e.g. 10% increase)

Yield gap estimations

Table 4: Relative yield gap

Zone	TEYG_I	EYG_I	EUYG_I	TYG_I	YG_I_Ycor
AMHARA	1565	629	2970	6706	11919
BG	990	506	4175	10122	16618
DIRE DAWA	948	614	4795	3128	9975
GAMBELLA	1497	1565	6725	6480	16267
HARARI	768	154	4017	751	5925
OROMIYA	1040	333	3559	8387	13821
SNNP	1180	677	4024	8105	14282
SOMALI	751	454	5305	8933	15444
TIGRAY	1251	2079	2904	4967	11201
Total	1146	572	3755	7682	13492

Closing the yield gap



Policies to close the yield gap

@ Michiel policy framework picture

Explaining the TEYG

Table 5: Third stage analysis

	Estimate	Std. Error	z value	Pr(>|z|)
Z_extension	-1.10	0.32	-3.38	0.00
Z_age	-0.01	0.02	-0.35	0.73
Z_I(age^2)	0.00	0.00	0.22	0.82
Z_ed_any	0.04	0.15	0.30	0.77
Z_sex	0.01	0.19	0.04	0.97
Z_title	-0.34	0.16	-2.17	0.03
Z_log(area_tot)	-0.07	0.06	-1.08	0.28

Wrap up

- New and better translog function means more flexibility of inputs
- optimal nitrogen levels calcualted per farmer using their actual values of other inputs
- Identified and dealt with bias introduced due to endogeneity and feedback loops

Next steps

- Calculate elasticities of second stage variables to get a better interpretation
- Think about how to link policies to yield gaps
- Finish writing paper
- Third wave of data???? but . . . . . time constraints