Essays in Agricultural Economics - Appendices

Francisco Pereira Fontes

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Abstract

This thesis explores topics in Agricultural Economics and is composed of five papers. In the first paper (Chapter 2), a latent-class stochastic frontier model is used to estimate efficiency scores of farmers in Ethiopia. Compared to conventional models, which assume a unique frontier, much lower inefficiencies are found, suggesting that part of the inefficiencies uncovered in the literature could be an artefact of the methods used. The second paper (Chapter 3) revisits the link between cereal diversity and productivity using a panel dataset in Ethiopia. The results suggest that the positive effect between cereal diversity and productivity becomes much smaller when households who produce teff (a low-productivity and high-value crop) are excluded from the sample, hinting at the possibility that results could be driven by yield differentials between cereals, rather than diversity. The third paper (Chapter 4) estimates the labour impacts of the adoption of Soil and Water Conservation technologies (SWC) in Ethiopia. The results suggest that adopting SWC technologies leads to an increase in adult and child labour. Understanding the labour impacts is important in itself, but it also raises concerns about using impact evaluation methods that require no change in inputs as an identifying assumption of impacts. Paper 4 (Chapter 5), assesses the pertinence of a drought index that has recently been proposed in the literature and argues that it defines drought too narrowly. An extension to this index is proposed and we show, using a dataset of Indian districts, that the original index is likely to underestimate the impacts of drought. In Paper 5 (Chapter 6), we identify data-driven ranges of rainfall for which the marginal effects of a rainfall-temperature index (RTI) are different and then we discuss how the impacts of drought have changed over the 1966-2009 period in India. Finally, Chapter 7 concludes.

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Chapter 2

"Blatent" Heterogeneity: Implications for Efficiency Measurement and Policy. A case study of Ethiopia.

A Appendix A - Additional results, figures and tables

Table 2A.1: Technical efficiency studies in Ethiopia (Part 1)

No.	Authors	Coverage	ERHS	Crop	N	TE score(s)	Additional notes/comments
1	Abate et al. (2013)	National	No	Crop value	1638	0.64	The study covers households in the Amhara, Oromia, SNNP and Tigray regions. The technical efficiency scores are computed using a stochastic frontier approach and a Cobb-Douglas specification is used. PSM used to estimate impact of cooperative membership on Technical efficiency. Technical efficiency scores computed by cooperative membership status. Efficiency scores for households who were cooperative members were higher (0.67) compared to non-members (0.62). There are 564 cooperative members and 1074 households who are not members of cooperatives. As such, the average technical efficiency score (weighted average) is
2	Abrar and Morrissey (2006)	Sub-national	Yes	Cereals	514	0.54	Technical efficiency scores are computed using DEA. The ERHS waves for the years 1994, 1995, 1997 and 2000 were used and the study covers 9 villages in Northern Ethiopia. Households with cultivated land below 0.1 hectares, zero labor and/or zero output are excluded from the dataset. TE scoers are computed separately by wave. Efficiency scores for 1995, 1997 and 2000 were 0.51, 0.54 and 0.57, respectively.
3	Ahmed et al. (2002)	Sub-national	No	Value of output	476	0.71	The study covers households in Oromyia. Technical efficiency scores are obtained using a Stocahstic frontier approach and a Cobb-Douglas specification is used. Survey was conducted in Oromyia in 1994. Value of output is calculated per hectare and refers to all grains and straws.
4	Alemu et al. (2009)	Sub-national	No	Value of crops	285	0.76	The study covers households in East Gojjam, in the Amhara region. A Cobb-Douglas specification is used in the study. Aim of the paper is to analyse inefficiencies by AEZ.
5	Alene et al. (2005)	Sub-national	No	Maize	60	0.75	The authors use a translog production function and aim of the paper is to quantify technical efficiency for a sample maize producers. The authors use data from the Bako area and use data from the ERHS. The authors also estimate cost efficiencies and the average score was 0.61.
6	Alene and Hassan (2003)	Sub-national	Yes	Maize	60	0.76	The study covers households in the Bako area, in Western Ethiopia. Data comes from the 1999 wave of the ERHS. A Translog specification is used. The sample covers the Bako area, where households produce maize and used both fertilizer and improved seed.
7	Alene & Hassan (2006)	Sub-national	No	Maize	98	0.71	The study covers households in the Meta district in Eastern Ethiopia. A Cobb-Douglas specification is used. The 47 household are not covered by the New Extension Programme (NEP) and cultivate traditional varities, whereas 51 households are covered by the NEP and cultivate hybrid varieties. The paper finds that households using traditional varieties have lower efficiency scores (0.62) than households using hybrid varieties (0.8). Given the relative proportion of households in each sub-sample, we obtain an average (weighted) technical efficiency score of 0.71
8	Alene et al. (2006)	Sub-national	Yes	Maize and coffee	124	0.72, 0.91	The dataset used in the study uses data from the 1999 wave of teh ERHS and focuses on two peasant associations (Durame and Gara Godo). The study computes technical efficiency scores using both DEA and SFA. The authors find efficiency sores of 0.72 using stochastic frontier analysis and 0.91 and 0.93 using output- and input- oriented DEA, respectivily. The main output variable is the value of maize and coffee.

Table 2A.1 : Technical efficiency studies in Ethiopia (Part 2)

No.	Authors	Coverage	ERHS	Crop	N	TE score(s)	Additional notes/comments
9	Asefa (2012)	Sub-national	No	Value output	326	0.6	Technical efficiency scores are estimated using SFA and a Cobb-Douglas production function is used. Data from the Tigray micro finance survey, collected in 2009. The dataset covers households in two woredas in Eastern and two woredas in Central Tigray.
10	Bachewe et al. (2015)	National	No	Yield	6,575	0.37, 0.37, 0.65	This study uses households from the Tigray, Amhara, Oromia and SNNP regions in Ethiopia. Tehnical efficiency scores are estimated using both SFA and DEA. A Cobb-Douglas production function is used when using SFA. For the full sample, average efficiency score is 0.37 when using SPF and 0.37 and 0.65 when using output- and input-oriented DEA, respectively. Note that the efficiency score if the TE for all crops are estimated separately, the TE increases to 0.46 for SFA. By crop, the lowest average efficiency is 0.27 (Barley) and the highest is Maize 0.69.
11	Bachewe et al. (2011)	National	ERHS	Cereal	7175	0.46-0.6	This study uses data from the ERHS (1994, 1999, 2004, 2009 waves) and covers four regions of Ethiopia (Tigray, Amhara, Oromyia, SNNP). The main outcome of interest is the value of cereal output. Technical efficiency scores are estimated using SFA and a Cobb-Douglas production function is used throughout. Average efficiency for the pooled sample is 0.46. Average efficiency when the TE scores are estimated by AEZ is 0.5. Finally, for the sub-sample of fertilizer users, the average efficiency score is 0.6.
12	Beshir et al. (2012)	Sub-national	No	Crops and livestock	252	0.62	This study covers households in the Dessie Zuria and Kutaber districts, in the Amhara region. A Cobb-Douglas specification is used and the outcome of interest is the value of crops and livestock. Technical efficiency estimated using SFA.
13	Croppenstedt and Muller (2000)	National	Yes	Crops	430	0.56	This study uses data from the 1994 wave of the ERHS and covers four regions in Ethiopia (Tigray, Amhara, Oromia and SNNP). A Cobb-Douglas specification was used. Mean efficiencies for normal half-normal distribution was 0.56 and for the exponential specification it was 0.76. The dependent variable is the value of crops.
14	Ferenji and Heidhues (2007)	Sub-national	No	Teff	750	0.88	A Cobb-Douglas specification is used. The dataset covers two administrative regions, namely Amhara and Oromia (districts of Shashamane and Ankober-Dinqi).
15	Gebregziabher et al. (2012)	Sub-National	No	Farm produce	613	0.62	This study uses data from a sruvey conducte in the Tigray region. Technical efficiency scores are estimated using SFA and a Cobb-Douglas specification was used. The authors find that households under rainfed agriculture have mean efficiencies of 0.82, compared with 0.45 for households using irrigation. 282 households practice rainfed agriculture, whereas 331 use irrigation. Consequently the weighted mean average technical efficiency score was 0.62
16	Gelaw (2013)	Sub-national	No	Crop-livestock	208	0.69	This paper uses data from Eastern Gojjam and Western Gojjam, in the Amhara region. Technical efficiency scores are estimated using SFA and the authors use a Cobb-Douglas production function. They find that non-poor households have a higher efficiency score (0.744) than poor households (0.583). The output is the value of all crops. The (weighted) average technical efficiency score is 0.69.

Table 2A.1 : Technical efficiency studies in Ethiopia (Part 3)

No.	Authors	Coverage	ERHS	Crop	N	TE score(s)	Additional notes/comments
17	Kebede and Adenew (2011)	Sub-national	No	Wheat	32	0.82	Technical efficiency scores were estimated using SFA and a Cobb-Douglas specification was used. This study focuses on commercial farms in the Bale zone. The output variable is wheat production.
18	Khairo and Battese (2005)	Sub-national	No	Maize	180	0.73	This Study focuses on the households covered the NEP and on households that fall outside the NEP. The geographical coverage of the study is limited to the Harari region.
19	Mekonnen et al. (2013)	National	Yes	Cereals	815	0.58	This paper covers four regions in Ethiopia (Tigray, Amhara, Oromia, SNNP) and uses data from the ERHS (1999 and 2004 waves). The study uses a GMM approach. The paper finds that, at the peasant association level, average technical efficiency scores range from 46.4% to 69.1%.
20	Mussa et al. (2012)	Sub-national	No	Wheat, Teff, Chick-peas	466	0.74	This paper uses DEA and the output variable is the output of wheat, teff and chickpeas.
21	Nsanzugwanko et al. (1996)	National	No	Crop-livestock	843	0.69	Cobb-Douglas specification was used. The sample covered 14 administrative regions. The majority (55%) of the households have efficiency scores between 0.7-0.85.
22	Sauer and Yilma (2007)	Sub-national	No	Maize	83	0.68	The authors use a translog function and the sample covers the Jimma in South-Western Ethiopia. The authors estimate a number of different models and report four results, 0.69,0.68,0.68 and 0.66.
23	Seebens and Sauer (2007)	National	Yes	Farm produce	558	0.59	This paper uses data from the 1997 wave of the ERHS. Technical efficiency scores are estimated using a Cobb-Douglas production function and the paper looks at bargaining power and inefficiency. The outcome variable is the household income which is used as a proxy for the output produced.
24	Suleiman (1995)	Sub-national	Yes	Farm produce	248	0.41	The authors uses DEA and the results by Peasant association range from 0.39-44. The weighted average (weighed by the proportion of households in a given PA in the sample) implies a TE score of 0.41. Data from the 1994 wave of the ERHS is used and the study areas include the Turufe Ketchema, Sirbana Godeti and Aze Deboa Peasant Associations.
25	Seyoum et al. (1998)	Sub-national	No	Maize	40	0.86	This paper focuses on Eastern Ethiopia and seeks to investigate the difference in technical efficiency for farmers in and out of the SG programme 2000. A Cobb-Douglas production function is used. Mean efficiencies for the farmers in the SG programme are 2000 program had an efficiency of 0.937 and those outside had a mean efficiency score of 0.794. This leads to an average score of 0.86.

Table 2A.1 : Technical efficiency studies in Ethiopia (Part 4)

No.	Authors	Coverage	ERHS	Crop	N	TE score(s)	Additional notes/comments
26	Tesfay et al. (2005)	Sub-National	No	Grain	518	0.65	This paper uses data from households in the Tigray region. The output variable is the gross value of grain and straw output in Birr. Technical efficiency scores are estimated using SFA and a Cobb-Douglas production function is used throughout. The average technical efficiency scores among plots that are owned by the household who is cultivatint the plot are slightly higher (0.66) compared to sharecropped plots (0.64). The average efficiency score is 0.65. The 518 plots are owned by 115 different households.
27	Tefera, T., and Subaro, D. V. (2013).	Sub-national	No	Farm produce	1786	0.81	This paper uses data from the Oromi and SNNP regions. Technical efficiency scores are estimated using SFA and authors use a Cobb-Douglas specification and the analysis is carried out at the plot level.
28	Ulimwengu (2009)	National	Yes	Farm produce	681	0.61	This paper uses data from the ERHS (1999 wave) and covers four regions (Tigray, Amhara, Oromia, SSNP). Technical efficiency scores are estimated using SFA and a Cobb-Douglas production function is used. The authors measure the technical efficiency of farmers that fell ill (0.60) agains the technical efficiency scores of farmers that did not (0.62). The average technical efficiency score for the whole sample was 0.61.
29	Yami et al. (2013)	Sub-national	No	Wheat	157	0.55	This paper uses data from the Digelu-tijo and Arsi-robe areas. Technical efficiency scores are estimated using SFA and authors use a translog production function. Translog and use wheat yield as an output variable. Overall, authors find that households with more plots have higher levels of technical efficiency than households with fewer plots. Households with less than 7 plots had an average technical efficiency score of 0.54 compared with households with more than 7 plots, who had an average efficiency score of 0.61.

Table 2A.2: Summary statistics by latent class
two-class translog - Year dummies only

	Full sample		Class 1		Class 2	
Variables	Mean	S. D.	Mean	S. D.	Mean	S. D.
Cereal production (kg)	815.99	1001.73	1410.51	1182.80	472.90	673.64
Cereal yield (kg/ha)	838.39	765.56	1195.74	821.13	632.17	647.42
Cereal area (ha)	1.18	1.12	1.50	1.19	0.99	1.04
Cereal area (proportion)	0.70	0.26	0.72	0.22	0.69	0.29
Fertilizer used (kg)	52.88	82.31	100.06	105.06	25.65	47.86
Number of oxen	0.91	1.11	1.23	1.24	0.72	0.98
Household size	6.16	2.70	6.35	2.70	6.05	2.70
Labour intensity (people/ha)	17.01	42.54	7.89	13.48	22.28	51.70
Fertilizer intensity (kg/ha)	57.72	112.83	85.33	123.26	41.79	103.06
Oxen intensity (oxen/ha)	1.20	2.88	1.10	1.95	1.26	3.30
Tigray	0.12	0.33	0.00	0.00	0.20	0.40
Amhara	0.35	0.48	0.39	0.49	0.32	0.47
Oromya	0.31	0.46	0.59	0.49	0.14	0.35
Enset	0.22	0.41	0.02	0.13	0.34	0.47
Northern Highlands	0.21	0.41	0.06	0.23	0.30	0.46
Central Highlands	0.36	0.48	0.58	0.49	0.24	0.43
Other	0.21	0.41	0.35	0.48	0.13	0.33
Enset	0.22	0.41	0.02	0.13	0.34	0.47
N	839		307		532	
Proportion	100.00		36.59		63.41	

S. D. refers to Standard deviations

Table 2A.3: Results - stochastic frontier model (translog)
Pooled OLS, Fixed effects and two-class LCM (Year dummies)

	Pooled OLS	F.E.	Latent Class	
			Class 1	Class 2
Constant	6.566***		7.303***	6.006***
	(0.115)		(0.189)	(0.144)
Area	0.530***	0.564***	0.060	0.726***
	(0.043)	(0.027)	(0.071)	(0.050)
Oxen	0.539***	0.464***	0.229	0.912***
	(0.143)	(0.100)	(0.168)	(0.202)
Household size	-0.087	-0.181***	-0.253**	-0.040
	(0.090)	(0.051)	(0.118)	(0.109)
Fertilizer	-0.279***	-0.355***	-0.218***	-0.166***
	(0.046)	(0.027)	(0.071)	(0.060)
Area sq	-0.073***	-0.066***	-0.296***	0.034*
	(0.015)	(0.010)	(0.029)	(0.018)
Oxen sq	0.049	0.056	0.623***	-0.586***
	(0.142)	(0.096)	(0.165)	(0.210)
Household size sq	0.127**	0.172***	0.302***	0.062
	(0.057)	(0.035)	(0.071)	(0.072)
Fertilizer sq	0.149***	0.174***	0.097***	0.069***
	(0.013)	(0.008)	(0.018)	(0.020)
Area * oxen	-0.024	-0.032	0.157***	0.009
	(0.039)	(0.027)	(0.052)	(0.053)
Area * Household size	0.055**	0.051***	0.098***	-0.023
	(0.023)	(0.015)	(0.036)	(0.027)
Area * Fertilizer	-0.006	-0.012***	0.029***	0.009
	(0.006)	(0.004)	(0.011)	(0.008)
Oxen * Household size	-0.063	-0.032	-0.083	-0.159
	(0.070)	(0.048)	(0.072)	(0.106)
Oxen * Fertilizer	-0.077***	-0.078***	-0.111***	0.024
	(0.015)	(0.011)	(0.020)	(0.022)
Household size * Fertilizer	-0.001	0.001	0.010	-0.003
	(0.012)	(0.008)	(0.016)	(0.016)
Dummy fertilizer	-0.481***	-0.583***	-0.464***	-0.388***
	(0.072)	(0.042)	(0.126)	(0.081)
Dummy oxen	-0.044	-0.046**	-0.051	-0.045
	(0.029)	(0.020)	(0.038)	(0.036)
1995	0.477***	0.459***	0.144***	0.759***
	(0.036)	(0.030)	(0.045)	(0.048)
1997	0.304***	0.289***	0.242***	0.450***
	(0.039)	(0.031)	(0.049)	(0.049)
1999	0.410***	0.406***	0.190***	0.632***
	(0.040)	(0.032)	(0.050)	(0.049)
2004	0.504***	0.498***	0.264***	0.731***
	(0.039)	(0.032)	(0.049)	(0.049)
2009	0.607***	0.597***	0.321***	0.823***
	(0.039)	(0.032)	(0.055)	(0.049)
			Selection equation	
Constant			-0.654	
			(0.791)	
Av. Proportion cereal			0.401	
			(0.862)	
Av. Area			0.015	
			(0.194)	
Av. Labour intensity			-0.161***	
			(0.021)	
Av. Fertilizer intensity			0.019***	
			(0.002)	
Av. Oxen intensity			-0.101	
			(0.118)	
Prior Probabilities			0.175	0.825
		Variance parameters		
Lambda	1.371***	1.190***	1.799***	1.037***
	(0.046)	(0.032)	(0.205)	(0.161)
Sigma	0.984***	1.011***	0.743***	0.870***
	(0.000)	(0.009)	(0.031)	(0.034)
AIC/N	2.268	2.325	2.060	
Log Likelihood	-5685.365	-4990.232	-5130.876	

All the variables are in natural logarithms with the exception of the dummy variables. Number in parentheses denote standard errors. *, **, *** denote statistical significance at the 10%, 5% and 1% level, respectively.

Table 2A.4: Summary statistics - Efficiency scores by method and agro-ecological zone (Translog - Year dummies)

All				
	Mean	S.D.	Min.	Max.
Pooled OLS	0.55	0.15	0.12	0.90
Fixed Effects	0.57	0.11	0.15	0.85
LCM (2 classes)	0.76	0.10	0.27	0.95
Northern Highlands				
	Mean	S.D.	Min.	Max.
Pooled OLS	0.53	0.15	0.16	0.86
Fixed Effects	0.59	0.11	0.20	0.82
LCM (2 classes)	0.74	0.11	0.39	0.94
Central Highlands				
	Mean	S.D.	Min.	Max.
Pooled OLS	0.59	0.13	0.13	0.84
Fixed Effects	0.59	0.09	0.22	0.80
LCM (2 classes)	0.77	0.10	0.40	0.94
Others				
	Mean	S.D.	Min.	Max.
Pooled OLS	0.60	0.12	0.16	0.89
Fixed Effects	0.59	0.09	0.21	0.85
LCM (2 classes)	0.77	0.10	0.27	0.95
Enset				
	Mean	S.D.	Min.	Max.
Pooled OLS	0.60	0.12	0.16	0.89
Fixed Effects	0.59	0.09	0.21	0.85
LCM (2 classes)	0.77	0.10	0.27	0.95

S. D. refers to standard deviations. Min. refers to the minimum value. Max. refers to the maximum value

Table 2A.5: Class allocation by peasant association two-class LCM translog - Year dummies only

	Full sample	Class 1		Class 2	
Peasant Association	N	N	Proportion	N	Proportion
Haresaw	51	0	0.00	51	100.00
Geblen	53	0	0.00	53	100.00
Dinki	46	5	10.87	41	89.13
Yetmen	36	32	88.89	4	11.11
Shumsheha	71	17	23.94	54	76.06
Sirbana Godeti	60	59	98.33	1	1.67
Adele Keke	36	31	86.11	5	13.89
Korodegaga	79	17	21.52	62	78.48
Trirufe Ketchema	84	75	89.29	9	10.71
Aze Deboa	51	0	0.00	51	100.00
Adado	28	1	3.57	27	96.43
Gara Godo	73	2	2.74	71	97.26
Doma	32	2	6.25	30	93.75
Debre Berhan Milki	45	19	42.22	26	57.78
Debre Berhan Kormargefia	47	21	44.68	26	55.32
Debre Berhan Karafino	27	13	48.15	14	51.85
Debre Berhan Bokafia	20	13	65.00	7	35.00
Total	839	307	36.59	532	63.41

N refers to the total number of households. The numbers in the proportion column were computed by dividing the number of households from a given peasant association in a given class by the total number of households from that peasant association in our sample. All proportions are rounded to two decimal places.

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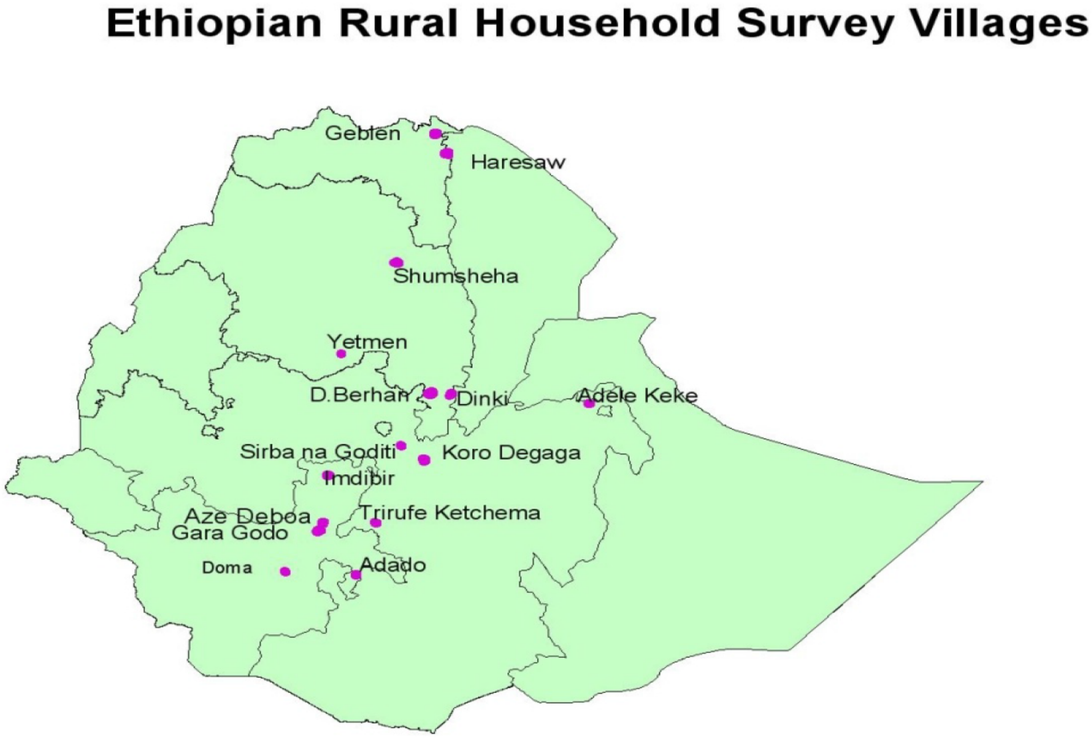
Chapter 3

Revisiting the link between cereal diversity and production in Ethiopia

A Appendix A - Additional figures and tables

Figure 3A.1: Map of Villages in the ERHS (up to 2004)



Source: Dercon and Hoddinott 2004

Figure 3A.2: Background information of Villages in the ERHS (up to 2004)

Survey site	Location	Background	Main crops	Perennial crops?	Mean Rainfall mm
Haresaw	Tigray	Poor and vulnerable area.	Cereals	no	558
Geblen	Tigray	Poor and vulnerable area; used to be quite wealthy.	Cereals	no	504
Dinki	N. Shoa	Badly affected in famine in 84/85; not easily accessible even though near Debre Berhan.	Millet, teff	no	1664
Debre Berhan	N.Shoa	Highland site. Near town.	Teff, barley, beans	no	919
Yetmen	Gojjam	Near Bichena. Ox-plough cereal farming system of highlands.	Teff, wheat and beans	no	1241
Shumsha	S.Wollo	Poor area in neighbourhood of airport near Lalibela.	Cereals	no	654
Sirbana Godeti	Shoa	Near Debre Zeit. Rich area. Much targeted by agricultural policy. Cereal, ox-plough system.	Teff	no	672
Adele Keke	Hararghe	Highland site. Drought in 85/86	Millet, maize, coffee, chat	yes, no food	748
Korodegaga	Arssi	Poor cropping area in neighbourhood of rich valley.	Cereals	no	874
Turfe Kechemane	S.Shoa	Near Shashemene. Ox-plough, rich cereal area. Highlands.	Wheat, barley, teff, potatoes	yes, some	812
Imdibir	Shoa (Gurage)	Densely populated enset area.	Enset, chat, coffee, maize	yes, including food	2205
Aze Deboa	Shoa (Kembata)	Densely populated. Long tradition of substantial seasonal and temporary migration.	Enset, coffee, maize, teff, sorghum	yes, including food	1509
Addado	Sidamo (Dilla)	Rich coffee producing area; densely populated.	Coffee, enset	yes, including food	1417
Gara Godo	Sidamo (Wolayta)	Densely packed enset-farming area. Famine in 83/84. Malaria in mid-88.	Barley, enset	yes, including food	1245
Doma	Gama Gofa	Resettlement Area (1985); Semi-arid; droughts in 85, 88,89,90; remote.	Enset, maize	yes, some	1150

Source: Dercon and Hoddinott 2004

Table 3A.1: List of Peasant Associations by AEZ

Agro-Ecological Zone	**Peasant Association**
Northern Highlands	Haresaw
	Geblen
	Shumsheha
Central Highlands	Dinki
	Debre Berhan Milki
	Debre Berhan Kormargefia
	Debre Berhan Karafino
	Debre Berhan Bokafia
	Yetmen
	Turufe Ketchema
Enset	Imdibir
	Aze-Deboa
	Adado
	Gara-Godo
	Do'oma
Other	Sirbana Godeti
	Korodegaga
	Adele Keke

Table 3A.2: Parametric translog full

	All	N. Highlands	C. Highlands	Other	Enset
Area	0.592***	0.548***	0.486***	0.357**	0.177
	(0.058)	(0.129)	(0.085)	(0.147)	(0.180)
Household size	0.019	0.304	-0.271	0.368	0.14
	(0.106)	(0.278)	(0.172)	(0.238)	(0.323)
Oxen	0.128***	0.124*	0.087**	0.150***	0.268**
	(0.029)	(0.069)	(0.044)	(0.053)	(0.114)
Fertilizer	0.017*	-0.073*	0.026**	0.023	-0.007
	(0.009)	(0.039)	(0.013)	(0.016)	(0.031)
Hoes	0.03	-0.003	0.039	0.100**	-0.059
	(0.021)	(0.053)	(0.030)	(0.043)	(0.071)
Ploughs	0.017	0.034	0.040*	0.049	-0.06
	(0.014)	(0.032)	(0.023)	(0.030)	(0.057)
Shannon index	0.046	0.026	0.030	0.122	0.032
	(0.029)	(0.054)	(0.047)	(0.075)	(0.068)
Area (square)	0.019	0.016	-0.067***	0.021	0.036
	(0.013)	(0.026)	(0.020)	(0.036)	(0.026)
Household size (square)	0.017	0.001	0.125**	-0.168**	-0.021
	(0.033)	(0.070)	(0.052)	(0.076)	(0.081)
Oxen (square)	0.009***	0.009*	0.006**	0.010***	0.019**
	(0.002)	(0.005)	(0.003)	(0.004)	(0.008)
Fertilizer (square)	0.001	-0.004	0.001	0.002**	-0.001
	(0.001)	(0.003)	(0.001)	(0.001)	(0.002)
Hoes (square)	0.002	-0.001	0.002	0.006*	-0.001
	(0.001)	(0.004)	(0.002)	(0.003)	(0.005)
Ploughs (square)	0.001	0.002	0.002	0.003	-0.005
	(0.001)	(0.002)	(0.002)	(0.002)	(0.004)
Shannon index (square)	0.003	0.003	0.002	0.007	0.001
	(0.002)	(0.004)	(0.003)	(0.005)	(0.004)
Area*Household size	-0.053*	-0.042	0.042	0.087	0.007
	(0.029)	(0.055)	(0.045)	(0.071)	(0.080)
Area*Oxen	-0.001	-0.001	-0.002	0.001	-0.001
	(0.002)	(0.005)	(0.003)	(0.005)	(0.005)
Area*Fertilizer	0.000	-0.001	0.000	-0.007*	-0.002
	(0.002)	(0.006)	(0.003)	(0.004)	(0.004)
Area*Hoes	0.002	-0.003	0.001	0.003	0.000
	(0.002)	(0.004)	(0.004)	(0.004)	(0.005)
Area*Ploughs	0.000	0.007*	-0.005	0.005	-0.010*
	(0.002)	(0.004)	(0.004)	(0.005)	(0.006)
Area*Shannon index	-0.006**	-0.009	-0.006	0.008	-0.017**
	(0.003)	(0.005)	(0.004)	(0.008)	(0.007)
Household size*Oxen	0.000	-0.001	0.005	-0.008	-0.005
	(0.003)	(0.008)	(0.005)	(0.007)	(0.011)
Household size*Fertilizer	0.001	0.016*	-0.002	0.007	-0.005
	(0.003)	(0.009)	(0.004)	(0.006)	(0.009)
Household size*Hoes	0.001	0.007	0.002	-0.007	0.015*
	(0.003)	(0.006)	(0.005)	(0.006)	(0.008)
Household size*Ploughs	-0.005	-0.016**	-0.007	-0.001	-0.007
	(0.003)	(0.008)	(0.006)	(0.008)	(0.008)
Household size*Shannon index	0.003	0.008	0.000	-0.006	-0.007
	(0.004)	(0.007)	(0.006)	(0.011)	(0.011)
Oxen*Fertilizer	-0.000**	-0.001	0.000	0.000	0.000
	(0.000)	(0.001)	(0.000)	(0.000)	(0.001)
Oxen*Hoes	0.000	0	0.001**	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)
Oxen*Ploughs	0.000	0.000	0.000	0.000	-0.001*
	(0.000)	(0.001)	(0.000)	(0.000)	(0.001)
Oxen*Shannon index	0.000	0.000	0.000	-0.001	0.000
	(0.000)	(0.001)	(0.000)	(0.001)	(0.001)
Fertilizer*Hoes	0.000**	0.001**	0.000	0.000	0.000
	(0.000)	(0.001)	(0.000)	(0.000)	(0.001)
Fertilizer*Ploughs	0.000*	-0.001	0.000	0.001	0.000
	(0.000)	(0.001)	(0.000)	(0.000)	(0.001)
Fertilizer*Shannon index	0.000	0.000	0.000	0.000	-0.001**
	(0.000)	(0.001)	(0.000)	(0.001)	(0.001)
Hoes*Ploughs	0.000	0.000	-0.001*	0.001	0.000
	(0.000)	(0.001)	(0.000)	(0.001)	(0.001)
Hoes*Shannon index	0.000	0.001***	0.000	0.000	-0.002**
	(0.000)	(0.000)	(0.000)	(0.001)	(0.001)
Ploughs*Shannon index	0.000	-0.001*	0.000	-0.001	0.002***
	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)
Constant	6.339***	4.919***	6.450***	5.943***	5.440***
	(0.110)	(0.353)	(0.171)	(0.234)	(0.411)
Elasticity of Shannon index	0.044*	0.035	0.025	0.115*	0.031
p-value	0.061	0.401	0.529	0.084	0.432
Fixed effects	✓	✓	✓	✓	✓
Village-year fixed effects	✓	✓	✓	✓	✓
Number of households	1280	289	428	299	264
Number of observations	5804	1323	2002	1456	1023
Average obs. per household	4.534	4.578	4.678	4.87	3.875
R-squared a	0.547	0.659	0.557	0.509	0.454
R-squared w	0.556	0.672	0.571	0.526	0.481

Notes: N. Highlands refers to Northern Highlands. C. Highlands refers to Central highlands. Numbers in parentheses represent clustered standard errors at the household level. As explained in the methodology section, this specification does not include the adjustment proposed by Battese (1997) since there is little within-household variation of input-use. Instead 0 values are assigned the value of 0.000001.

Table 3A.3: Parametric translog full (teff only)

	All	N. Highlands	C. Highlands	Other	Enset
Area	0.584***	0.571**	0.538***	0.523**	-0.016
	(0.095)	(0.258)	(0.160)	(0.221)	(0.261)
Household size	0.163	0.043	-0.273	0.514**	-0.151
	(0.146)	(0.505)	(0.336)	(0.250)	(0.396)
Oxen	0.164***	0.157	0.074	0.163***	0.260*
	(0.038)	(0.095)	(0.074)	(0.056)	(0.147)
Fertilizer	0.032**	-0.068	0.039*	0.026	-0.001
	(0.013)	(0.045)	(0.022)	(0.018)	(0.049)
Hoes	0.033	-0.067	-0.026	0.092**	0.057
	(0.028)	(0.062)	(0.051)	(0.045)	(0.093)
Ploughs	-0.017	0.086	-0.034	-0.001	-0.163**
	(0.021)	(0.061)	(0.037)	(0.034)	(0.078)
Shannon index	0.177***	0.129	0.065	0.299***	0.190
	(0.047)	(0.086)	(0.066)	(0.076)	(0.133)
Area (square)	0.077***	0.091*	0.004	-0.104	0.072**
	(0.022)	(0.054)	(0.048)	(0.065)	(0.034)
Household size (square)	-0.043	0.100	0.128	-0.243***	0.001
	(0.047)	(0.148)	(0.095)	(0.090)	(0.103)
Oxen (square)	0.011***	0.007	0.004	0.011***	0.015
	(0.003)	(0.007)	(0.005)	(0.004)	(0.010)
Fertilizer (square)	0.002**	-0.003	0.002	0.002	-0.001
	(0.001)	(0.004)	(0.002)	(0.001)	(0.003)
Hoes (square)	0.002	-0.005	-0.001	0.004	0.008
	(0.002)	(0.004)	(0.004)	(0.003)	(0.007)
Ploughs (square)	-0.001	0.008**	-0.003	0.000	-0.011**
	(0.001)	(0.004)	(0.003)	(0.002)	(0.005)
Shannon index (square)	0.011***	0.015**	0.003	0.018***	0.006
	(0.003)	(0.006)	(0.004)	(0.005)	(0.009)
Area*Household size	-0.104**	-0.180	-0.016	0.148	0.157
	(0.048)	(0.143)	(0.087)	(0.131)	(0.112)
Area*Oxen	0.001	-0.003	-0.001	0.013*	0.003
	(0.003)	(0.007)	(0.006)	(0.007)	(0.007)
Area*Fertilizer	-0.001	0.000	0.001	-0.021***	-0.004
	(0.003)	(0.008)	(0.006)	(0.007)	(0.007)
Area*Hoes	0.003	-0.013*	0.005	0.005	0.009
	(0.003)	(0.007)	(0.006)	(0.007)	(0.007)
Area*Ploughs	-0.006	0.012	-0.021**	0.004	-0.020**
	(0.004)	(0.009)	(0.008)	(0.009)	(0.008)
Area*Shannon index	-0.019***	-0.035***	-0.017**	-0.009	-0.022**
	(0.005)	(0.012)	(0.009)	(0.016)	(0.009)
Household size*Oxen	-0.007	-0.016	-0.004	-0.012	-0.026*
	(0.005)	(0.011)	(0.009)	(0.009)	(0.013)
Household size*Fertilizer	-0.002	0.019	-0.001	0.009	-0.004
	(0.005)	(0.017)	(0.008)	(0.009)	(0.017)
Household size*Hoes	-0.003	0.008	0.011	-0.017**	0.022
	(0.005)	(0.011)	(0.007)	(0.008)	(0.014)
Household size*Ploughs	0.007	-0.014	-0.005	0.005	0.007
	(0.005)	(0.014)	(0.010)	(0.011)	(0.012)
Household size*Shannon index	0.000	0.028	-0.006	-0.015	-0.040***
	(0.006)	(0.018)	(0.011)	(0.015)	(0.015)
Oxen*Fertilizer	0.000	0.002	0.000	0.000	0.000
	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)
Oxen*Hoes	0.000	0.000	0.000	0.000	0.000
	(0.000)	(0.001)	(0.000)	(0.000)	(0.001)
Oxen*Ploughs	0.000	0.002**	0.000	0.000	-0.001
	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)
Oxen*Shannon index	0.000	-0.001	0.000	0.001	0.001
	(0.000)	(0.002)	(0.001)	(0.001)	(0.001)
Fertilizer*Hoes	0.000	0.001	0.000	0.000	0.001
	(0.000)	(0.001)	(0.000)	(0.000)	(0.001)
Fertilizer*Ploughs	0.000	-0.003**	0.001	0.001	-0.001
	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)
Fertilizer*Shannon index	0.000	-0.002	0.000	0.000	-0.001
	(0.000)	(0.002)	(0.001)	(0.001)	(0.001)
Hoes*Ploughs	0.000	-0.001	-0.002**	0.000	0.001
	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)
Hoes*Shannon index	0.001	0.002	0.002**	0.002*	-0.002*
	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)
Ploughs*Shannon index	0.001**	-0.002	0.001	-0.003**	0.003***
	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)
Constant	6.345***	5.469***	6.846***	5.786***	5.771***
	(0.146)	(0.553)	(0.340)	(0.232)	(0.563)
Elasticity of Shannon index	0.153***	0.186**	0.036	0.252***	0.096
p-value	0.000	0.019	0.536	0.000	0.254
Fixed effects	✓	✓	✓	✓	✓
Village-year fixed effects	✓	✓	✓	✓	✓
Number of households	782	152	217	211	202
Number of observations	2799	544	679	960	616
Average obs. per household	3.579	3.579	3.129	4.55	3.05
R-squared a	0.511	0.358	0.557	0.597	0.535
R-squared w	0.526	0.412	0.59	0.616	0.573

Notes: N. Highlands refers to Northern Highlands. C. Highlands refers to Central highlands. Numbers in parentheses represent clustered standard errors at the household level. As explained in the methodology section, this specification does not include the adjustment proposed by Battese (1997) since there is little within-household variation of input-use. Instead 0 values are assigned the value of 0.000001.

Table 3A.4: Parametric translog full (no teff)

	All	N. Highlands	C. Highlands	Other	Enset
Area	0.556***	0.733***	0.463***	0.150	-0.070
	(0.078)	(0.256)	(0.109)	(0.219)	(0.463)
Household size	-0.134	0.246	-0.315	0.069	0.216
	(0.162)	(0.363)	(0.215)	(0.574)	(0.871)
Oxen	0.101**	0.073	0.093	-0.057	0.296
	(0.047)	(0.117)	(0.058)	(0.205)	(0.233)
Fertilizer	0.016	-0.094	0.032**	0.019	0.028
	(0.014)	(0.062)	(0.016)	(0.033)	(0.067)
Hoes	0.033	0.143	0.096**	0.058	-0.258**
	(0.034)	(0.116)	(0.040)	(0.121)	(0.121)
Ploughs	0.058**	0.029	0.061**	0.244***	0.180
	(0.024)	(0.048)	(0.031)	(0.084)	(0.149)
Shannon index	-0.004	-0.094	0.095	-0.069	0.011
	(0.050)	(0.072)	(0.081)	(0.136)	(0.131)
Area (square)	-0.015	-0.075	-0.089***	0.053	-0.009
	(0.018)	(0.064)	(0.025)	(0.062)	(0.045)
Household size (square)	0.071	0.018	0.125*	-0.033	-0.06
	(0.047)	(0.084)	(0.064)	(0.149)	(0.188)
Oxen (square)	0.008**	0.008	0.007*	-0.004	0.023
	(0.003)	(0.009)	(0.004)	(0.015)	(0.016)
Fertilizer (square)	0.001	-0.006	0.003*	0.004	0.002
	(0.001)	(0.006)	(0.001)	(0.003)	(0.004)
Hoes (square)	0.002	0.010	0.006**	0.003	-0.019**
	(0.002)	(0.009)	(0.003)	(0.009)	(0.008)
Ploughs (square)	0.003*	0.000	0.004*	0.016***	0.008
	(0.002)	(0.003)	(0.002)	(0.006)	(0.009)
Shannon index (square)	-0.001	-0.007	0.006	-0.009	-0.002
	(0.003)	(0.005)	(0.006)	(0.009)	(0.008)
Area*Household size	-0.01	-0.102	0.087	0.205*	0.059
	(0.039)	(0.089)	(0.056)	(0.104)	(0.120)
Area*Oxen	-0.004	-0.001	-0.004	-0.001	-0.018**
	(0.003)	(0.009)	(0.005)	(0.009)	(0.009)
Area*Fertilizer	0.002	0.007	-0.003	-0.016**	-0.005
	(0.003)	(0.010)	(0.004)	(0.006)	(0.006)
Area*Hoes	0.001	0.001	0.000	0.006	-0.008
	(0.003)	(0.007)	(0.005)	(0.008)	(0.008)
Area*Ploughs	0.005	0.015**	0.002	0.013	0.01
	(0.003)	(0.008)	(0.005)	(0.009)	(0.009)
Area*Shannon index	-0.002	0.004	-0.002	0.012	-0.017
	(0.004)	(0.009)	(0.005)	(0.011)	(0.026)
Household size*Oxen	0.004	0.005	0.01	0.002	0.001
	(0.005)	(0.013)	(0.007)	(0.015)	(0.022)
Household size*Fertilizer	0.003	0.020*	-0.003	0.011	0.003
	(0.004)	(0.011)	(0.005)	(0.010)	(0.017)
Household size*Hoes	0.003	0.008	-0.003	0.003	0.008
	(0.004)	(0.008)	(0.007)	(0.010)	(0.018)
Household size*Ploughs	-0.013**	-0.021*	-0.007	-0.013	-0.024
	(0.005)	(0.011)	(0.009)	(0.014)	(0.020)
Household size*Shannon index	0.000	0.005	-0.004	-0.029*	-0.016
	(0.005)	(0.008)	(0.007)	(0.016)	(0.035)
Oxen*Fertilizer	-0.001**	-0.002*	0.000	0.000	-0.002
	(0.000)	(0.001)	(0.000)	(0.001)	(0.001)
Oxen*Hoes	0.000	-0.001	0.001***	0.000	0.001
	(0.000)	(0.001)	(0.000)	(0.001)	(0.001)
Oxen*Ploughs	-0.001***	-0.001	-0.001*	-0.001	-0.003*
	(0.000)	(0.001)	(0.001)	(0.001)	(0.002)
Oxen*Shannon index	0.000	0.000	0.000	-0.001	0.000
	(0.000)	(0.001)	(0.001)	(0.001)	(0.002)
Fertilizer*Hoes	0.000*	0.002**	-0.001	0.000	0.000
	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)
Fertilizer*Ploughs	0.001*	-0.001	0.001	0.001	0.003**
	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)
Fertilizer*Shannon index	0.000	0.000	0.000	0.001	0.000
	(0.000)	(0.001)	(0.000)	(0.001)	(0.002)
Hoes*Ploughs	0.000	0.000	-0.001	0.000	0.000
	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)
Hoes*Shannon index	0.000	0.001	-0.001	0.000	0.001
	(0.000)	(0.001)	(0.001)	(0.001)	(0.002)
Ploughs*Shannon index	0.000	0.000	0.000	0.000	0.003
	(0.000)	(0.001)	(0.001)	(0.001)	(0.003)
Constant	6.305***	4.852***	6.347***	6.115***	5.745***
	(0.175)	(0.537)	(0.222)	(0.728)	(1.268)
Elasticity of Shannon index	0.000	-0.058	0.076	-0.105	-0.016
p-value	0.997	0.219	0.272	0.382	0.838
Fixed effects	✓	✓	✓	✓	✓
Village-year fixed effects	✓	✓	✓	✓	✓
Number of households	893	211	344	128	210
Number of observations	3005	779	1323	496	407
Average obs. per household	3.365	3.692	3.846	3.875	1.938
R-squared a	0.547	0.659	0.557	0.509	0.454
R-squared w	0.556	0.672	0.571	0.526	0.481

Notes: N. Highlands refers to Northern Highlands. C. Highlands refers to Central highlands. Numbers in parentheses represent clustered standard errors at the household level. As explained in the methodology section, this specification does not include the adjustment proposed by Battese (1997) since there is little within-household variation of input-use. Instead 0 values are assigned the value of 0.000001.

Table 3A.5: Semi-parametric model: Parametric component (Full sample)

	All	Teff	No teff
Area	0.635***	0.687***	0.593***
	(0.065)	(0.100)	(0.085)
Household size	-0.135	0.006	-0.127
	(0.134)	(0.153)	(0.229)
Oxen	0.000	0.009	-0.011
	(0.008)	(0.010)	(0.012)
Fertilizer	-0.004	0.002	-0.009
	(0.007)	(0.010)	(0.010)
Hoes	0.001	0.003	0.002
	(0.007)	(0.010)	(0.010)
Ploughs	0.008	-0.009	0.024**
	(0.008)	(0.011)	(0.012)
Area (square)	0.010	0.030	-0.008
	(0.025)	(0.038)	(0.034)
Household size (square)	0.137	0.028	0.159
	(0.084)	(0.100)	(0.139)
Oxen (square)	0.117**	0.171**	0.071
	(0.057)	(0.072)	(0.099)
Fertilizer (square)	0.009*	0.005	0.013
	(0.005)	(0.006)	(0.008)
Hoes (square)	0.034	0.020	0.069
	(0.029)	(0.038)	(0.047)
Ploughs (square)	0.020	0.019	0.041
	(0.017)	(0.025)	(0.025)
Area*Household size	-0.063*	-0.106**	-0.027
	(0.033)	(0.049)	(0.042)
Area*Oxen	0.000	0.001	-0.002
	(0.002)	(0.003)	(0.003)
Area*Fertilizer	-0.002	-0.006**	-0.001
	(0.002)	(0.003)	(0.003)
Area*Hoes	0.006***	0.007**	0.004
	(0.002)	(0.003)	(0.003)
Area*Ploughs	0.000	-0.005	0.006**
	(0.002)	(0.003)	(0.003)
Household size*Oxen	0.002	-0.002	0.006
	(0.004)	(0.006)	(0.007)
Household size*Fertilizer	0.003	0.002	0.004
	(0.003)	(0.005)	(0.005)
Household size*Hoes	0.000	-0.003	0.003
	(0.003)	(0.005)	(0.005)
Household size*Ploughs	-0.007*	0.000	-0.014**
	(0.004)	(0.005)	(0.006)
Oxen*Fertilizer	-0.000*	0.000	-0.001**
	(0.000)	(0.000)	(0.000)
Oxen*Hoes	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)
Oxen*Ploughs	0.000	0.000	-0.001*
	(0.000)	(0.000)	(0.000)
Fertilizer*Hoes	0.000	0.000	0.001*
	(0.000)	(0.000)	(0.000)
Fertilizer*Ploughs	0.001***	0.000	0.001*
	(0.000)	(0.000)	(0.000)
Hoes*Ploughs	0.000	-0.001	0.000
	(0.000)	(0.000)	(0.000)
Village-year fixed effects	✓	✓	✓
Number of observations	4289	2149	2140
Number of households	1280	782	893
R-squared a	0.485	0.484	0.5

Table 3A.6: Semi-parametric model: Parametric component (Northern Highlands)

	All	Teff	No teff
Area	0.696***	0.474*	0.988***
	(0.143)	(0.255)	(0.244)
Household size	0.022	-0.385	0.116
	(0.392)	(0.481)	(0.529)
Oxen	-0.008	0.052*	-0.032
	(0.022)	(0.027)	(0.034)
Fertilizer	0.008	-0.003	0.024
	(0.021)	(0.028)	(0.036)
Hoes	0.005	-0.004	0.007
	(0.017)	(0.030)	(0.023)
Ploughs	0.001	-0.008	0.016
	(0.025)	(0.047)	(0.031)
Area (square)	0.041	0.046	0.010
	(0.057)	(0.096)	(0.104)
Household size (square)	-0.028	0.286	-0.155
	(0.221)	(0.281)	(0.302)
Oxen (square)	0.126	0.042	0.180
	(0.202)	(0.208)	(0.387)
Fertilizer (square)	-0.016	-0.033	-0.027
	(0.026)	(0.023)	(0.046)
Hoes (square)	-0.129**	-0.119	-0.044
	(0.065)	(0.072)	(0.211)
Ploughs (square)	0.063*	0.076	0.081
	(0.037)	(0.051)	(0.075)
Area*Household size	-0.060	-0.016	-0.116
	(0.069)	(0.135)	(0.091)
Area*Oxen	0.003	0.001	0.010
	(0.005)	(0.007)	(0.010)
Area*Fertilizer	0.000	-0.004	0.008
	(0.006)	(0.006)	(0.011)
Area*Hoes	0.007	-0.006	0.007
	(0.004)	(0.007)	(0.007)
Area*Ploughs	0.004	0.004	0.015*
	(0.005)	(0.008)	(0.008)
Household size*Oxen	0.001	-0.020	0.009
	(0.012)	(0.015)	(0.016)
Household size*Fertilizer	-0.002	0.007	-0.005
	(0.010)	(0.015)	(0.015)
Household size*Hoes	0.009	0.013	0.009
	(0.008)	(0.014)	(0.010)
Household size*Ploughs	-0.014	-0.010	-0.018
	(0.010)	(0.014)	(0.012)
Oxen*Fertilizer	-0.001	0.001	-0.003**
	(0.001)	(0.001)	(0.001)
Oxen*Hoes	0.000	-0.001	0.000
	(0.001)	(0.001)	(0.001)
Oxen*Ploughs	0.000	0.002	-0.002*
	(0.001)	(0.001)	(0.001)
Fertilizer*Hoes	0.002**	0.001	0.002***
	(0.001)	(0.001)	(0.001)
Fertilizer*Ploughs	-0.001	-0.001	0.000
	(0.001)	(0.002)	(0.001)
Hoes*Ploughs	0.000	-0.001	0.000
	(0.001)	(0.001)	(0.001)
Village-year fixed effects	✓	✓	✓
Number of observations	977	428	549
Number of households	289	152	211
R-squared a	0.597	0.305	0.694

Table 3A.7: Semi-parametric model: Parametric component (Central Highlands)

	All	Teff	No teff
Area	0.615***	0.589***	0.634***
	(0.110)	(0.176)	(0.126)
Household size	-0.374*	-0.380	-0.412
	(0.206)	(0.291)	(0.265)
Oxen	-0.001	0.003	-0.005
	(0.012)	(0.019)	(0.014)
Fertilizer	0.002	0.020	-0.005
	(0.011)	(0.018)	(0.014)
Hoes	0.008	0.004	0.011
	(0.010)	(0.017)	(0.013)
Ploughs	0.019	-0.007	0.021
	(0.014)	(0.023)	(0.018)
Area (square)	-0.154***	-0.172*	-0.160***
	(0.045)	(0.089)	(0.051)
Household size (square)	0.350***	0.311*	0.393**
	(0.129)	(0.172)	(0.167)
Oxen (square)	0.009	0.108	-0.027
	(0.096)	(0.154)	(0.115)
Fertilizer (square)	0.013*	0.020*	0.012
	(0.007)	(0.011)	(0.009)
Hoes (square)	0.083**	0.034	0.136***
	(0.033)	(0.056)	(0.043)
Ploughs (square)	0.000	-0.012	0.037
	(0.023)	(0.037)	(0.029)
Area*Household size	-0.039	-0.025	-0.040
	(0.061)	(0.091)	(0.072)
Area*Oxen	0.000	0.011*	-0.004
	(0.005)	(0.007)	(0.006)
Area*Fertilizer	-0.002	0.000	-0.005
	(0.004)	(0.006)	(0.005)
Area*Hoes	0.001	0.008	-0.001
	(0.005)	(0.006)	(0.006)
Area*Ploughs	-0.002	-0.018**	0.003
	(0.005)	(0.008)	(0.006)
Household size*Oxen	0.006	0.004	0.006
	(0.006)	(0.011)	(0.008)
Household size*Fertilizer	0.000	-0.012	0.006
	(0.006)	(0.009)	(0.007)
Household size*Hoes	0.000	-0.003	0.002
	(0.006)	(0.010)	(0.007)
Household size*Ploughs	-0.012	-0.002	-0.015
	(0.007)	(0.011)	(0.009)
Oxen*Fertilizer	0.000	0.000	0.000
	(0.000)	(0.001)	(0.000)
Oxen*Hoes	0.001	0.000	0.001**
	(0.000)	(0.001)	(0.001)
Oxen*Ploughs	0.000	0.001	-0.001**
	(0.000)	(0.001)	(0.001)
Fertilizer*Hoes	-0.001*	0.000	-0.001
	(0.000)	(0.000)	(0.001)
Fertilizer*Ploughs	0.001	0.000	0.001
	(0.000)	(0.001)	(0.001)
Hoes*Ploughs	-0.001	-0.002**	-0.001
	(0.001)	(0.001)	(0.001)
Village-year fixed effects	✓	✓	✓
Number of observations	1490	507	983
Number of households	428	217	344
R-squared a	0.399	0.392	0.416

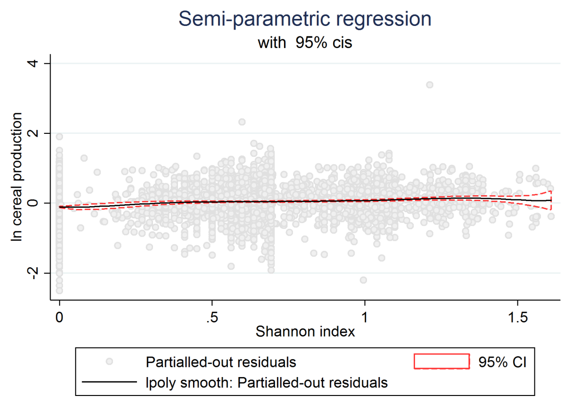
Table 3A.8: Semi-parametric model: Parametric component (Arusi/Bale (Other))

	All	Teff	No teff
Area	0.417***	0.748***	0.401
	(0.160)	(0.276)	(0.254)
Household size	0.228	0.640***	-0.545
	(0.236)	(0.245)	(0.470)
Oxen	0.009	-0.005	0.017
	(0.013)	(0.016)	(0.025)
Fertilizer	-0.007	0.005	-0.042
	(0.012)	(0.015)	(0.025)
Hoes	0.021*	0.032**	0.025
	(0.013)	(0.015)	(0.023)
Ploughs	-0.007	-0.023	0.034
	(0.016)	(0.020)	(0.025)
Area (square)	0.080	-0.133	0.275**
	(0.073)	(0.140)	(0.139)
Household size (square)	-0.202	-0.414**	0.178
	(0.156)	(0.192)	(0.268)
Oxen (square)	0.162*	0.165*	0.302
	(0.090)	(0.092)	(0.449)
Fertilizer (square)	0.002	-0.002	0.035*
	(0.007)	(0.008)	(0.021)
Hoes (square)	0.062	0.061	0.094
	(0.065)	(0.072)	(0.166)
Ploughs (square)	0.019	0.012	0.156*
	(0.033)	(0.035)	(0.092)
Area*Household size	0.025	-0.048	0.067
	(0.077)	(0.161)	(0.113)
Area*Oxen	-0.004	0.007	-0.009
	(0.005)	(0.008)	(0.009)
Area*Fertilizer	-0.004	-0.015**	-0.011
	(0.004)	(0.006)	(0.007)
Area*Hoes	0.004	0.004	0.011
	(0.005)	(0.007)	(0.008)
Area*Ploughs	0.002	-0.004	0.011
	(0.005)	(0.008)	(0.008)
Household size*Oxen	-0.003	0.001	-0.006
	(0.007)	(0.010)	(0.012)
Household size*Fertilizer	0.007	0.007	0.011
	(0.006)	(0.008)	(0.009)
Household size*Hoes	-0.009	-0.015*	-0.006
	(0.007)	(0.009)	(0.011)
Household size*Ploughs	0.004	0.009	-0.012
	(0.007)	(0.009)	(0.013)
Oxen*Fertilizer	0.000	0.000	0.000
	(0.000)	(0.000)	(0.001)
Oxen*Hoes	0.000	0.000	0.001
	(0.000)	(0.001)	(0.001)
Oxen*Ploughs	0.000	-0.001	0.000
	(0.001)	(0.001)	(0.001)
Fertilizer*Hoes	0.000	0.000	0.000
	(0.000)	(0.001)	(0.001)
Fertilizer*Ploughs	0.001	0.000	0.000
	(0.000)	(0.001)	(0.001)
Hoes*Ploughs	0.000	0.000	0.000
	(0.001)	(0.001)	(0.001)
Village-year fixed effects	✓	✓	✓
Number of observations	1125	735	390
Number of households	299	211	128
R-squared a	0.469	0.568	0.325

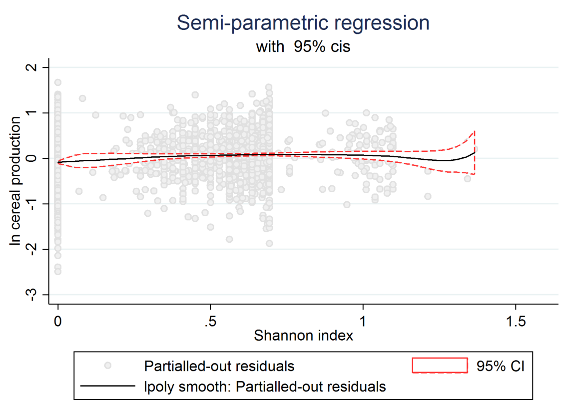
Table 3A.9: Semi-parametric model: Parametric component (Enset)

	All	Teff	No teff
Area	0.365*	0.578**	-0.063
	(0.192)	(0.277)	(0.275)
Household size	-0.127	-0.359	1.214
	(0.399)	(0.476)	(0.867)
Oxen	-0.004	0.011	-0.034
	(0.029)	(0.033)	(0.045)
Fertilizer	-0.018	-0.003	-0.045
	(0.023)	(0.038)	(0.057)
Hoes	-0.059**	-0.066**	-0.024
	(0.025)	(0.030)	(0.047)
Ploughs	-0.010	-0.012	0.012
	(0.025)	(0.029)	(0.052)
Area (square)	0.017	0.026	0.022
	(0.054)	(0.076)	(0.085)
Household size (square)	0.276	0.298	-0.191
	(0.223)	(0.253)	(0.464)
Oxen (square)	0.221	0.280	0.054
	(0.173)	(0.248)	(0.386)
Fertilizer (square)	0.000	-0.003	-0.022
	(0.017)	(0.019)	(0.031)
Hoes (square)	-0.018	0.212	-0.347
	(0.135)	(0.172)	(0.265)
Ploughs (square)	0.146	0.134	0.062
	(0.117)	(0.137)	(0.165)
Area*Household size	-0.016	-0.118	0.201*
	(0.087)	(0.119)	(0.115)
Area*Oxen	-0.001	-0.001	-0.002
	(0.006)	(0.008)	(0.008)
Area*Fertilizer	-0.008*	-0.009	-0.007
	(0.005)	(0.006)	(0.008)
Area*Hoes	-0.001	-0.002	-0.008
	(0.006)	(0.007)	(0.009)
Area*Ploughs	-0.007	0.000	-0.006
	(0.006)	(0.008)	(0.009)
Household size*Oxen	0.002	-0.005	0.016
	(0.013)	(0.015)	(0.023)
Household size*Fertilizer	0.010	0.010	0.031
	(0.011)	(0.016)	(0.027)
Household size*Hoes	0.021**	0.020	0.020
	(0.011)	(0.013)	(0.019)
Household size*Ploughs	-0.011	-0.007	-0.021
	(0.010)	(0.011)	(0.019)
Oxen*Fertilizer	0.001	0.002	-0.001
	(0.001)	(0.001)	(0.001)
Oxen*Hoes	0.000	0.000	0.001
	(0.001)	(0.001)	(0.002)
Oxen*Ploughs	-0.002*	-0.002	-0.001
	(0.001)	(0.001)	(0.002)
Fertilizer*Hoes	0.000	0.000	0.001
	(0.001)	(0.001)	(0.001)
Fertilizer*Ploughs	-0.001	0.000	-0.001
	(0.001)	(0.001)	(0.001)
Hoes*Ploughs	-0.001	-0.001	0.000
	(0.001)	(0.001)	(0.001)
Village-year fixed effects	✓	✓	✓
Number of observations	697	479	218
Number of households	264	202	210
R-squared a	0.479	0.546	0.312

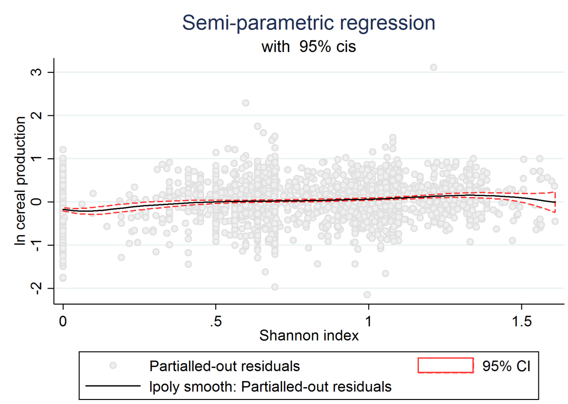
Figure 3A.3: Effect of Shannon index Semi parametric Full sample



(a) Full sample

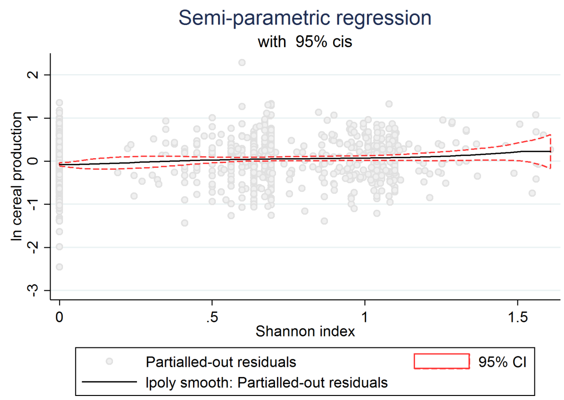


(b) Non teff-producing households

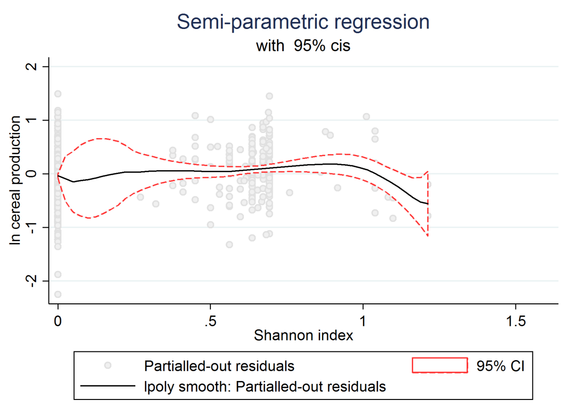


(c) Teff-producing households

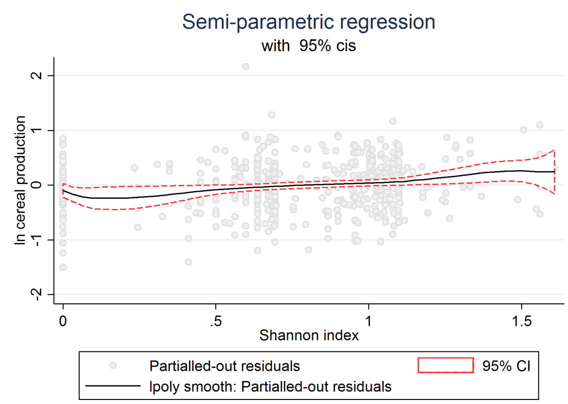
Figure 3A.4: Effect of Shannon index Semi parametric Northern Highlands



(a) Full sample

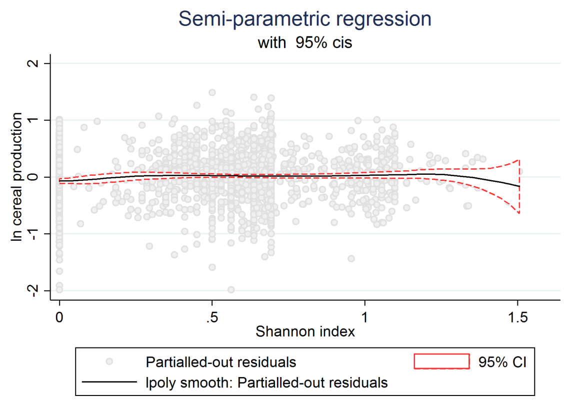


(b) Non teff-producing households

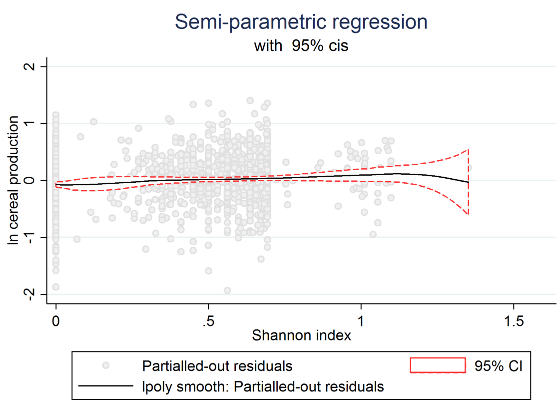


(c) Teff-producing households

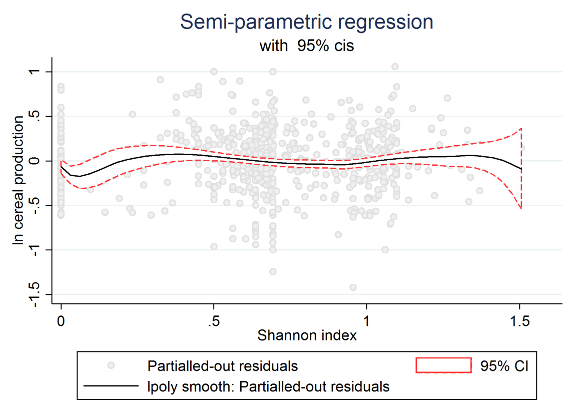
Figure 3A.5: Effect of Shannon index Semi parametric Central Highlands



(a) Full sample

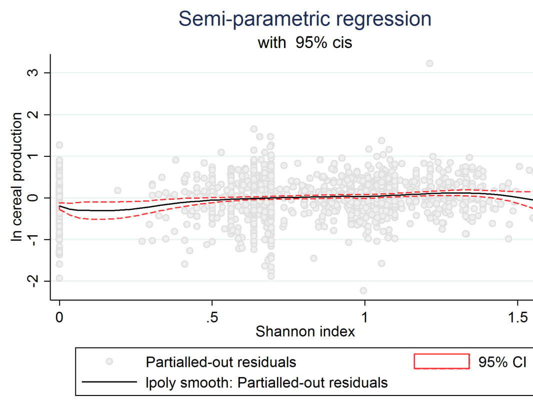


(b) Non teff-producing households

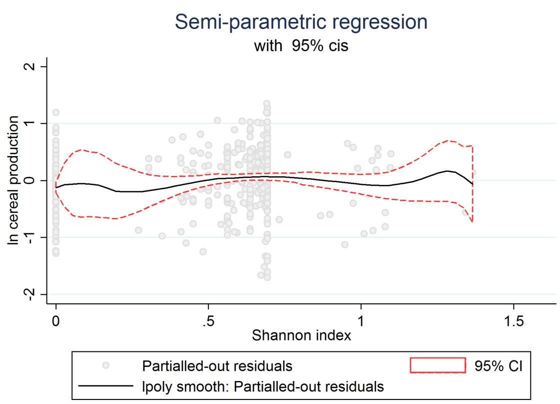


(c) Teff-producing households

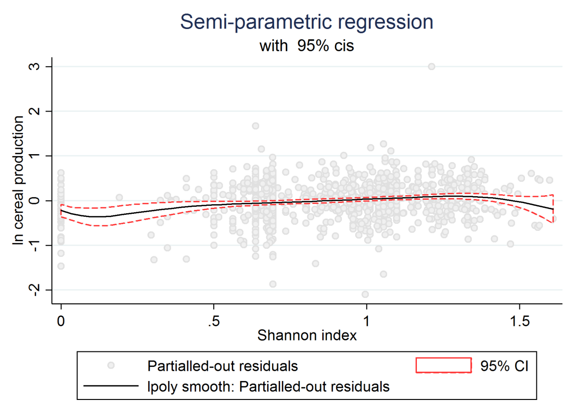
Figure 3A.6: Effect of Shannon index Semi parametric Arussi/Bale



(a) Full sample

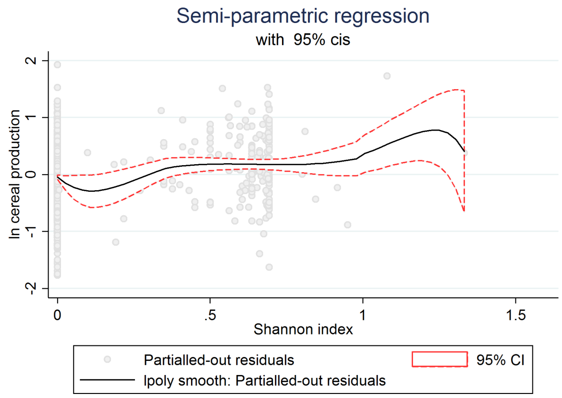


(b) Non teff-producing households

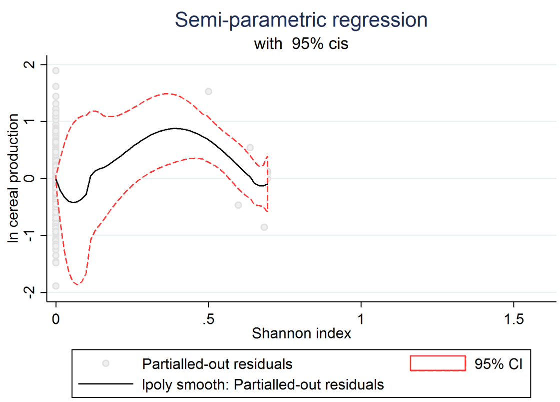


(c) Teff-producing households

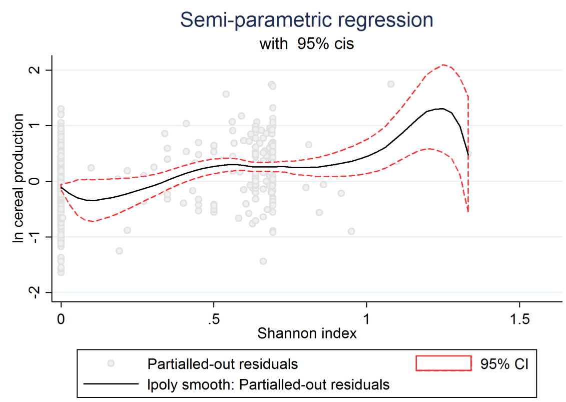
Figure 3A.7: Effect of Shannon index Semi parametric Enset



(a) Full sample



(b) Non teff-producing households



(c) Teff-producing households

Table 3A.10: Bandwidth choice

	All	N. Highlands	C. Highlands	Other	Enset
Main	0.43	0.67	0.51	0.43	0.44
No teff	0.35	0.29	0.46	0.36	0.22
Teff	0.5	0.51	0.4	0.49	0.33

A.1 Battese Correction Main Sample

Table 3A.11: Main results : Parametric translog (Battese adjustment)

	All	N. Highlands	C. Highlands	Other	Enset
Shannon index dummy	-0.174***	-0.132**	-0.110***	-0.139**	-0.224**
	(0.026)	(0.053)	(0.042)	(0.066)	(0.091)
Shannon index	0.090**	-0.073	0.103	0.154	0.141
	(0.043)	(0.148)	(0.133)	(0.179)	(0.131)
Shannon index (square)	0.004*	-0.003	0.002	-0.012	0.006
	(0.002)	(0.007)	(0.005)	(0.009)	(0.008)
Area*Shannon index	0.016**	0.059	-0.001	0.172***	0.011
	(0.007)	(0.071)	(0.054)	(0.065)	(0.011)
Household size*Shannon index	0.011	0.070	-0.063	-0.041	0.002
	(0.016)	(0.076)	(0.073)	(0.095)	(0.028)
Oxen*Shannon index	-0.029	0.116	0.019	-0.116*	-0.153
	(0.031)	(0.105)	(0.087)	(0.062)	(0.482)
Fertilizer*Shannon index	-0.001	-0.015	0.019	0.041	0.004
	(0.006)	(0.052)	(0.019)	(0.026)	(0.012)
Hoes*Shannon index	0.010	0.071	-0.004	-0.284***	0.027
	(0.020)	(0.068)	(0.062)	(0.110)	(0.028)
Ploughs*Shannon index	-0.015	0.004	-0.061	-0.142*	0.012
	(0.014)	(0.026)	(0.045)	(0.084)	(0.029)
Constant	6.985***	5.848***	6.338***	5.646***	5.873***
	(0.153)	(0.227)	(0.150)	(0.189)	(0.269)
Elasticity of Shannon index	0.094***	0.025	0.034	0.093	0.133
p-value	0.002	0.759	0.461	0.12	0.301
Household fixed effects					
Village-year fixed effects	✓	✓	✓	✓	✓
Dummies	✓	✓	✓	✓	✓
Linear variables	✓	✓	✓	✓	✓
Squares	✓	✓	✓	✓	✓
Interactions	✓	✓	✓	✓	✓
Number of households	1280	289	428	299	264
Number of observations	5804	1323	2002	1456	1023
R-squared a	0.787	0.752	0.687	0.624	0.55

Notes: N. Highlands refers to Northern Highlands. C. Highlands refers to Central highlands. The specification in the regression is a translog specification and the full list of coefficients can be seen in Table 3A.21

Table 3A.12: Main results : Parametric translog - Teff only (Battese adjustment)

	All	N. Highlands	C. Highlands	Other	Enset
Shannon index dummy	-0.351***	-0.273**	-0.087	-0.294***	-0.502***
	(0.044)	(0.112)	(0.084)	(0.094)	(0.111)
Shannon index	0.095	0.265	-0.171	0.465**	0.088
	(0.070)	(0.307)	(0.193)	(0.232)	(0.173)
Shannon index (square)	0.008**	0.094***	-0.011	0.011	-0.001
	(0.004)	(0.027)	(0.009)	(0.120)	(0.011)
Area*Shannon index	0.012	-0.158	-0.229**	0.114	0.253**
	(0.026)	(0.121)	(0.116)	(0.105)	(0.127)
Household size*Shannon index	0.055	0.018	0.101	-0.002	0.239**
	(0.034)	(0.206)	(0.114)	(0.119)	(0.102)
Oxen*Shannon index	0.003	-0.072	0.169	0.018	-1.024
	(0.082)	(0.244)	(0.168)	(0.131)	(0.677)
Fertilizer*Shannon index	0.000	-0.055	0.010	-0.046	-0.027
	(0.013)	(0.091)	(0.030)	(0.029)	(0.043)
Hoes*Shannon index	0.006	0.074	0.021	-0.277**	0.404
	(0.050)	(0.083)	(0.110)	(0.115)	(0.248)
Ploughs*Shannon index	-0.036	0.135	-0.057	-0.107	-0.147*
	(0.024)	(0.091)	(0.081)	(0.089)	(0.075)
Constant	5.925***	5.867***	6.526***	5.187***	5.355***
	(0.575)	(0.314)	(0.277)	(0.226)	(0.457)
Elasticity of Shannon index	0.176***	0.321***	0.002	0.236***	0.207
p-value	0.000	0.001	0.979	0.001	0.213
Household fixed effects					
Village-year fixed effects	✓	✓	✓	✓	✓
Dummies	✓	✓	✓	✓	✓
Linear variables	✓	✓	✓	✓	✓
Squares	✓	✓	✓	✓	✓
Interactions	✓	✓	✓	✓	✓
Number of households	782	152	217	211	202
Number of observations	2799	544	679	960	616
R-squared a	0.783	0.517	0.73	0.699	0.521

Notes: N. Highlands refers to Northern Highlands. C. Highlands refers to Central highlands. The specification in the regression is a translog specification and the full list of coefficients can be seen in Table 3A.21

Table 3A.13: Main results : Parametric translog - No teff (Battese adjustment)

	All	N. Highlands	C. Highlands	Other	Enset
Shannon index dummy	-0.097**	-0.014	-0.132*	0.027	-0.098
	(0.041)	(0.082)	(0.070)	(0.117)	(0.338)
Shannon index	-0.023	-0.191	0.110	-0.848*	0.090
	(0.078)	(0.308)	(0.247)	(0.467)	(0.490)
Shannon index (square)	-0.008*	-0.014	-0.033	-0.028*	-0.002
	(0.004)	(0.011)	(0.069)	(0.017)	(0.028)
Area*Shannon index	0.030***	0.043	0.053	-0.067	0.021*
	(0.009)	(0.113)	(0.066)	(0.153)	(0.013)
Household size*Shannon index	-0.024	0.005	-0.047	0.170	-0.038
	(0.021)	(0.127)	(0.104)	(0.238)	(0.042)
Oxen*Shannon index	-0.062	0.057	-0.073	-0.210**	-0.356
	(0.039)	(0.188)	(0.111)	(0.094)	(1.538)
Fertilizer*Shannon index	0.021*	0.023	0.012	0.138**	-0.031
	(0.012)	(0.070)	(0.026)	(0.063)	(0.028)
Hoes*Shannon index	0.025	-0.319	0.050	-0.445	0.030
	(0.023)	(0.280)	(0.084)	(0.395)	(0.029)
Ploughs*Shannon index	-0.003	0.012	-0.090	0.080	0.162*
	(0.021)	(0.030)	(0.063)	(0.269)	(0.089)
Constant	6.996***	6.308***	6.417***	6.089***	5.732***
	(0.185)	(0.397)	(0.219)	(0.391)	(0.492)
Elasticity of Shannon index	-0.041	-0.234	0.029	-0.291*	-0.046
p-value	0.485	0.166	0.820	0.075	0.925
Household fixed effects					
Village-year fixed effects	✓	✓	✓	✓	✓
Dummies	✓	✓	✓	✓	✓
Linear variables	✓	✓	✓	✓	✓
Squares	✓	✓	✓	✓	✓
Interactions	✓	✓	✓	✓	✓
Number of households	893	211	344	128	210
Number of observations	3005	779	1323	496	407
R-squared a	0.789	0.751	0.668	0.447	0.62

Notes: N. Highlands refers to Northern Highlands. C. Highlands refers to Central highlands. The specification in the regression is a translog specification and the full list of coefficients can be seen in Table 3A.21

Table 3A.14: Parametric translog full (Battese transformation)

	All	N. Highlands	C. Highlands	Other	Enset
Fertilizer dummy	-0.229***	-0.469**	-0.225**	-0.133	-0.303**
	(0.056)	(0.190)	(0.102)	(0.111)	(0.120)
Oxen dummy	-0.070***	-0.099**	-0.088**	-0.151***	-0.066
	(0.022)	(0.046)	(0.038)	(0.045)	(0.059)
Hoe dummy	-0.017	0.031	-0.014	-0.103**	0.054
	(0.021)	(0.041)	(0.037)	(0.042)	(0.060)
Plough dummy	-0.085***	0.002	-0.109**	-0.073	-0.099*
	(0.024)	(0.049)	(0.042)	(0.050)	(0.054)
Shannon index dummy	-0.174***	-0.132**	-0.110***	-0.139**	-0.224**
	(0.026)	(0.053)	(0.042)	(0.066)	(0.091)
Area	0.641***	0.562***	0.633***	0.618***	0.543***
	(0.036)	(0.074)	(0.068)	(0.099)	(0.104)
Household size	-0.070	0.120	-0.217**	0.177	-0.348*
	(0.060)	(0.121)	(0.103)	(0.143)	(0.200)
Oxen	0.411***	0.610*	0.279*	0.288	1.601***
	(0.106)	(0.325)	(0.160)	(0.208)	(0.567)
Fertilizer	-0.138***	-0.339**	-0.136**	-0.048	-0.285***
	(0.035)	(0.169)	(0.057)	(0.066)	(0.099)
Hoes	0.006	-0.430**	0.250**	-0.049	0.085
	(0.081)	(0.217)	(0.124)	(0.161)	(0.270)
Ploughs	-0.009	0.107	-0.030	0.050	-0.032
	(0.062)	(0.132)	(0.093)	(0.127)	(0.349)
Shannon index	0.090**	-0.073	0.103	0.154	0.141
	(0.043)	(0.148)	(0.133)	(0.179)	(0.131)
Area (square)	-0.002	-0.005	-0.072***	0.023	0.012
	(0.007)	(0.018)	(0.015)	(0.022)	(0.017)
Household size (square)	0.044**	0.009	0.057*	-0.059	0.135**
	(0.020)	(0.043)	(0.035)	(0.047)	(0.060)
Oxen (square)	-0.015	-0.319	-0.059	0.130	0.046
	(0.055)	(0.254)	(0.082)	(0.098)	(0.241)
Fertilizer (square)	0.035***	0.040	0.031***	0.023***	0.049***
	(0.005)	(0.034)	(0.008)	(0.009)	(0.015)
Hoes (square)	0.016	-0.006	0.014	0.065	-0.156
	(0.028)	(0.075)	(0.038)	(0.062)	(0.112)
Ploughs (square)	0.000	0.012	0.017	0.028	-0.054
	(0.018)	(0.043)	(0.026)	(0.035)	(0.099)
Shannon index (square)	0.004*	-0.003	0.002	-0.012	0.006
	(0.002)	(0.007)	(0.005)	(0.009)	(0.008)
Area*Household size	-0.033*	0.006	0.031	-0.042	0.019
	(0.018)	(0.039)	(0.035)	(0.050)	(0.049)
Area*Oxen	0.041	-0.043	0.036	0.258***	-0.124
	(0.032)	(0.072)	(0.055)	(0.071)	(0.124)
Area*Fertilizer	-0.008	-0.005	-0.021**	-0.023*	-0.036**
	(0.006)	(0.025)	(0.010)	(0.012)	(0.016)
Area*Hoes	0.024	-0.125**	0.105**	-0.084*	0.027
	(0.023)	(0.063)	(0.045)	(0.048)	(0.054)
Area*Ploughs	0.009	0.048	-0.061*	-0.042	-0.010
	(0.018)	(0.037)	(0.031)	(0.045)	(0.067)
Area*Shannon index	0.016**	0.059	-0.001	0.172***	0.011
	(0.007)	(0.071)	(0.054)	(0.065)	(0.011)
Household size*Oxen	-0.073	-0.073	0.042	-0.140	-0.738**
	(0.053)	(0.135)	(0.082)	(0.096)	(0.289)
Household size*Fertilizer	-0.006	0.045	0.011	0.001	0.010
	(0.008)	(0.039)	(0.014)	(0.018)	(0.029)
Household size*Hoes	0.046	0.261**	-0.016	0.041	0.071
	(0.037)	(0.117)	(0.060)	(0.071)	(0.114)
Household size*Ploughs	0.021	-0.047	-0.004	0.107*	0.066
	(0.029)	(0.062)	(0.046)	(0.062)	(0.132)
Household size*Shannon index	0.011	0.070	-0.063	-0.041	0.002
	(0.016)	(0.076)	(0.073)	(0.095)	(0.028)
Oxen*Fertilizer	-0.026**	-0.043	-0.029	-0.026	0.025
	(0.012)	(0.050)	(0.020)	(0.026)	(0.055)
Oxen*Hoes	-0.055	0.046	-0.072	0.011	-0.048
	(0.044)	(0.150)	(0.067)	(0.082)	(0.178)
Oxen*Ploughs	0.006	-0.060	0.086*	-0.132*	-0.088
	(0.034)	(0.094)	(0.049)	(0.068)	(0.206)
Oxen*Shannon index	-0.029	0.116	0.019	-0.116*	-0.153
	(0.031)	(0.105)	(0.087)	(0.062)	(0.482)
Fertilizer*Hoes	0.005	0.021	-0.010	0.003	0.032
	(0.010)	(0.049)	(0.015)	(0.022)	(0.033)
Fertilizer*Ploughs	0.004	-0.029	0.008	-0.027	-0.034
	(0.007)	(0.028)	(0.011)	(0.017)	(0.038)
Fertilizer*Shannon index	-0.001	-0.015	0.019	0.041	0.004
	(0.006)	(0.052)	(0.019)	(0.026)	(0.012)
Hoes*Ploughs	-0.038*	-0.008	-0.078**	0.000	0.09
	(0.022)	(0.056)	(0.032)	(0.049)	(0.094)
Hoes*Shannon index	0.010	0.071	-0.004	-0.284***	0.027
	(0.020)	(0.068)	(0.062)	(0.110)	(0.028)
Ploughs*Shannon index	-0.015	0.004	-0.061	-0.142*	0.012
	(0.014)	(0.026)	(0.045)	(0.084)	(0.029)
Constant	6.985***	5.848***	6.338***	5.646***	5.873***
	(0.153)	(0.227)	(0.150)	(0.189)	(0.269)
Elasticity of Shannon index	0.094***	0.025	0.034	0.093	0.133
p-value	0.002	0.759	0.461	0.12	0.301
Fixed effects					
Village-year fixed effects	✓	✓	✓	✓	✓
Number of households	1280	289	428	299	264
Number of observations	5804	1323	2002	1456	1023
R-squared a	0.787	0.752	0.687	0.624	0.55

Notes: N. Highlands refers to Northern Highlands. C. Highlands refers to Central highlands.

Table 3A.15: Parametric translog teff only (Battese transformation)

	All	N. Highlands	C. Highlands	Other	Enset
Fertilizer dummy	-0.095	-0.338	-0.175	-0.118	-0.012
	(0.079)	(0.248)	(0.140)	(0.137)	(0.186)
Oxen dummy	-0.070**	-0.101	-0.119*	-0.035	-0.047
	(0.032)	(0.082)	(0.065)	(0.054)	(0.070)
Hoe dummy	-0.018	-0.020	-0.044	-0.086*	0.110
	(0.030)	(0.071)	(0.057)	(0.047)	(0.079)
Plough dummy	-0.101***	0.061	-0.113	-0.056	-0.138**
	(0.035)	(0.088)	(0.073)	(0.064)	(0.067)
Shannon index dummy	-0.351***	-0.273**	-0.087	-0.294***	-0.502***
	(0.044)	(0.112)	(0.084)	(0.094)	(0.111)
Area	0.652***	0.635***	0.692***	0.694***	0.423**
	(0.054)	(0.134)	(0.124)	(0.156)	(0.171)
Household size	0.004	-0.008	0.026	0.375**	-0.369
	(0.090)	(0.220)	(0.170)	(0.177)	(0.334)
Oxen	0.270*	0.220	-0.148	0.048	1.521*
	(0.142)	(0.430)	(0.306)	(0.201)	(0.908)
Fertilizer	-0.024	0.073	-0.072	-0.010	-0.160
	(0.047)	(0.280)	(0.080)	(0.073)	(0.145)
Hoes	-0.116	-0.505*	-0.097	0.050	0.329
	(0.101)	(0.290)	(0.194)	(0.159)	(0.373)
Ploughs	0.006	0.185	0.050	-0.066	-0.274
	(0.081)	(0.201)	(0.148)	(0.124)	(0.414)
Shannon index	0.095	0.265	-0.171	0.465**	0.088
	(0.070)	(0.307)	(0.193)	(0.232)	(0.173)
Area (square)	0.027**	0.008	-0.075**	-0.098**	0.056*
	(0.011)	(0.032)	(0.038)	(0.039)	(0.030)
Household size (square)	0.029	0.057	-0.040	-0.137**	0.184**
	(0.030)	(0.086)	(0.060)	(0.061)	(0.085)
Oxen (square)	-0.027	-0.573*	0.129	0.065	-0.246
	(0.070)	(0.314)	(0.191)	(0.089)	(0.380)
Fertilizer (square)	0.022***	-0.031	0.021*	0.011	0.037*
	(0.007)	(0.058)	(0.012)	(0.010)	(0.020)
Hoes (square)	0.013	-0.031	0.056	0.041	-0.224
	(0.035)	(0.096)	(0.055)	(0.058)	(0.153)
Ploughs (square)	0.001	0.021	0.004	-0.015	0.013
	(0.024)	(0.057)	(0.043)	(0.034)	(0.122)
Shannon index (square)	0.008**	0.094***	-0.011	0.011	-0.001
	(0.004)	(0.027)	(0.009)	(0.120)	(0.011)
Area*Household size	-0.067**	-0.087	-0.047	0.093	0.098
	(0.027)	(0.086)	(0.070)	(0.088)	(0.075)
Area*Oxen	0.094**	-0.043	0.064	0.261***	-0.092
	(0.048)	(0.111)	(0.118)	(0.074)	(0.235)
Area*Fertilizer	-0.002	-0.048	-0.003	-0.049***	-0.016
	(0.008)	(0.039)	(0.020)	(0.018)	(0.024)
Area*Hoes	0.038	-0.107	0.085	0.008	0.210**
	(0.031)	(0.108)	(0.077)	(0.065)	(0.082)
Area*Ploughs	0.012	0.063	-0.057	0.012	-0.077
	(0.024)	(0.067)	(0.055)	(0.058)	(0.077)
Area*Shannon index	0.012	-0.158	-0.229**	0.114	0.253**
	(0.026)	(0.121)	(0.116)	(0.105)	(0.127)
Household size*Oxen	0.000	0.225	0.251*	-0.080	-0.629
	(0.070)	(0.211)	(0.149)	(0.092)	(0.493)
Household size*Fertilizer	-0.025**	-0.085	0.017	-0.002	-0.002
	(0.012)	(0.084)	(0.021)	(0.020)	(0.043)
Household size*Hoes	0.090*	0.304*	0.109	-0.024	0.135
	(0.048)	(0.171)	(0.099)	(0.072)	(0.152)
Household size*Ploughs	-0.005	-0.126	-0.063	0.074	0.043
	(0.039)	(0.110)	(0.074)	(0.065)	(0.152)
Household size*Shannon index	0.055	0.018	0.101	-0.002	0.239**
	(0.034)	(0.206)	(0.114)	(0.119)	(0.102)
Oxen*Fertilizer	-0.025	0.183**	-0.065**	0.012	0.03
	(0.016)	(0.090)	(0.030)	(0.024)	(0.094)
Oxen*Hoes	-0.066	-0.105	-0.201*	-0.054	-0.083
	(0.055)	(0.196)	(0.106)	(0.078)	(0.310)
Oxen*Ploughs	0.048	0.078	0.159*	-0.038	0.135
	(0.044)	(0.125)	(0.082)	(0.063)	(0.286)
Oxen*Shannon index	0.003	-0.072	0.169	0.018	-1.024
	(0.082)	(0.244)	(0.168)	(0.131)	(0.677)
Fertilizer*Hoes	0.007	0.118	-0.003	0.004	0.013
	(0.012)	(0.076)	(0.021)	(0.023)	(0.048)
Fertilizer*Ploughs	-0.003	-0.133*	-0.001	0.003	-0.028
	(0.009)	(0.072)	(0.016)	(0.018)	(0.048)
Fertilizer*Shannon index	0.000	-0.055	0.010	-0.046	-0.027
	(0.013)	(0.091)	(0.030)	(0.029)	(0.043)
Hoes*Ploughs	-0.019	0.054	-0.081*	0.006	0.143
	(0.028)	(0.071)	(0.047)	(0.048)	(0.112)
Hoes*Shannon index	0.006	0.074	0.021	-0.277**	0.404
	(0.050)	(0.083)	(0.110)	(0.115)	(0.248)
Ploughs*Shannon index	-0.036	0.135	-0.057	-0.107	-0.147*
	(0.024)	(0.091)	(0.081)	(0.089)	(0.075)
Constant	5.925***	5.867***	6.526***	5.187***	5.355***
	(0.575)	(0.314)	(0.277)	(0.226)	(0.457)
Elasticity of Shannon index	0.176***	0.321***	0.002	0.236***	0.207
p-value	0.000	0.001	0.979	0.001	0.213
Fixed effects					
Village-year fixed effects	✓	✓	✓	✓	✓
Number of households	782	152	217	211	202
Number of observations	2799	544	679	960	616
R-squared a	0.783	0.517	0.73	0.699	0.521

Notes: N. Highlands refers to Northern Highlands. C. Highlands refers to Central highlands.

Table 3A.16: Parametric translog noteff (Battese transformation)

	All	N. Highlands	C. Highlands	Other	Enset
Fertilizer dummy	-0.275***	-1.032***	-0.246*	-0.054	-0.506***
	(0.082)	(0.341)	(0.145)	(0.190)	(0.167)
Oxen dummy	-0.073**	-0.055	-0.082*	-0.212***	-0.090
	(0.031)	(0.057)	(0.048)	(0.076)	(0.114)
Hoe dummy	-0.025	0.087*	-0.026	-0.148*	-0.100
	(0.030)	(0.050)	(0.049)	(0.085)	(0.092)
Plough dummy	-0.083**	-0.055	-0.112**	-0.117	0.031
	(0.032)	(0.059)	(0.053)	(0.084)	(0.091)
Shannon index dummy	-0.097**	-0.014	-0.132*	0.027	-0.098
	(0.041)	(0.082)	(0.070)	(0.117)	(0.338)
Area	0.611***	0.653***	0.622***	0.505**	0.570***
	(0.053)	(0.161)	(0.089)	(0.205)	(0.145)
Household size	-0.169**	0.081	-0.311**	-0.009	-0.187
	(0.083)	(0.165)	(0.133)	(0.290)	(0.292)
Oxen	0.561***	0.725	0.433**	0.409	1.208
	(0.163)	(0.658)	(0.200)	(1.031)	(0.830)
Fertilizer	-0.191***	-0.650**	-0.169**	-0.145	-0.198
	(0.052)	(0.277)	(0.080)	(0.144)	(0.184)
Hoes	0.216	0.126	0.417**	-0.324	0.793*
	(0.136)	(0.517)	(0.167)	(0.539)	(0.440)
Ploughs	-0.004	0.128	-0.102	0.531	0.777
	(0.096)	(0.212)	(0.122)	(0.375)	(1.027)
Shannon index	-0.023	-0.191	0.110	-0.848*	0.090
	(0.078)	(0.308)	(0.247)	(0.467)	(0.490)
Area (square)	-0.025**	0.014	-0.066***	0.034	-0.008
	(0.011)	(0.042)	(0.018)	(0.050)	(0.025)
Household size (square)	0.070**	0.004	0.104**	0.021	0.107
	(0.028)	(0.051)	(0.043)	(0.099)	(0.097)
Oxen (square)	0.002	-0.220	-0.128	1.432	-0.312
	(0.089)	(0.564)	(0.096)	(1.115)	(0.505)
Fertilizer (square)	0.038***	0.086*	0.036***	0.042**	0.039
	(0.008)	(0.051)	(0.011)	(0.020)	(0.032)
Hoes (square)	0.026	0.021	0.018	0.169	-0.165
	(0.048)	(0.144)	(0.057)	(0.222)	(0.173)
Ploughs (square)	-0.006	0.024	0.020	0.099	-0.305
	(0.028)	(0.073)	(0.033)	(0.123)	(0.256)
Shannon index (square)	-0.008*	-0.014	-0.033	-0.028*	-0.002
	(0.004)	(0.011)	(0.069)	(0.017)	(0.028)
Area*Household size	-0.023	-0.015	0.055	0.015	0.002
	(0.026)	(0.062)	(0.044)	(0.097)	(0.072)
Area*Oxen	-0.015	-0.225	-0.012	0.056	-0.108
	(0.048)	(0.168)	(0.066)	(0.319)	(0.174)
Area*Fertilizer	-0.006	0.053	-0.028**	-0.061**	-0.035
	(0.009)	(0.047)	(0.013)	(0.026)	(0.029)
Area*Hoes	0.076**	0.092	0.192***	-0.020	0.012
	(0.037)	(0.139)	(0.061)	(0.132)	(0.082)
Area*Ploughs	0.020	0.052	-0.062	0.129	-0.153
	(0.029)	(0.067)	(0.040)	(0.120)	(0.199)
Area*Shannon index	0.030***	0.043	0.053	-0.067	0.021*
	(0.009)	(0.113)	(0.066)	(0.153)	(0.013)
Household size*Oxen	-0.182**	-0.214	-0.035	-0.531	-0.219
	(0.082)	(0.199)	(0.100)	(0.589)	(0.453)
Household size*Fertilizer	0.016	0.080*	0.006	0.027	-0.016
	(0.013)	(0.048)	(0.019)	(0.046)	(0.067)
Household size*Hoes	-0.022	0.092	-0.030	0.050	-0.314
	(0.061)	(0.219)	(0.077)	(0.260)	(0.196)
Household size*Ploughs	0.046	-0.028	0.009	0.007	-0.231
	(0.043)	(0.080)	(0.061)	(0.206)	(0.445)
Household size*Shannon index	-0.024	0.005	-0.047	0.170	-0.038
	(0.021)	(0.127)	(0.104)	(0.238)	(0.042)
Oxen*Fertilizer	-0.014	-0.155**	-0.011	-0.069	-0.147
	(0.019)	(0.068)	(0.028)	(0.123)	(0.126)
Oxen*Hoes	-0.066	-0.183	-0.033	0.164	-0.237
	(0.073)	(0.394)	(0.089)	(0.450)	(0.279)
Oxen*Ploughs	-0.041	-0.286	0.024	-1.064*	-0.813*
	(0.056)	(0.202)	(0.066)	(0.608)	(0.478)
Oxen*Shannon index	-0.062	0.057	-0.073	-0.210**	-0.356
	(0.039)	(0.188)	(0.111)	(0.094)	(1.538)
Fertilizer*Hoes	-0.004	-0.042	-0.041*	0.014	0.102
	(0.017)	(0.088)	(0.023)	(0.064)	(0.068)
Fertilizer*Ploughs	0.009	-0.041	0.025	-0.077*	0.052
	(0.012)	(0.034)	(0.017)	(0.044)	(0.090)
Fertilizer*Shannon index	0.021*	0.023	0.012	0.138**	-0.031
	(0.012)	(0.070)	(0.026)	(0.063)	(0.028)
Hoes*Ploughs	-0.05	-0.140	-0.055	-0.174	0.341
	(0.036)	(0.118)	(0.045)	(0.147)	(0.314)
Hoes*Shannon index	0.025	-0.319	0.050	-0.445	0.030
	(0.023)	(0.280)	(0.084)	(0.395)	(0.029)
Ploughs*Shannon index	-0.003	0.012	-0.090	0.080	0.162*
	(0.021)	(0.030)	(0.063)	(0.269)	(0.089)
Constant	6.996***	6.308***	6.417***	6.089***	5.732***
	(0.185)	(0.397)	(0.219)	(0.391)	(0.492)
Elasticity of Shannon index	-0.041	-0.234	0.029	-0.291*	-0.046
p-value	0.485	0.166	0.82	0.075	0.925
Fixed effects					
Village-year fixed effects	✓	✓	✓	✓	✓
Number of households	893	211	344	128	210
Number of observations	3005	779	1323	496	407
R-squared a	0.789	0.751	0.668	0.447	0.62

Notes: N. Highlands refers to Northern Highlands. C. Highlands refers to Central highlands.

A.2 No imputed data

Table 3A.17: Summary Statistics

	All		**N. Highlands**		**C. Highlands**		**Other**		**Enset**	
	Mean	**S.D.**	**Mean**	**S.D.**	**Mean**	**S.D.**	**Mean**	**S.D.**	**Mean**	**S.D.**
Cereal Production (kgs)	867.93	1034.91	393.47	446.98	1125.83	972.21	1271.63	1344.75	244.42	379.56
Cereal Yield (kg/ha)	907.23	1415.54	602.71	945.14	1040.78	1761.87	988.61	989.41	843.05	1541.48
Cereal area (ha)	1.26	1.13	1.00	1.05	1.46	1.02	1.67	1.27	0.52	0.67
Shannon index	0.52	0.42	0.51	0.44	0.51	0.34	0.79	0.36	0.14	0.27
Number of oxen	0.92	1.13	0.69	0.87	1.25	1.14	0.98	1.30	0.39	0.80
Household Size	6.12	2.71	5.27	2.36	5.93	2.65	6.34	2.59	7.11	3.02
Quantity Ferilizer used in cereals (kgs)	49.37	81.65	2.53	10.11	71.21	80.15	76.88	109.81	14.04	19.47
Tigray	0.08	0.28	0.44	0.50	0.00	0.00	0.00	0.00	0.00	0.00
Amhara	0.39	0.49	0.56	0.50	0.77	0.42	0.00	0.00	0.00	0.00
Oromia	0.35	0.48	0.00	0.00	0.23	0.42	1.00	0.00	0.00	0.00
SSN	0.18	0.38	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00
Northern Highlands	0.19	0.39	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Central Highlands	0.36	0.48	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
Other	0.27	0.44	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00
Enset	0.18	0.38	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00
Number of observations	5107		987		1848		1371		901	

Table 3A.18: Parametric translog full (No imputed data)

	All	N. Highlands	C. Highlands	Other	Enset
Area	0.587***	0.573**	0.464***	0.317**	0.423*
	(0.078)	(0.250)	(0.117)	(0.144)	(0.219)
Household size	0.001	0.28	-0.379**	0.230	0.387
	(0.149)	(0.525)	(0.192)	(0.280)	(0.434)
Oxen	0.130***	0.079	0.138***	0.160***	0.303**
	(0.033)	(0.103)	(0.047)	(0.057)	(0.144)
Fertilizer	0.020*	-0.159***	0.037***	0.011	0.045
	(0.011)	(0.058)	(0.013)	(0.020)	(0.040)
Shannon index	0.070*	0.133	0.028	0.170*	-0.013
	(0.040)	(0.100)	(0.050)	(0.093)	(0.077)
Area (square)	0.010	-0.039	-0.010	-0.001	-0.014
	(0.017)	(0.051)	(0.031)	(0.038)	(0.033)
Household size (square)	0.031	0.014	0.162***	-0.110	-0.170
	(0.045)	(0.149)	(0.060)	(0.088)	(0.105)
Oxen (square)	0.009***	0.008	0.010***	0.009**	0.021**
	(0.002)	(0.007)	(0.003)	(0.004)	(0.010)
Fertilizer (square)	0.001	-0.013***	0.002*	0.001	0.002
	(0.001)	(0.005)	(0.001)	(0.002)	(0.003)
Shannon index (square)	0.004	0.009	0.001	0.01	-0.004
	(0.003)	(0.007)	(0.003)	(0.006)	(0.005)
Area*Household size	-0.088**	-0.168	0.023	0.061	-0.106
	(0.039)	(0.112)	(0.068)	(0.072)	(0.082)
Area*Oxen	0.001	-0.002	-0.006	0.004	0.005
	(0.003)	(0.007)	(0.004)	(0.005)	(0.007)
Area*Fertilizer	0.004*	0.000	-0.003	-0.002	0.006
	(0.002)	(0.011)	(0.004)	(0.004)	(0.006)
Area*Shannon index	0.001	0.012	-0.003	0.022**	-0.004
	(0.003)	(0.010)	(0.006)	(0.010)	(0.007)
Household size*Oxen	-0.001	0.011	0.005	-0.017**	-0.006
	(0.004)	(0.014)	(0.005)	(0.007)	(0.011)
Household size*Fertilizer	-0.003	0.005	-0.005	0.004	-0.009
	(0.003)	(0.019)	(0.005)	(0.006)	(0.010)
Household size*Shannon index	0.004	0.021*	-0.002	-0.007	-0.011
	(0.005)	(0.012)	(0.007)	(0.011)	(0.013)
Oxen*Fertilizer	0.000	-0.002**	0.000	0.000	0.000
	(0.000)	(0.001)	(0.000)	(0.000)	(0.001)
Oxen*Shannon index	0.000	0.001	-0.001	-0.002*	0.000
	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)
Fertilizer*Shannon index	0.000	0.000	0.000	0.000	-0.001
	(0.000)	(0.001)	(0.000)	(0.001)	(0.001)
Constant	6.360***	5.069***	6.455***	6.032***	5.357***
	(0.148)	(0.632)	(0.182)	(0.271)	(0.523)
Elasticity of Shannon index	0.067**	0.058**	0.025	0.166**	-0.010
p-value	0.039	0.02	0.571	0.046	0.83
Fixed effects	✓	✓	✓	✓	✓
Village-year fixed effects	✓	✓	✓	✓	✓
Number of households	1243	276	417	298	252
Number of observations	5107	987	1848	1371	901
Average obs. per household	4.109	3.576	4.432	4.601	3.575
R-squared a	0.401	0.291	0.459	0.471	0.366
R-squared w	0.413	0.316	0.474	0.484	0.391

Notes: N. Highlands refers to Northern Highlands. C. Highlands refers to Central highlands. Numbers in parentheses represent clustered standard errors at the household level. As explained in the methodology section, this specification does not include the adjustment proposed by Battese (1997) since there is little within-household variation of input-use. Instead 0 values are assigned the value of 0.000001.

Table 3A.19: Parametric translog teff only (No imputed data)

	All	N. Highlands	C. Highlands	Other	Enset
Area	0.493***	0.398	0.523**	0.547**	0.443
	(0.110)	(0.319)	(0.254)	(0.213)	(0.298)
Household size	-0.047	0.093	-0.599	0.190	-0.323
	(0.203)	(0.596)	(0.412)	(0.349)	(0.508)
Oxen	0.158***	0.055	-0.001	0.187***	0.535***
	(0.042)	(0.123)	(0.085)	(0.059)	(0.153)
Fertilizer	0.023	-0.119	0.059**	0.010	-0.008
	(0.016)	(0.082)	(0.026)	(0.023)	(0.052)
Shannon index	0.230***	0.176	0.088	0.371***	0.066
	(0.060)	(0.127)	(0.074)	(0.109)	(0.117)
Area (square)	0.030	-0.001	0.003	-0.116*	0.054
	(0.029)	(0.096)	(0.070)	(0.062)	(0.053)
Household size (square)	0.009	0.147	0.201	-0.125	-0.037
	(0.062)	(0.162)	(0.123)	(0.115)	(0.123)
Oxen (square)	0.009***	0.001	0.001	0.010***	0.036***
	(0.003)	(0.008)	(0.006)	(0.004)	(0.011)
Fertilizer (square)	0.001	-0.006	0.003	0.001	-0.001
	(0.001)	(0.006)	(0.002)	(0.002)	(0.003)
Shannon index (square)	0.014***	0.018**	0.004	0.023***	-0.001
	(0.004)	(0.009)	(0.005)	(0.007)	(0.008)
Area*Household size	-0.074	-0.178	-0.008	0.085	-0.11
	(0.053)	(0.137)	(0.137)	(0.127)	(0.095)
Area*Oxen	0.000	0.004	-0.014	0.015*	-0.008
	(0.004)	(0.009)	(0.011)	(0.008)	(0.010)
Area*Fertilizer	0.001	-0.014	-0.002	-0.010	-0.003
	(0.003)	(0.017)	(0.008)	(0.007)	(0.010)
Area*Shannon index	-0.005	0.000	-0.004	0.018	-0.014
	(0.006)	(0.015)	(0.013)	(0.016)	(0.010)
Household size*Oxen	-0.012**	-0.017	0.009	-0.030***	-0.015
	(0.005)	(0.013)	(0.013)	(0.010)	(0.012)
Household size*Fertilizer	-0.005	0.03	-0.011	0.005	-0.005
	(0.005)	(0.024)	(0.011)	(0.010)	(0.013)
Household size*Shannon index	-0.002	0.063***	-0.017	-0.015	-0.024
	(0.007)	(0.023)	(0.013)	(0.014)	(0.016)
Oxen*Fertilizer	0.000	0.000	0.000	0.001	0.001
	(0.000)	(0.002)	(0.001)	(0.000)	(0.001)
Oxen*Shannon index	0.000	-0.003*	0.000	0.001	0.002**
	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)
Fertilizer*Shannon index	-0.001	0.000	0.001	-0.002**	-0.001
	(0.001)	(0.003)	(0.001)	(0.001)	(0.001)
Constant	6.640***	5.193***	7.075***	5.900***	6.203***
	(0.199)	(0.730)	(0.378)	(0.312)	(0.687)
Elasticity of Shannon index	0.205***	0.284**	0.052	0.341***	0.022
p-value	0.000	0.014	0.403	0.001	0.766
Fixed effects	✓	✓	✓	✓	✓
Village-year fixed effects	✓	✓	✓	✓	✓
Number of households	763	143	214	210	196
Number of observations	2635	509	615	933	578
Average obs. per household	3.453	3.559	2.874	4.443	2.949
R-squared a	0.458	0.233	0.501	0.579	0.434
R-squared w	0.472	0.276	0.529	0.592	0.468

Notes: N. Highlands refers to Northern Highlands. C. Highlands refers to Central highlands. Numbers in parentheses represent clustered standard errors at the household level. As explained in the methodology section, this specification does not include the adjustment proposed by Battese (1997) since there is little within-household variation of input-use. Instead 0 values are assigned the value of 0.000001.

Table 3A.20: Parametric translog no teff (No imputed data)

	All	N. Highlands	C. Highlands	Other	Enset
Area	0.546***	1.623**	0.443***	0.342	-0.911
	(0.117)	(0.625)	(0.138)	(0.279)	(0.634)
Household size	-0.198	0.207	-0.528**	-0.219	0.390
	(0.277)	(1.145)	(0.226)	(0.523)	(1.182)
Oxen	0.114**	0.259	0.168***	-0.187	0.030
	(0.057)	(0.211)	(0.060)	(0.229)	(0.361)
Fertilizer	0.023	-0.194**	0.047***	0.018	-0.025
	(0.016)	(0.096)	(0.018)	(0.036)	(0.095)
Shannon index	-0.040	-0.048	0.069	-0.090	0.067
	(0.072)	(0.242)	(0.086)	(0.142)	(0.148)
Area (square)	0.008	0.047	-0.015	-0.012	-0.104*
	(0.023)	(0.109)	(0.038)	(0.076)	(0.060)
Household size (square)	0.106	-0.067	0.208***	0.074	-0.295
	(0.080)	(0.305)	(0.070)	(0.139)	(0.262)
Oxen (square)	0.009**	0.026	0.013***	-0.012	-0.001
	(0.004)	(0.017)	(0.004)	(0.017)	(0.025)
Fertilizer (square)	0.001	-0.022**	0.003*	0.000	0.001
	(0.001)	(0.009)	(0.002)	(0.003)	(0.006)
Shannon index (square)	-0.003	0.000	0.004	-0.008	-0.001
	(0.005)	(0.016)	(0.006)	(0.010)	(0.010)
Area*Household size	-0.029	-0.451	0.047	0.005	0.369**
	(0.063)	(0.284)	(0.084)	(0.131)	(0.150)
Area*Oxen	-0.001	0.002	-0.008	-0.003	0.007
	(0.004)	(0.016)	(0.005)	(0.011)	(0.008)
Area*Fertilizer	0.009***	0.035*	-0.003	0.007	0.018*
	(0.003)	(0.020)	(0.005)	(0.009)	(0.010)
Area*Shannon index	-0.002	0.008	-0.004	0.008	-0.033
	(0.005)	(0.017)	(0.007)	(0.015)	(0.033)
Household size*Oxen	0.008	0.034	0.007	0.019	-0.046**
	(0.008)	(0.029)	(0.007)	(0.018)	(0.021)
Household size*Fertilizer	-0.003	-0.020	-0.005	0.001	0.032
	(0.005)	(0.028)	(0.006)	(0.009)	(0.022)
Household size*Shannon index	0.000	0.037*	-0.007	-0.01	-0.061*
	(0.007)	(0.021)	(0.008)	(0.021)	(0.034)
Oxen*Fertilizer	-0.001	-0.004***	0.000	0.000	-0.002
	(0.000)	(0.001)	(0.000)	(0.001)	(0.001)
Oxen*Shannon index	0.000	0.000	-0.001	-0.001	-0.003*
	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)
Fertilizer*Shannon index	0.000	-0.001	0.000	0.001	-0.001
	(0.000)	(0.001)	(0.001)	(0.001)	(0.003)
Constant	6.338***	5.391***	6.308***	6.507***	5.893***
	(0.263)	(1.532)	(0.217)	(0.692)	(1.312)
Elasticity of Shannon index	-0.025	0.008	0.052	-0.093	0.043
p-value	0.648	0.960	0.483	0.470	0.604
Fixed effects	✓	✓	✓	✓	✓
Village-year fixed effects	✓	✓	✓	✓	✓
Number of households	838	197	323	125	193
Number of observations	2472	478	1233	438	323
Average obs. per household	2.95	2.426	3.817	3.504	1.674
R-squared a	0.383	0.35	0.464	0.217	0.525
R-squared w	0.404	0.398	0.483	0.267	0.575

Notes: N. Highlands refers to Northern Highlands. C. Highlands refers to Central highlands. Numbers in parentheses represent clustered standard errors at the household level. As explained in the methodology section, this specification does not include the adjustment proposed by Battese (1997) since there is little within-household variation of input-use. Instead 0 values are assigned the value of 0.000001.

Table 3A.21: Parametric translog full (Battese transformation, no imputed data)

	All	N. Highlands	C. Highlands	Other	Enset
Fertilizer dummy	-0.104	-0.506**	-0.073	-0.325**	-0.022
	(0.071)	(0.251)	(0.121)	(0.155)	(0.126)
Oxen dummy	-0.154***	-0.168**	-0.162***	-0.302***	-0.124*
	(0.030)	(0.079)	(0.046)	(0.060)	(0.069)
Shannon index dummy	-0.249***	-0.346***	-0.135***	-0.227**	-0.211*
	(0.035)	(0.089)	(0.050)	(0.091)	(0.117)
Area	0.569***	0.505***	0.741***	0.420***	0.197
	(0.048)	(0.116)	(0.087)	(0.130)	(0.134)
Household size	-0.085	0.233	-0.336**	-0.035	-0.369
	(0.084)	(0.211)	(0.131)	(0.186)	(0.264)
Oxen	0.353***	0.574	0.195	0.323	2.406***
	(0.135)	(0.501)	(0.188)	(0.252)	(0.822)
Fertilizer	-0.055	-0.243	-0.020	-0.098	-0.167
	(0.045)	(0.235)	(0.068)	(0.089)	(0.126)
Shannon index	0.118**	0.249	0.165	0.183	0.011
	(0.060)	(0.227)	(0.164)	(0.225)	(0.200)
Area (square)	0.013	-0.026	0.01	0.033	-0.034
	(0.010)	(0.028)	(0.019)	(0.029)	(0.022)
Household size (square)	0.080***	0.001	0.108**	0.065	0.160**
	(0.028)	(0.075)	(0.043)	(0.060)	(0.075)
Oxen (square)	0.083	-0.164	0.039	0.130	0.131
	(0.068)	(0.388)	(0.094)	(0.118)	(0.271)
Fertilizer (square)	0.029***	0.005	0.019**	0.031***	0.049**
	(0.007)	(0.052)	(0.010)	(0.012)	(0.020)
Shannon index (square)	0.007***	0.016	0.002	-0.001	0.004
	(0.003)	(0.011)	(0.006)	(0.011)	(0.011)
Area*Household size	-0.048**	-0.095	0.033	-0.067	0.012
	(0.025)	(0.064)	(0.044)	(0.065)	(0.063)
Area*Oxen	0.023	-0.090	-0.138**	0.321***	0.051
	(0.041)	(0.108)	(0.063)	(0.090)	(0.151)
Area*Fertilizer	-0.005	-0.026	-0.048***	-0.012	-0.013
	(0.008)	(0.039)	(0.014)	(0.017)	(0.024)
Area*Shannon index	0.021**	0.049	0.044	0.09	0.024*
	(0.010)	(0.124)	(0.063)	(0.080)	(0.014)
Household size*Oxen	-0.078	-0.103	0.052	-0.186	-1.094**
	(0.067)	(0.220)	(0.096)	(0.114)	(0.435)
Household size*Fertilizer	-0.011	0.029	0.002	0.001	0.028
	(0.011)	(0.081)	(0.017)	(0.023)	(0.038)
Household size*Shannon index	0.031	0.024	-0.101	-0.033	0.063*
	(0.021)	(0.120)	(0.088)	(0.118)	(0.035)
Oxen*Fertilizer	-0.030*	-0.083	-0.005	-0.043	-0.028
	(0.015)	(0.084)	(0.022)	(0.032)	(0.077)
Oxen*Shannon index	-0.046	0.138	-0.021	-0.181**	-0.310
	(0.040)	(0.164)	(0.097)	(0.075)	(0.669)
Fertilizer*Shannon index	-0.006	-0.150*	0.001	0.030	0.010
	(0.008)	(0.088)	(0.022)	(0.034)	(0.018)
Constant	6.872***	5.806***	6.148***	5.723***	5.094***
	(0.190)	(0.322)	(0.181)	(0.244)	(0.331)
Elasticity of Shannon index	0.143***	0.247**	0.000	0.185**	0.101
p-value	0.000	0.020	0.992	0.020	0.577
Fixed effects					
Village-year fixed effects	✓	✓	✓	✓	✓
Number of households	1243	276	417	298	252
Number of observations	5107	987	1848	1371	901
R-squared a	0.677	0.497	0.597	0.526	0.409

Notes: N. Highlands refers to Northern Highlands. C. Highlands refers to Central highlands.

Table 3A.22: Parametric translog teff only (Battese transformation, no imputed data)

	All	N. Highlands	C. Highlands	Other	Enset
Fertilizer dummy	-0.134	-0.263	-0.234	-0.263	-0.052
	(0.094)	(0.288)	(0.176)	(0.185)	(0.170)
Oxen dummy	-0.169***	-0.254**	-0.148*	-0.139*	-0.150*
	(0.041)	(0.105)	(0.079)	(0.074)	(0.077)
Shannon index dummy	-0.467***	-0.684***	-0.087	-0.580***	-0.330**
	(0.055)	(0.147)	(0.098)	(0.130)	(0.132)
Area	0.557***	0.405**	0.619***	0.564***	0.550***
	(0.067)	(0.178)	(0.161)	(0.204)	(0.187)
Household size	-0.052	-0.109	0.008	0.153	-0.55
	(0.116)	(0.293)	(0.212)	(0.225)	(0.364)
Oxen	0.135	0.149	-0.303	0.083	0.893
	(0.171)	(0.546)	(0.345)	(0.246)	(1.246)
Fertilizer	-0.065	-0.086	-0.046	-0.091	-0.212
	(0.058)	(0.327)	(0.103)	(0.098)	(0.170)
Shannon index	0.173*	0.377	-0.404*	0.440	-0.055
	(0.089)	(0.373)	(0.219)	(0.303)	(0.409)
Area (square)	0.015	-0.039	-0.044	-0.071	0.018
	(0.014)	(0.040)	(0.046)	(0.053)	(0.032)
Household size (square)	0.065*	0.117	-0.004	-0.016	0.155
	(0.038)	(0.110)	(0.071)	(0.079)	(0.096)
Oxen (square)	0.124	-0.271	0.202	0.098	-0.061
	(0.084)	(0.405)	(0.209)	(0.109)	(0.331)
Fertilizer (square)	0.031***	-0.051	0.020	0.029**	0.042*
	(0.009)	(0.072)	(0.015)	(0.013)	(0.025)
Shannon index (square)	0.017***	0.094***	-0.014	0.051	0.005
	(0.004)	(0.031)	(0.009)	(0.159)	(0.012)
Area*Household size	-0.059*	-0.044	0.038	0.069	-0.072
	(0.035)	(0.113)	(0.088)	(0.114)	(0.082)
Area*Oxen	0.072	-0.197	-0.032	0.295***	-0.139
	(0.059)	(0.146)	(0.129)	(0.093)	(0.267)
Area*Fertilizer	-0.005	-0.084	-0.029	-0.036	-0.016
	(0.011)	(0.055)	(0.024)	(0.024)	(0.034)
Area*Shannon index	-0.023	-0.110	-0.372***	0.020	0.005
	(0.028)	(0.153)	(0.135)	(0.139)	(0.064)
Household size*Oxen	-0.003	0.111	0.288*	-0.134	-0.192
	(0.083)	(0.270)	(0.163)	(0.110)	(0.651)
Household size*Fertilizer	-0.019	0.046	-0.008	-0.014	0.054
	(0.015)	(0.126)	(0.025)	(0.026)	(0.050)
Household size*Shannon index	0.044	0.194	0.202	-0.061	0.063
	(0.044)	(0.241)	(0.125)	(0.155)	(0.096)
Oxen*Fertilizer	-0.032	0.102	-0.047	-0.002	-0.184
	(0.019)	(0.120)	(0.034)	(0.031)	(0.134)
Oxen*Shannon index	-0.151	-0.233	0.115	-0.263*	-2.241**
	(0.097)	(0.305)	(0.173)	(0.156)	(1.018)
Fertilizer*Shannon index	0.02	-0.251**	0.024	0.018	0.049
	(0.016)	(0.115)	(0.033)	(0.040)	(0.072)
Constant	6.164***	5.870***	6.193***	5.050***	5.479***
	(0.685)	(0.382)	(0.325)	(0.291)	(0.470)
Elasticity of Shannon index	0.257***	0.554***	-0.031	0.309***	0.061
p-value	0.000	0.000	0.705	0.001	0.755
Fixed effects					
Village-year fixed effects	✓	✓	✓	✓	✓
Number of households	763	143	214	210	196
Number of observations	2635	509	615	933	578
R-squared a	0.718	0.389	0.667	0.619	0.418

Notes: N. Highlands refers to Northern Highlands. C. Highlands refers to Central highlands.

Table 3A.23: Parametric translog no teff (Battese transformation, no imputed data)

	All	N. Highlands	C. Highlands	Other	Enset
Fertilizer dummy	-0.033	-0.881*	-0.032	-0.146	-0.019
	(0.110)	(0.461)	(0.161)	(0.271)	(0.208)
Oxen dummy	-0.154***	-0.047	-0.175***	-0.415***	-0.057
	(0.044)	(0.122)	(0.057)	(0.098)	(0.146)
Shannon index dummy	-0.152**	-0.291	-0.158*	0.055	-0.161
	(0.060)	(0.192)	(0.085)	(0.156)	(0.451)
Area	0.546***	1.058***	0.810***	0.337	-0.257
	(0.077)	(0.330)	(0.110)	(0.261)	(0.217)
Household size	-0.153	0.297	-0.520***	-0.432	-0.090
	(0.125)	(0.349)	(0.166)	(0.370)	(0.438)
Oxen	0.607***	1.353	0.366	0.542	3.582***
	(0.219)	(1.307)	(0.231)	(1.248)	(1.319)
Fertilizer	0.006	-0.322	-0.009	-0.053	0.115
	(0.071)	(0.437)	(0.090)	(0.197)	(0.246)
Shannon index	-0.046	0.774	0.435	-0.652	0.123
	(0.128)	(0.658)	(0.306)	(0.588)	(0.644)
Area (square)	0.004	0.104	0.029	-0.048	-0.088***
	(0.015)	(0.085)	(0.023)	(0.062)	(0.034)
Household size (square)	0.108***	-0.093	0.164***	0.188	0.162
	(0.041)	(0.109)	(0.054)	(0.121)	(0.136)
Oxen (square)	0.054	0.097	-0.026	0.655	0.823
	(0.114)	(1.051)	(0.110)	(1.040)	(0.675)
Fertilizer (square)	0.021*	0.041	0.018	0.028	0.006
	(0.011)	(0.086)	(0.013)	(0.029)	(0.045)
Shannon index (square)	-0.005	0.009	0.001	-0.022	0.01
	(0.007)	(0.027)	(0.079)	(0.019)	(0.037)
Area*Household size	-0.026	-0.257**	0.042	-0.045	0.158
	(0.038)	(0.129)	(0.055)	(0.121)	(0.105)
Area*Oxen	-0.03	0.148	-0.212***	0.010	0.168
	(0.062)	(0.340)	(0.077)	(0.343)	(0.205)
Area*Fertilizer	0.003	0.051	-0.056***	-0.005	0.01
	(0.013)	(0.104)	(0.017)	(0.036)	(0.045)
Area*Shannon index	0.031**	0.122	0.154**	-0.024	0.030*
	(0.012)	(0.335)	(0.078)	(0.180)	(0.017)
Household size*Oxen	-0.201*	-0.474	-0.04	-0.502	-2.096***
	(0.111)	(0.414)	(0.119)	(0.623)	(0.742)
Household size*Fertilizer	-0.003	0.016	0.003	0.015	-0.011
	(0.018)	(0.121)	(0.022)	(0.059)	(0.094)
Household size*Shannon index	0.014	-0.307	-0.213*	0.153	0.062
	(0.029)	(0.278)	(0.128)	(0.274)	(0.059)
Oxen*Fertilizer	-0.024	-0.225*	0.015	-0.023	0.027
	(0.026)	(0.135)	(0.029)	(0.120)	(0.184)
Oxen*Shannon index	-0.047	-0.323	-0.116	-0.151	-1.398
	(0.053)	(0.387)	(0.128)	(0.100)	(1.871)
Fertilizer*Shannon index	0.007	0.027	-0.015	0.071	-0.076
	(0.025)	(0.162)	(0.030)	(0.086)	(0.136)
Constant	6.669***	6.417***	6.250***	6.627***	4.240***
	(0.244)	(0.630)	(0.253)	(0.497)	(0.665)
Elasticity of Shannon index	-0.031	0.153	0.002	-0.259	0.022
p-value	0.713	0.714	0.991	0.230	0.972
Fixed effects					
Village-year fixed effects	✓	✓	✓	✓	✓
Elasticity of Shannon index	-0.031	0.153	0.002	-0.259	0.022
p-value	0.713	0.714	0.991	0.230	0.972

Notes: N. Highlands refers to Northern Highlands. C. Highlands refers to Central highlands.

Table 3A.24: Semi-parametric model: Parametric component (Full sample), no imputed values

	All	Teff	No teff
Area	0.609***	0.539***	0.627***
	(0.094)	(0.126)	(0.131)
Household size	-0.161	-0.091	-0.198
	(0.199)	(0.205)	(0.382)
Oxen	0.009	0.029**	-0.012
	(0.011)	(0.013)	(0.017)
Fertilizer	-0.001	0.002	-0.003
	(0.009)	(0.012)	(0.013)
Area (square)	0.033	0.042	0.016
	(0.037)	(0.057)	(0.048)
Household size (square)	0.153	0.097	0.173
	(0.121)	(0.133)	(0.222)
Oxen (square)	0.153**	0.193***	0.102
	(0.062)	(0.074)	(0.114)
Fertilizer (square)	0.008	0.002	0.012
	(0.006)	(0.008)	(0.009)
Area*Household size	-0.132***	-0.111*	-0.137**
	(0.046)	(0.062)	(0.066)
Area*Oxen	0.000	0.002	-0.004
	(0.003)	(0.004)	(0.005)
Area*Fertilizer	0.001	-0.002	0.006*
	(0.003)	(0.004)	(0.004)
Household size*Oxen	-0.002	-0.011	0.007
	(0.006)	(0.007)	(0.009)
Household size*Fertilizer	0.000	0.000	0.002
	(0.004)	(0.006)	(0.007)
Oxen*Fertilizer	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)
Village-year fixed effects	✓	✓	✓
Number of observations	3496	1898	1598
Number of households	1243	763	838
R-squared a	0.328	0.400	0.245

Table 3A.25: Semi-parametric model: Parametric component (Northern Highlands), no imputed value

	All	Teff	No teff
Area	0.553*	0.140	0.921*
	(0.309)	(0.382)	(0.482)
Household size	-0.053	-0.629	0.496
	(0.671)	(0.713)	(1.037)
Oxen	-0.052	0.035	-0.151**
	(0.036)	(0.033)	(0.066)
Fertilizer	0.027	-0.026	0.088
	(0.033)	(0.041)	(0.061)
Area (square)	-0.069	-0.114	-0.026
	(0.126)	(0.171)	(0.212)
Household size (square)	0.047	0.687	-0.721
	(0.401)	(0.423)	(0.618)
Oxen (square)	0.308	0.194	0.789
	(0.259)	(0.288)	(0.530)
Fertilizer (square)	-0.107***	-0.081	-0.118*
	(0.035)	(0.052)	(0.070)
Area*Household size	-0.134	-0.011	-0.294
	(0.142)	(0.188)	(0.227)
Area*Oxen	-0.002	-0.003	-0.009
	(0.008)	(0.011)	(0.017)
Area*Fertilizer	0.005	-0.011	0.024
	(0.012)	(0.014)	(0.023)
Household size*Oxen	0.013	-0.026	0.061**
	(0.019)	(0.016)	(0.030)
Household size*Fertilizer	-0.004	0.028	-0.034
	(0.016)	(0.021)	(0.026)
Oxen*Fertilizer	-0.004***	-0.002	-0.005***
	(0.001)	(0.001)	(0.002)
Village-year fixed effects	✓	✓	✓
Number of observations	649	386	263
Number of households	276	143	197
R-squared a	0.191	0.150	0.238

Table 3A.26: Semi-parametric model: Parametric component (Central Highlands), no imputed values

	All	Teff	No teff
Area	0.611***	0.547**	0.634***
	(0.142)	(0.251)	(0.155)
Household size	-0.580***	-0.447*	-0.679**
	(0.221)	(0.241)	(0.289)
Oxen	0.008	-0.014	0.017
	(0.012)	(0.019)	(0.015)
Fertilizer	0.013	0.029	0.006
	(0.014)	(0.020)	(0.016)
Area (square)	-0.008	-0.071	-0.009
	(0.064)	(0.131)	(0.069)
Household size (square)	0.459***	0.416***	0.504***
	(0.143)	(0.141)	(0.192)
Oxen (square)	0.135	0.273*	0.101
	(0.102)	(0.159)	(0.120)
Fertilizer (square)	0.011	0.008	0.016
	(0.008)	(0.014)	(0.010)
Area*Household size	-0.103	-0.073	-0.116
	(0.083)	(0.134)	(0.096)
Area*Oxen	-0.010*	-0.008	-0.012*
	(0.006)	(0.008)	(0.006)
Area*Fertilizer	0.000	0.004	-0.003
	(0.005)	(0.010)	(0.005)
Household size*Oxen	-0.002	0.008	-0.008
	(0.007)	(0.012)	(0.009)
Household size*Fertilizer	-0.006	-0.017*	-0.001
	(0.008)	(0.010)	(0.010)
Oxen*Fertilizer	0.000	0.000	0.001
	(0.000)	(0.001)	(0.001)
Village-year fixed effects	✓	✓	✓
Number of observations	1282	395	887
Number of households	417	214	323
R-squared a	0.292	0.336	0.288

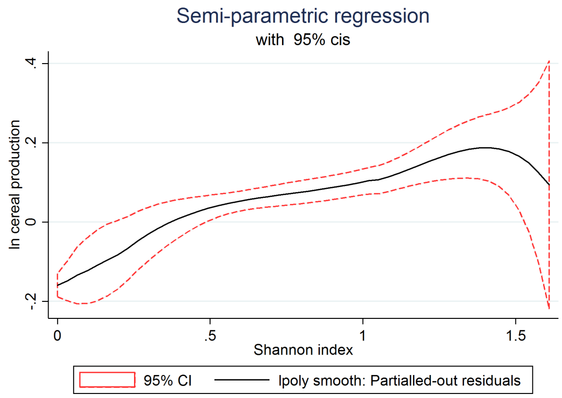
Table 3A.27: Semi-parametric model: Parametric component (Arusi/Bale (Other)), no imputed values

	All	Teff	No teff
Area	0.337**	0.668**	0.220
	(0.158)	(0.263)	(0.243)
Household size	0.299	0.297	-0.056
	(0.293)	(0.346)	(0.593)
Oxen	0.028	0.034	-0.037
	(0.017)	(0.022)	(0.029)
Fertilizer	-0.005	0.000	0.009
	(0.013)	(0.018)	(0.019)
Area (square)	0.095	-0.023	0.032
	(0.092)	(0.144)	(0.148)
Household size (square)	-0.228	-0.195	-0.017
	(0.186)	(0.237)	(0.358)
Oxen (square)	0.189**	0.172*	0.396
	(0.092)	(0.091)	(0.499)
Fertilizer (square)	0.000	-0.004	0.003
	(0.009)	(0.011)	(0.022)
Area*Household size	-0.012	-0.075	-0.053
	(0.079)	(0.149)	(0.115)
Area*Oxen	-0.003	0.011	-0.021*
	(0.006)	(0.008)	(0.011)
Area*Fertilizer	0.000	-0.012	0.013
	(0.005)	(0.008)	(0.008)
Household size*Oxen	-0.010	-0.019	0.019
	(0.009)	(0.012)	(0.014)
Household size*Fertilizer	0.007	0.006	0.006
	(0.006)	(0.010)	(0.009)
Oxen*Fertilizer	0.001*	0.001	0.001
	(0.000)	(0.001)	(0.001)
Village-year fixed effects	✓	✓	✓
Number of observations	1004	692	312
Number of households	298	210	125
R-squared a	0.437	0.530	0.233

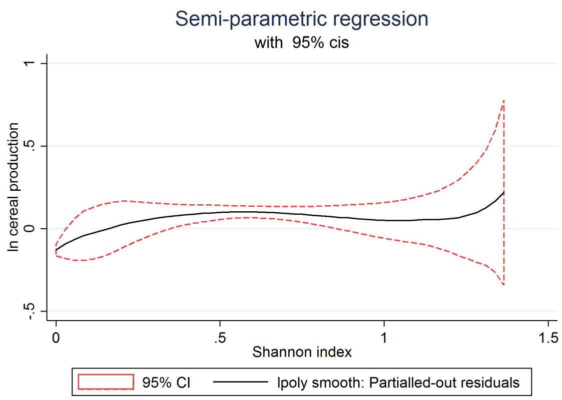
Table 3A.28: Semi-parametric model: Parametric component (Enset), No imputed values

	All	Teff	No teff
Area	0.476*	0.608**	0.459
	(0.246)	(0.295)	(0.547)
Household size	0.240	0.046	1.251
	(0.511)	(0.515)	(1.631)
Oxen	0.015	0.024	0.021
	(0.028)	(0.032)	(0.059)
Fertilizer	-0.004	0.000	-0.080
	(0.026)	(0.034)	(0.093)
Area (square)	0.011	0.073	-0.001
	(0.078)	(0.121)	(0.110)
Household size (square)	-0.063	-0.110	-0.311
	(0.289)	(0.317)	(0.854)
Oxen (square)	0.334**	0.580***	0.189
	(0.160)	(0.222)	(0.492)
Fertilizer (square)	0.024	0.007	0.064
	(0.023)	(0.024)	(0.073)
Area*Household size	-0.126	-0.182	-0.052
	(0.096)	(0.115)	(0.216)
Area*Oxen	0.005	-0.001	0.011
	(0.008)	(0.009)	(0.014)
Area*Fertilizer	-0.007	-0.006	-0.002
	(0.006)	(0.009)	(0.012)
Household size*Oxen	-0.003	-0.008	-0.018
	(0.014)	(0.015)	(0.029)
Household size*Fertilizer	-0.001	0.002	0.027
	(0.012)	(0.014)	(0.041)
Oxen*Fertilizer	0.001	0.001	-0.001
	(0.001)	(0.002)	(0.001)
Village-year fixed effects	✓	✓	✓
Number of observations	561	425	136
Number of households	252	196	193
R-squared a	0.407	0.457	0.250

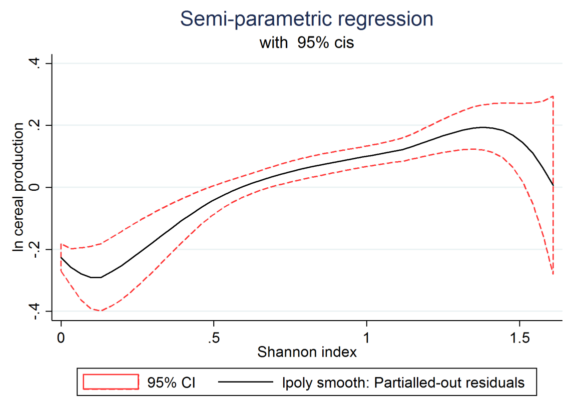
Figure 3A.8: Effect of Shannon index Semi parametric Full sample (No imputed values)



(a) Full sample

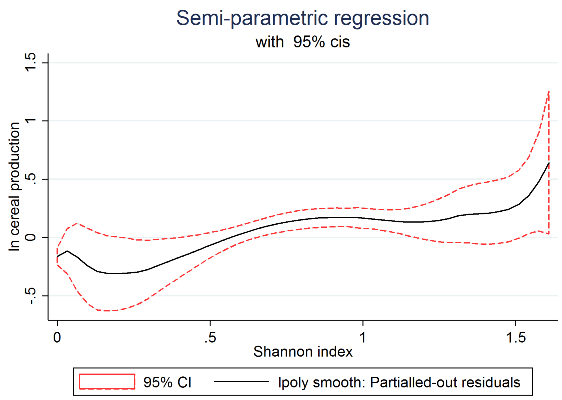


(b) Non teff-producing households

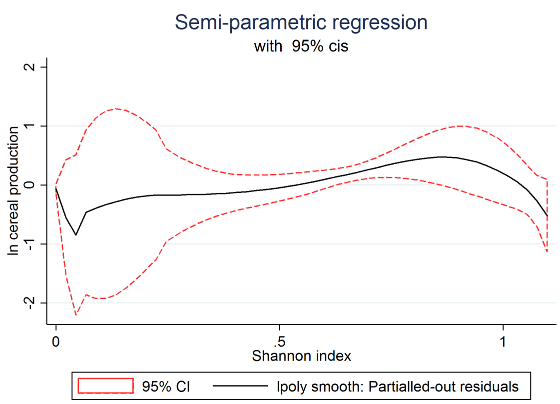


(c) Teff-producing households

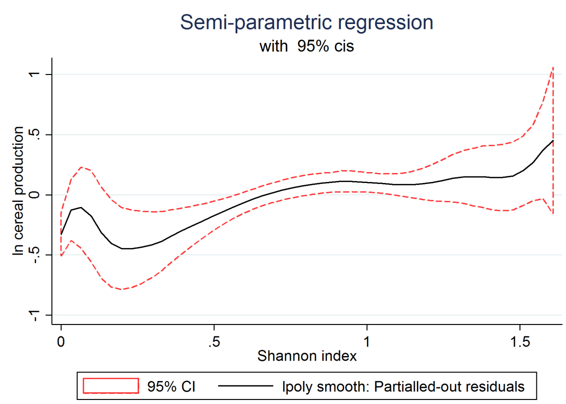
Figure 3A.9: Effect of Shannon index Semi parametric Northern Highlands (No imputed values)



(a) Full sample

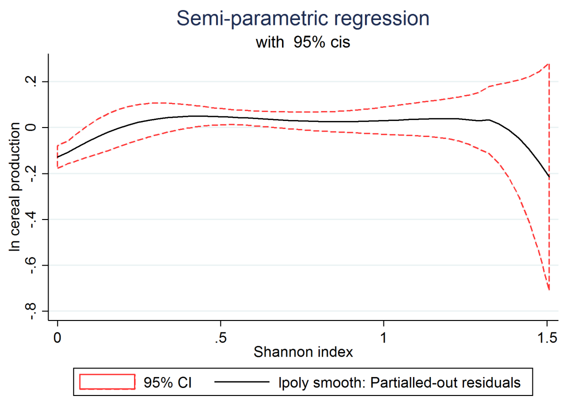


(b) Non teff-producing households

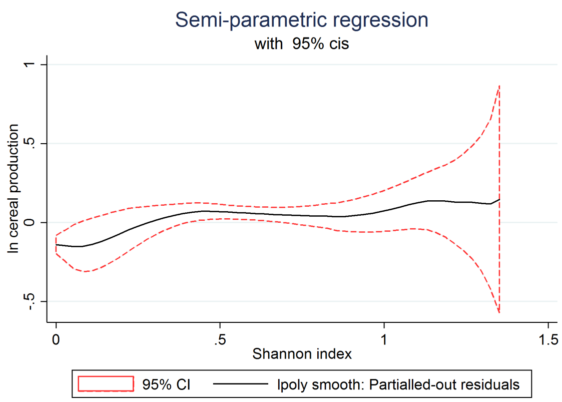


(c) Teff-producing households

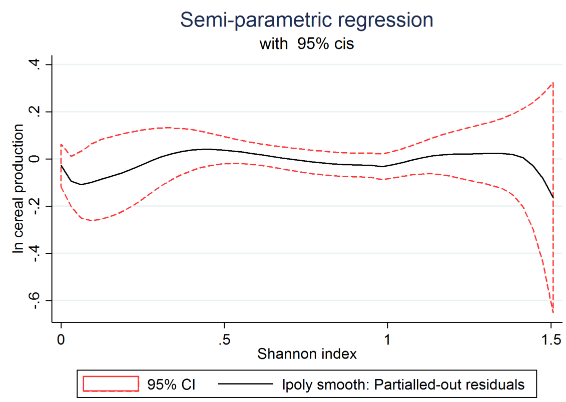
Figure 3A.10: Effect of Shannon index Semi parametric Central Highlands (No imputed values)



(a) Full sample

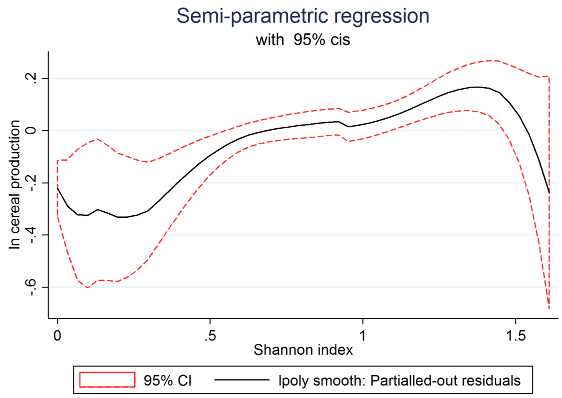


(b) Non teff-producing households

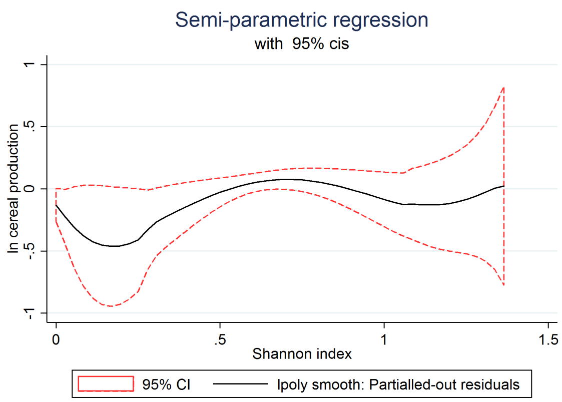


(c) Teff-producing households

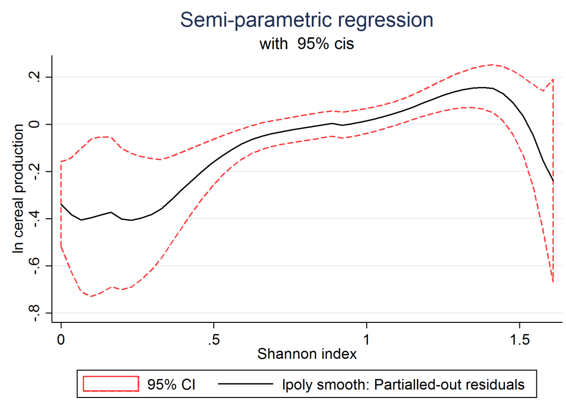
Figure 3A.11: Effect of Shannon index Semi parametric Arussi/Bale (No imputed values)



(a) Full sample

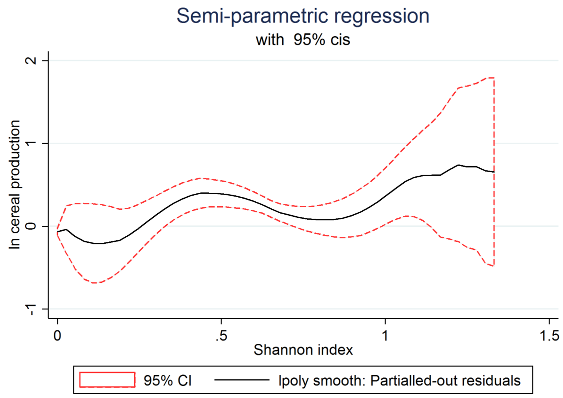


(b) Non teff-producing households

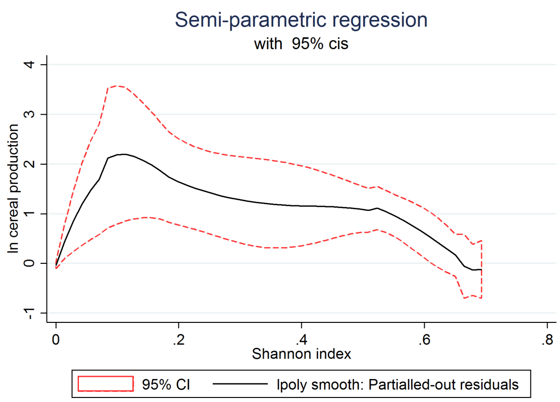


(c) Teff-producing households

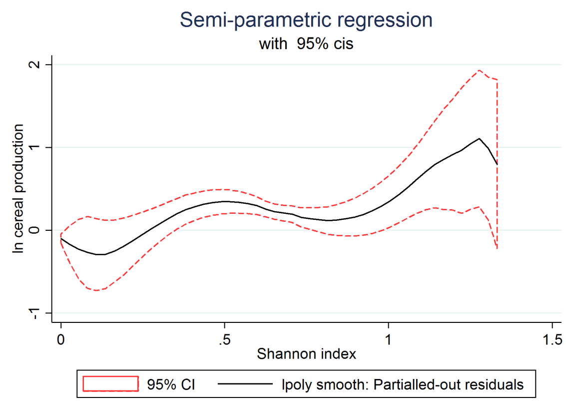
Figure 3A.12: Effect of Shannon index Semi parametric Enset (No imputed values)



(a) Full sample

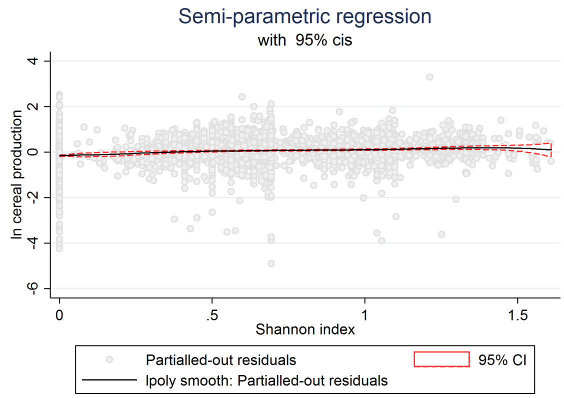


(b) Non teff-producing households

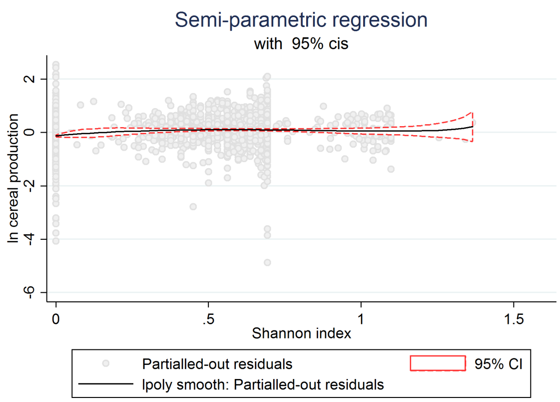


(c) Teff-producing households

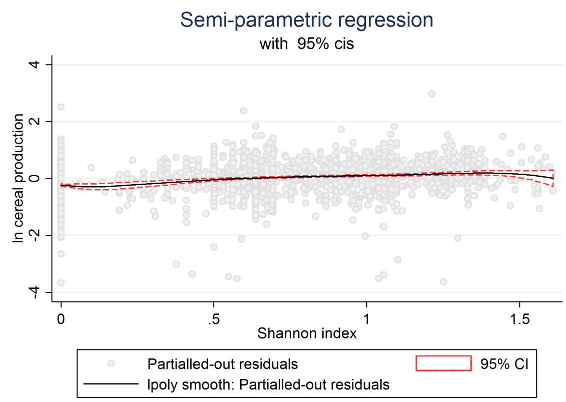
Figure 3A.13: Effect of Shannon index Semi parametric Full sample (No imputed values, with scatter)



(a) Full sample

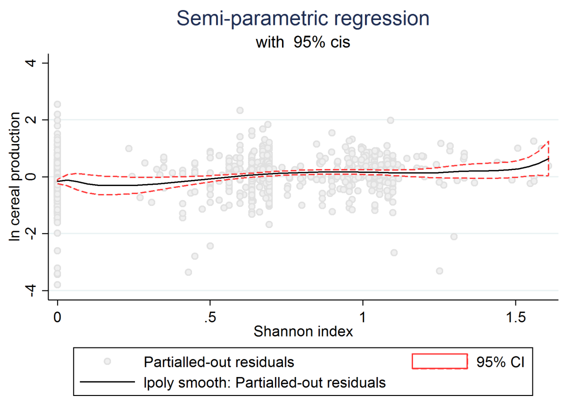


(b) Non teff-producing households

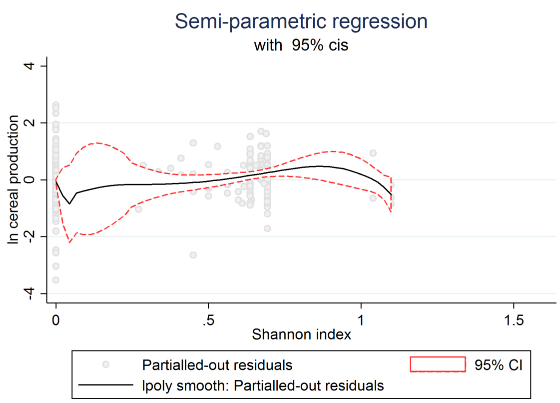


(c) Teff-producing households

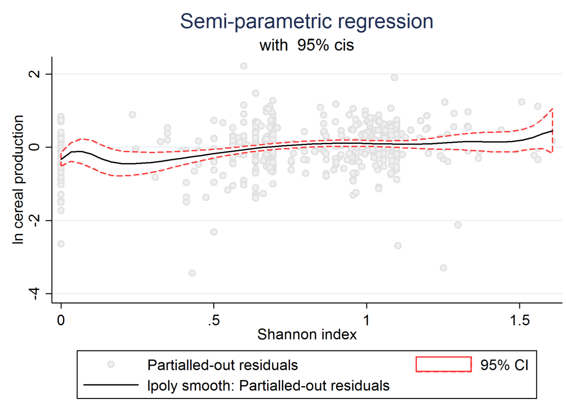
Figure 3A.14: Effect of Shannon index Semi parametric Northern Highlands (No imputed values, with scatter)



(a) Full sample

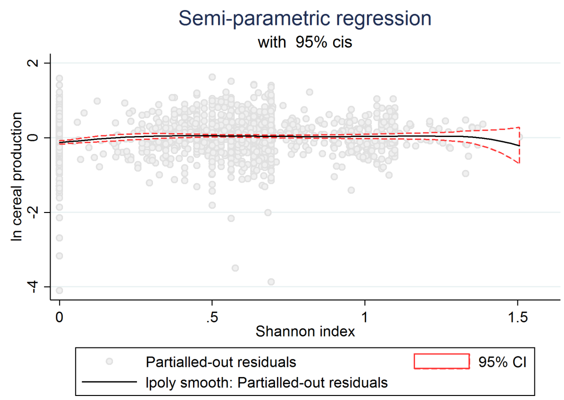


(b) Non teff-producing households

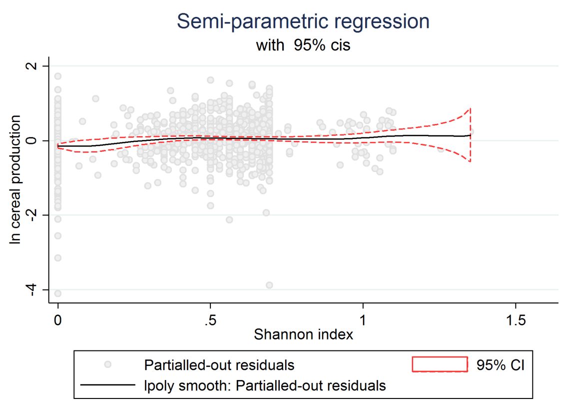


(c) Teff-producing households

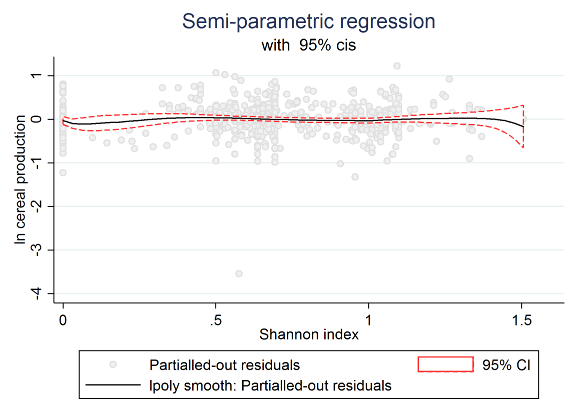
Figure 3A.15: Effect of Shannon index Semi parametric Central Highlands (No imputed values, with scatter)



(a) Full sample

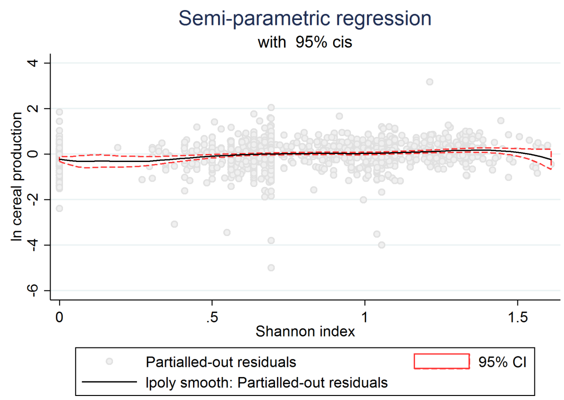


(b) Non teff-producing households

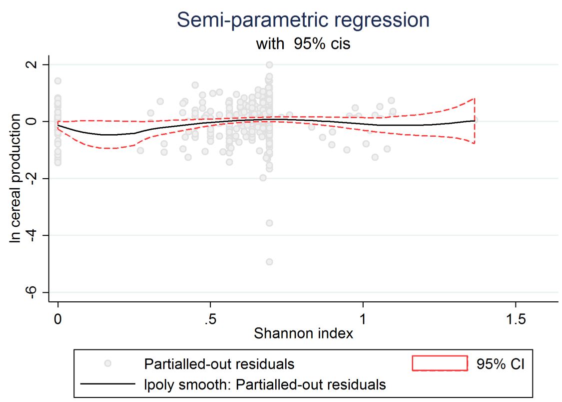


(c) Teff-producing households

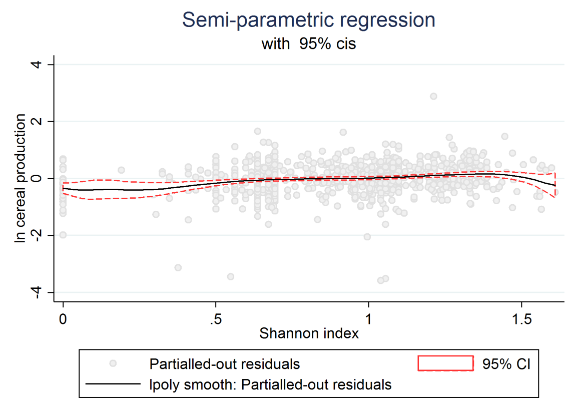
Figure 3A.16: Effect of Shannon index Semi parametric Arussi/Bale (No imputed values, with scatter)



(a) Full sample

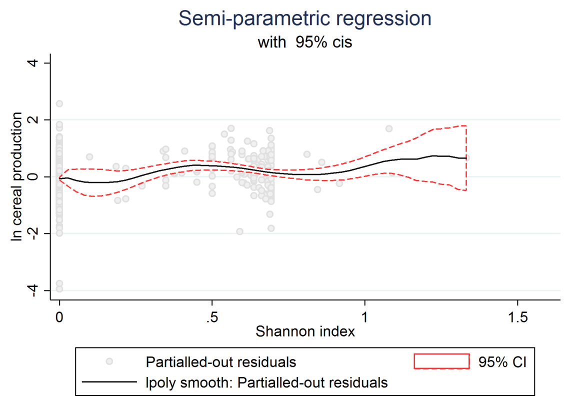


(b) Non teff-producing households

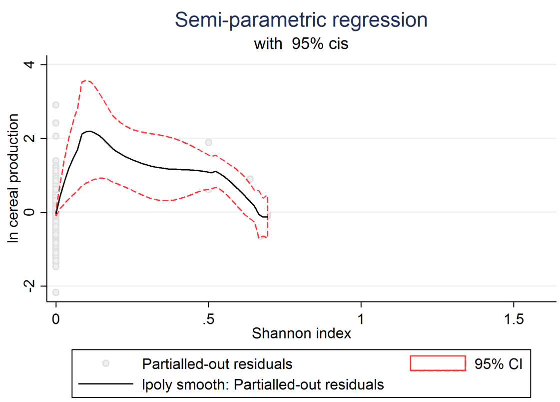


(c) Teff-producing households

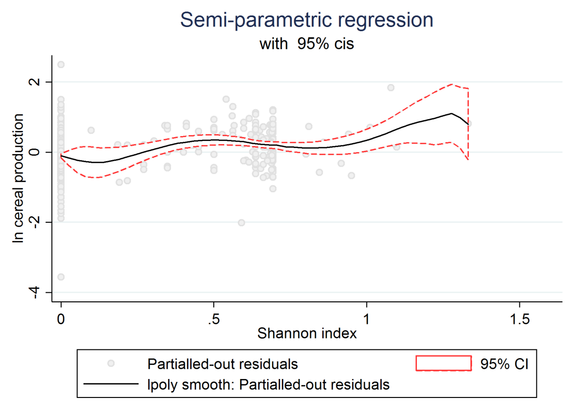
Figure 3A.17: Effect of Shannon index Semi parametric Enset (No imputed values, with scatter)



(a) Full sample



(b) Non teff-producing households



(c) Teff-producing households

Table 3A.29: Bandwidth choice - (no imputed values)

	All	N. Highlands	C. Highlands	Other	Enset
Main	0.46	0.43	0.59	0.42	0.29
No teff	0.39	0.29	0.38	0.48	0.23
Teff	0.44	0.41	0.43	0.41	0.32

A.3 Balanced Sample

Table 3A.30: Summary Statistics

	All		N. Highlands		C. Highlands		Other		Enset	
	Mean	**S.D.**	**Mean**	**S.D.**	**Mean**	**S.D.**	**Mean**	**S.D.**	**Mean**	**S.D.**
Cereal Production (kgs)	898.44	947.28	381.94	465.49	1142.46	946.49	1327.81	1105.42	261.95	275.03
Cereal Yield (kg/ha)	799.94	739.96	548.56	540.62	885.57	751.41	935.13	784.31	744.92	818.33
Cereal Area (ha)	1.35	1.16	0.92	1.03	1.57	1.05	1.82	1.28	0.54	0.62
Shannon index	0.54	0.41	0.49	0.44	0.53	0.33	0.82	0.37	0.15	0.28
Number of oxen	1.04	1.14	0.77	0.87	1.33	1.12	1.09	1.29	0.56	1.04
Household Size	6.15	2.56	5.59	2.42	6.02	2.45	6.39	2.45	7.12	3.03
Quantity Ferilizer (kgs)	59.73	87.61	3.42	12.47	87.66	88.80	86.55	110.76	27.25	33.52
Number of ploughs (units)	2.04	3.16	2.01	3.30	2.49	3.40	1.83	3.05	1.10	1.85
Number of hoes (units)	1.23	1.63	0.94	1.46	1.46	1.73	1.22	1.66	1.13	1.41
Tigray	0.14	0.34	0.57	0.50	0.00	0.00	0.00	0.00	0.00	0.00
Amhara	0.42	0.49	0.43	0.50	0.84	0.37	0.00	0.00	0.00	0.00
Oromia	0.32	0.46	0.00	0.00	0.16	0.37	1.00	0.00	0.00	0.00
SSN	0.12	0.33	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00
Northern Highlands	0.24	0.43	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Central Highlands	0.38	0.49	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
Other	0.25	0.43	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00
Enset	0.12	0.33	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00
Number of observations	3702		888		1422		936		456	

Table 3A.31: Parametric translog full (Balanced Panel)

	All	N. Highlands	C. Highlands	Other	Enset
Area	0.613***	0.501***	0.568***	0.371*	0.191
	(0.075)	(0.146)	(0.126)	(0.214)	(0.260)
Household size	0.007	0.063	-0.206	0.565*	-0.262
	(0.130)	(0.315)	(0.234)	(0.301)	(0.428)
Oxen	0.103***	0.130	0.057	0.125*	0.257*
	(0.032)	(0.079)	(0.049)	(0.065)	(0.133)
Fertilizer	0.021*	-0.111***	0.021	0.036*	0.015
	(0.011)	(0.042)	(0.015)	(0.020)	(0.039)
Hoes	0.037	-0.009	0.047	0.090*	0.019
	(0.024)	(0.063)	(0.034)	(0.051)	(0.081)
Ploughs	0.014	0.062	0.052*	0.015	-0.095
	(0.016)	(0.043)	(0.027)	(0.032)	(0.069)
Shannon index	0.063*	0.027	0.027	0.157*	0.030
	(0.036)	(0.060)	(0.057)	(0.090)	(0.105)
Area (square)	0.015	0.032	-0.079***	-0.006	0.039
	(0.016)	(0.032)	(0.026)	(0.044)	(0.034)
Household size (square)	0.02	0.089	0.115	-0.213**	0.068
	(0.040)	(0.075)	(0.072)	(0.096)	(0.110)
Oxen (square)	0.007***	0.010*	0.004	0.009*	0.017*
	(0.002)	(0.006)	(0.004)	(0.005)	(0.009)
Fertilizer (square)	0.001	-0.007**	0.001	0.002	0.001
	(0.001)	(0.004)	(0.001)	(0.001)	(0.003)
Hoes (square)	0.002	-0.002	0.003	0.004	0.005
	(0.002)	(0.005)	(0.002)	(0.004)	(0.006)
Ploughs (square)	0.000	0.004	0.002	0.001	-0.006
	(0.001)	(0.002)	(0.002)	(0.002)	(0.005)
Shannon index (square)	0.005*	0.002	0.001	0.012**	0.002
	(0.002)	(0.004)	(0.004)	(0.006)	(0.007)
Area*Household size	-0.071*	-0.037	-0.013	0.066	-0.042
	(0.039)	(0.067)	(0.068)	(0.105)	(0.107)
Area*Oxen	0.000	-0.002	0.002	0.006	-0.004
	(0.003)	(0.006)	(0.004)	(0.006)	(0.008)
Area*Fertilizer	0.001	-0.001	0.000	-0.003	0.003
	(0.002)	(0.006)	(0.004)	(0.005)	(0.006)
Area*Hoes	0.002	-0.003	0.001	0.001	0.013*
	(0.003)	(0.005)	(0.005)	(0.005)	(0.007)
Area*Ploughs	0.000	0.007	-0.009	0.002	-0.01
	(0.003)	(0.004)	(0.006)	(0.008)	(0.009)
Area*Shannon index	-0.005	-0.008	-0.008	0.009	-0.025***
	(0.003)	(0.006)	(0.005)	(0.012)	(0.009)
Household size*Oxen	-0.002	-0.005	0.002	-0.003	-0.008
	(0.004)	(0.008)	(0.006)	(0.009)	(0.014)
Household size*Fertilizer	0.000	0.020*	0.002	-0.004	0.001
	(0.004)	(0.012)	(0.006)	(0.009)	(0.013)
Household size*Hoes	0.000	0.005	0.001	-0.012	0.015
	(0.004)	(0.007)	(0.007)	(0.008)	(0.014)
Household size*Ploughs	-0.004	-0.014	-0.012	0.007	-0.005
	(0.004)	(0.009)	(0.008)	(0.010)	(0.013)
Household size*Shannon index	0.007	0.006	-0.001	0.015	-0.006
	(0.005)	(0.007)	(0.008)	(0.013)	(0.012)
Oxen*Fertilizer	-0.000*	-0.002*	0.000	0.000	0.001
	(0.000)	(0.001)	(0.000)	(0.001)	(0.001)
Oxen*Hoes	0.000	0.000	0.000	0.000	0.001
	(0.000)	(0.001)	(0.000)	(0.000)	(0.001)
Oxen*Ploughs	0.000	0.000	0.000	-0.001	-0.002
	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)
Oxen*Shannon index	0.000	0.000	0.000	-0.002*	0.001
	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)
Fertilizer*Hoes	0.001***	0.002*	0.000	0.000	0.000
	(0.000)	(0.001)	(0.000)	(0.000)	(0.001)
Fertilizer*Ploughs	0.001**	0.000	0.001	0.001	0.000
	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)
Fertilizer*Shannon index	0.000	0.000	0.000	0.000	-0.002**
	(0.000)	(0.001)	(0.000)	(0.001)	(0.001)
Hoes*Ploughs	0.000	0.000	-0.001	0.001	-0.001
	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)
Hoes*Shannon index	0.000	0.002**	0.000	0.000	-0.003***
	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)
Ploughs*Shannon index	0.000	0.000	0.000	-0.001	0.001
	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)
Constant	6.225***	5.758***	6.489***	5.848***	5.611***
	(0.129)	(0.428)	(0.223)	(0.303)	(0.541)
Elasticity of Shannon index	0.065**	0.028	0.020	0.189**	0.039
p-value	0.025	0.554	0.690	0.017	0.545
Fixed effects	✓	✓	✓	✓	✓
Village-year fixed effects	✓	✓	✓	✓	✓
Number of households	617	148	237	156	76
Number of observations	3702	888	1422	936	456
Average obs. per household	6	6	6	6	6
R-squared a	0.545	0.632	0.534	0.55	0.417
R-squared w	0.559	0.653	0.555	0.574	0.481

Notes: N. Highlands refers to Northern Highlands. C. Highlands refers to Central highlands. Numbers in parentheses represent clustered standard errors at the household level. As explained in the methodology section, this specification does not include the adjustment proposed by Battese (1997) since there is little within-household variation of input-use. Instead 0 values are assigned the value of 0.000001.

Table 3A.32: Parametric translog teff only (Balanced Panel)

	All	N. Highlands	C. Highlands	Other	Enset
Area	0.614***	0.606*	0.507***	0.574**	-0.116
	(0.122)	(0.324)	(0.166)	(0.220)	(0.384)
Household size	0.136	-0.014	-0.339	0.546*	0.122
	(0.190)	(0.763)	(0.384)	(0.287)	(0.555)
Oxen	0.159***	0.148	0.087	0.099	0.450**
	(0.043)	(0.113)	(0.082)	(0.065)	(0.180)
Fertilizer	0.042***	-0.139**	0.027	0.050**	0.040
	(0.015)	(0.058)	(0.026)	(0.020)	(0.059)
Hoes	0.015	-0.043	-0.074	0.076	0.100
	(0.033)	(0.069)	(0.061)	(0.049)	(0.124)
Ploughs	-0.01	0.107	-0.053	-0.001	-0.174
	(0.024)	(0.071)	(0.041)	(0.036)	(0.105)
Shannon index	0.178***	0.154	-0.007	0.389***	0.043
	(0.056)	(0.099)	(0.080)	(0.088)	(0.204)
Area (square)	0.065**	0.151***	-0.005	-0.162***	0.102**
	(0.028)	(0.057)	(0.053)	(0.058)	(0.049)
Household size (square)	-0.032	0.141	0.150	-0.238**	-0.045
	(0.061)	(0.226)	(0.102)	(0.099)	(0.136)
Oxen (square)	0.010***	0.007	0.005	0.008*	0.028**
	(0.003)	(0.008)	(0.006)	(0.004)	(0.012)
Fertilizer (square)	0.002**	-0.009**	0.002	0.002	0.001
	(0.001)	(0.004)	(0.002)	(0.001)	(0.003)
Hoes (square)	0.001	-0.005	-0.004	0.003	0.013
	(0.002)	(0.005)	(0.004)	(0.004)	(0.009)
Ploughs (square)	-0.001	0.007*	-0.006**	0.000	-0.009
	(0.002)	(0.004)	(0.003)	(0.002)	(0.007)
Shannon index (square)	0.011***	0.012*	-0.003	0.025***	0.000
	(0.004)	(0.006)	(0.005)	(0.006)	(0.014)
Area*Household size	-0.118*	-0.181	-0.009	0.153	0.133
	(0.064)	(0.184)	(0.101)	(0.128)	(0.161)
Area*Oxen	0.001	0.005	-0.001	0.015	-0.004
	(0.004)	(0.009)	(0.007)	(0.009)	(0.011)
Area*Fertilizer	0.000	-0.001	0.004	-0.024***	-0.001
	(0.003)	(0.010)	(0.007)	(0.008)	(0.010)
Area*Hoes	0.002	-0.005	0.000	0.004	0.024**
	(0.004)	(0.008)	(0.008)	(0.007)	(0.010)
Area*Ploughs	0.000	0.005	-0.019	0.012	-0.029**
	(0.005)	(0.011)	(0.012)	(0.009)	(0.011)
Area*Shannon index	-0.017***	-0.026*	-0.022**	-0.012	-0.036***
	(0.006)	(0.015)	(0.009)	(0.019)	(0.012)
Household size*Oxen	-0.006	-0.010	-0.008	0.001	-0.042**
	(0.006)	(0.014)	(0.009)	(0.011)	(0.021)
Household size*Fertilizer	-0.006	0.025	0.001	-0.003	-0.007
	(0.006)	(0.021)	(0.009)	(0.010)	(0.023)
Household size*Hoes	0.003	0.010	0.013	-0.018*	0.031
	(0.006)	(0.016)	(0.010)	(0.009)	(0.024)
Household size*Ploughs	0.004	-0.033	0.000	0.000	0.020
	(0.007)	(0.021)	(0.011)	(0.011)	(0.023)
Household size*Shannon index	-0.001	0.008	-0.014	-0.007	-0.023
	(0.008)	(0.026)	(0.013)	(0.016)	(0.019)
Oxen*Fertilizer	0.000	0.001	0.000	0.000	0.001
	(0.000)	(0.002)	(0.001)	(0.001)	(0.001)
Oxen*Hoes	0.000	0.000	-0.001	0.000	-0.001
	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)
Oxen*Ploughs	0.000	0.003**	0.002*	0.000	-0.001
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Oxen*Shannon index	0.000	-0.001	0.001	-0.001	0.000
	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)
Fertilizer*Hoes	0.000	0.003*	0.000	0.000	0.001
	(0.000)	(0.002)	(0.001)	(0.001)	(0.002)
Fertilizer*Ploughs	0.000	-0.003**	0.001*	0.001	0.001
	(0.000)	(0.001)	(0.001)	(0.001)	(0.002)
Fertilizer*Shannon index	0.000	-0.001	-0.001	0.000	-0.001
	(0.001)	(0.003)	(0.001)	(0.001)	(0.002)
Hoes*Ploughs	0.000	-0.001	-0.001	0.001	0.000
	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)
Hoes*Shannon index	0.001	0.004**	0.001	0.003*	-0.003*
	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)
Ploughs*Shannon index	0.000	-0.002	0.001	-0.003*	0.003***
	(0.001)	(0.002)	(0.001)	(0.002)	(0.001)
Constant	6.230***	5.568***	6.506***	5.772***	4.597***
	(0.184)	(0.765)	(0.395)	(0.283)	(0.860)
Elasticity of Shannon index	0.157***	0.161*	-0.043	0.359***	0.0333
p-value	0.002	0.056	0.547	0.000	0.803
Fixed effects	✓	✓	✓	✓	✓
Village-year fixed effects	✓	✓	✓	✓	✓
Number of households	400	85	118	125	72
Number of observations	1882	384	483	712	303
Average obs. per household	4.705	4.518	4.093	5.696	4.208
R-squared a	0.523	0.341	0.589	0.619	0.543
R-squared w	0.545	0.42	0.632	0.643	0.619

Notes: N. Highlands refers to Northern Highlands. C. Highlands refers to Central highlands. Numbers in parentheses represent clustered standard errors at the household level. As explained in the methodology section, this specification does not include the adjustment proposed by Battese (1997) since there is little within-household variation of input-use. Instead 0 values are assigned the value of 0.000001.

Table 3A.33: Parametric translog no teff (Balanced Panel)

	All	N. Highlands	C. Highlands	Other	Enset
Area	0.585***	0.536*	0.543***	-0.165	-80.294***
	(0.102)	(0.308)	(0.181)	(0.419)	(25.466)
Household size	-0.159	-0.229	-0.127	-1.264	162.488***
	(0.183)	(0.340)	(0.326)	(1.523)	(51.395)
Oxen	0.055	0.037	0.047	0.028	2.464***
	(0.053)	(0.132)	(0.064)	(0.367)	(0.740)
Fertilizer	0.005	-0.084	0.033*	0.062	3.264***
	(0.016)	(0.070)	(0.017)	(0.060)	(1.026)
Hoes	0.061	0.130	0.118***	0.068	-13.294***
	(0.041)	(0.145)	(0.045)	(0.187)	(4.334)
Ploughs	0.036	0.044	0.075**	0.086	-7.955***
	(0.027)	(0.069)	(0.036)	(0.101)	(2.485)
Shannon index	-0.033	-0.048	0.058	0.045	-20.255***
	(0.056)	(0.086)	(0.094)	(0.151)	(6.390)
Area (square)	-0.013	-0.104	-0.105***	0.103	0.013
	(0.023)	(0.074)	(0.033)	(0.100)	(0.096)
Household size (square)	0.096*	0.142**	0.091	0.323	-0.285
	(0.053)	(0.067)	(0.101)	(0.419)	(0.301)
Oxen (square)	0.004	0.005	0.003	0.000	-0.003
	(0.004)	(0.010)	(0.005)	(0.027)	(0.025)
Fertilizer (square)	0.000	-0.006	0.002	0.004	0.005
	(0.001)	(0.006)	(0.002)	(0.005)	(0.007)
Hoes (square)	0.004	0.008	0.007**	0.003	-0.011
	(0.003)	(0.011)	(0.003)	(0.013)	(0.017)
Ploughs (square)	0.001	0.001	0.004*	0.004	-0.021
	(0.002)	(0.004)	(0.002)	(0.007)	(0.017)
Shannon index (square)	-0.002	-0.005	0.004	0.003	0.729***
	(0.004)	(0.006)	(0.007)	(0.010)	(0.241)
Area*Household size	-0.042	-0.101	0.029	0.356*	-0.070
	(0.051)	(0.109)	(0.092)	(0.212)	(0.200)
Area*Oxen	-0.001	-0.005	0.002	-0.006	-0.004
	(0.004)	(0.010)	(0.006)	(0.013)	(0.016)
Area*Fertilizer	0.006*	0.003	-0.002	-0.006	-0.005
	(0.003)	(0.010)	(0.006)	(0.012)	(0.011)
Area*Hoes	0.004	0.007	-0.001	0.013	-0.002
	(0.004)	(0.008)	(0.005)	(0.011)	(0.021)
Area*Ploughs	0.001	0.010	-0.003	0.001	0.025
	(0.005)	(0.008)	(0.008)	(0.019)	(0.018)
Area*Shannon index	-0.005	0.005	-0.004	0.009	-5.845***
	(0.004)	(0.010)	(0.007)	(0.019)	(1.858)
Household size*Oxen	0.001	0.000	0.006	-0.013	0.005
	(0.006)	(0.010)	(0.009)	(0.022)	(0.034)
Household size*Fertilizer	0.005	0.016	-0.004	-0.009	0.063
	(0.005)	(0.016)	(0.006)	(0.019)	(0.041)
Household size*Hoes	-0.002	0.002	-0.006	-0.008	0.036
	(0.006)	(0.009)	(0.010)	(0.022)	(0.022)
Household size*Ploughs	-0.01	-0.011	-0.013	-0.017	-0.020
	(0.007)	(0.010)	(0.012)	(0.033)	(0.021)
Household size*Shannon index	0.01	0.002	0.000	0.018	11.661***
	(0.007)	(0.009)	(0.011)	(0.033)	(3.760)
Oxen*Fertilizer	-0.001**	-0.002**	0.000	0.001	0.001
	(0.000)	(0.001)	(0.000)	(0.001)	(0.003)
Oxen*Hoes	0.000	-0.001	0.001**	0.000	0.003
	(0.000)	(0.001)	(0.001)	(0.001)	(0.003)
Oxen*Ploughs	-0.001**	-0.001	-0.001	-0.002	-0.004
	(0.000)	(0.001)	(0.001)	(0.002)	(0.004)
Oxen*Shannon index	0.000	-0.001	0.000	0.000	0.184***
	(0.000)	(0.001)	(0.001)	(0.002)	(0.059)
Fertilizer*Hoes	0.001**	0.002*	0.000	0.000	-0.001
	(0.000)	(0.001)	(0.001)	(0.001)	(0.003)
Fertilizer*Ploughs	0.001**	0.000	0.000	0.003**	0.001
	(0.000)	(0.001)	(0.001)	(0.001)	(0.002)
Fertilizer*Shannon index	0.000	0.001	0.000	-0.001	0.238***
	(0.000)	(0.001)	(0.001)	(0.002)	(0.079)
Hoes*Ploughs	0.000	0.001	-0.001	0.000	0.001
	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)
Hoes*Shannon index	0.000	0.001	0.000	0.000	-0.950***
	(0.000)	(0.001)	(0.001)	(0.002)	(0.302)
Ploughs*Shannon index	0.001	0.001	0.001	0.001	-0.559***
	(0.001)	(0.001)	(0.001)	(0.002)	(0.185)
Constant	6.017***	6.259***	6.189***	7.619***	-416.855***
	(0.199)	(0.643)	(0.304)	(1.584)	(134.138)
Elasticity of Shannon index	-0.011	-0.04	0.049	0.065	9.2***
p-value	0.804	0.492	0.562	0.603	0.003
Fixed effects	✓	✓	✓	✓	✓
Village-year fixed effects	✓	✓	✓	✓	✓
Number of households	419	108	188	57	66
Number of observations	1820	504	939	224	153
Average obs. per household	4.344	4.667	4.995	3.93	2.318
R-squared a	0.589	0.737	0.52	0.388	0.569
R-squared w	0.612	0.763	0.551	0.508	0.705

Notes: N. Highlands refers to Northern Highlands. C. Highlands refers to Central highlands. Numbers in parentheses represent clustered standard errors at the household level. As explained in the methodology section, this specification does not include the adjustment proposed by Battese (1997) since there is little within-household variation of input-use. Instead 0 values are assigned the value of 0.000001.

Table 3A.34: Parametric translog full (Battese transformation)

	All	N. Highlands	C. Highlands	Other	Enset
Fertilizer dummy	-0.243***	-0.629**	-0.217*	-0.271*	-0.108
	(0.075)	(0.268)	(0.122)	(0.148)	(0.206)
Oxen dummy	-0.087***	-0.164***	-0.053	-0.199***	-0.021
	(0.028)	(0.056)	(0.046)	(0.058)	(0.086)
Hoe dummy	-0.010	0.066	-0.018	-0.076	-0.028
	(0.026)	(0.048)	(0.047)	(0.052)	(0.095)
Plough dummy	-0.063*	0.027	-0.077	-0.009	-0.170**
	(0.032)	(0.064)	(0.056)	(0.068)	(0.085)
Shannon index dummy	-0.216***	-0.185***	-0.129**	-0.303***	-0.171
	(0.032)	(0.063)	(0.053)	(0.090)	(0.149)
Area	0.571***	0.425***	0.689***	0.424***	0.436**
	(0.049)	(0.094)	(0.096)	(0.135)	(0.185)
Household size	-0.007	0.089	-0.07	0.375*	-0.844***
	(0.087)	(0.169)	(0.152)	(0.201)	(0.318)
Oxen	0.453***	0.670*	0.430**	0.101	0.837
	(0.125)	(0.373)	(0.197)	(0.259)	(0.761)
Fertilizer	-0.152***	-0.484**	-0.154**	-0.074	-0.283*
	(0.044)	(0.229)	(0.065)	(0.086)	(0.166)
Hoes	0.016	-0.495*	0.354**	-0.025	0.024
	(0.098)	(0.253)	(0.165)	(0.191)	(0.397)
Ploughs	-0.040	0.192	-0.085	0.105	-0.141
	(0.074)	(0.169)	(0.111)	(0.152)	(0.492)
Shannon index	0.127**	-0.103	0.102	0.475**	0.071
	(0.056)	(0.184)	(0.184)	(0.231)	(0.180)
Area (square)	0.005	-0.011	-0.052**	0.004	-0.003
	(0.010)	(0.021)	(0.022)	(0.025)	(0.030)
Household size (square)	0.028	0.030	0.004	-0.087	0.220**
	(0.028)	(0.057)	(0.049)	(0.063)	(0.099)
Oxen (square)	-0.058	-0.258	-0.079	0.149	-0.204
	(0.060)	(0.286)	(0.090)	(0.111)	(0.291)
Fertilizer (square)	0.036***	0.047	0.032***	0.034***	0.052**
	(0.006)	(0.043)	(0.009)	(0.012)	(0.024)
Hoes (square)	0.018	0.007	0.054	-0.016	-0.072
	(0.034)	(0.089)	(0.050)	(0.068)	(0.164)
Ploughs (square)	0.019	-0.011	0.028	0.044	0.104
	(0.020)	(0.049)	(0.029)	(0.042)	(0.132)
Shannon index (square)	0.006**	0.003	0.001	0.012	-0.011
	(0.003)	(0.009)	(0.006)	(0.012)	(0.013)
Area*Household size	-0.037	0.010	-0.010	-0.003	-0.065
	(0.025)	(0.050)	(0.051)	(0.068)	(0.089)
Area*Oxen	0.087**	0.043	0.082	0.303***	0.004
	(0.037)	(0.081)	(0.066)	(0.088)	(0.183)
Area*Fertilizer	0.004	0.005	-0.016	-0.008	0.004
	(0.007)	(0.031)	(0.014)	(0.016)	(0.027)
Area*Hoes	0.021	-0.024	0.099*	-0.109**	0.116
	(0.028)	(0.074)	(0.056)	(0.055)	(0.091)
Area*Ploughs	0.005	0.033	-0.060	-0.026	-0.005
	(0.021)	(0.043)	(0.038)	(0.051)	(0.111)
Area*Shannon index	0.011	-0.020	0.111	0.131	0.050
	(0.014)	(0.088)	(0.076)	(0.082)	(0.043)
Household size*Oxen	-0.048	-0.097	-0.004	-0.034	-0.113
	(0.062)	(0.148)	(0.098)	(0.118)	(0.358)
Household size*Fertilizer	-0.007	0.083*	0.022	-0.039	0.034
	(0.011)	(0.047)	(0.018)	(0.024)	(0.046)
Household size*Hoes	0.022	0.238*	-0.061	0.032	0.026
	(0.046)	(0.136)	(0.081)	(0.084)	(0.177)
Household size*Ploughs	0.025	-0.056	0.044	0.020	-0.071
	(0.035)	(0.077)	(0.055)	(0.078)	(0.186)
Household size*Shannon index	0.005	0.088	-0.082	-0.020	-0.107
	(0.021)	(0.097)	(0.093)	(0.126)	(0.082)
Oxen*Fertilizer	-0.038***	-0.058	-0.031	-0.044	-0.084
	(0.014)	(0.055)	(0.023)	(0.030)	(0.070)
Oxen*Hoes	-0.032	0.039	-0.043	0.061	0.071
	(0.051)	(0.170)	(0.078)	(0.096)	(0.241)
Oxen*Ploughs	-0.027	-0.111	0.026	-0.154*	-0.035
	(0.038)	(0.101)	(0.056)	(0.079)	(0.233)
Oxen*Shannon index	-0.007	0.185	0.032	-0.131**	0.215
	(0.034)	(0.118)	(0.104)	(0.063)	(0.651)
Fertilizer*Hoes	0.011	0.008	-0.019	0.026	0.085*
	(0.011)	(0.056)	(0.019)	(0.026)	(0.049)
Fertilizer*Ploughs	0.007	-0.027	0.007	-0.015	0.043
	(0.008)	(0.036)	(0.013)	(0.020)	(0.056)
Fertilizer*Shannon index	-0.002	-0.071	0.015	-0.007	0.002
	(0.006)	(0.057)	(0.024)	(0.034)	(0.023)
Hoes*Ploughs	-0.047*	0.046	-0.115***	0.015	-0.048
	(0.026)	(0.066)	(0.038)	(0.057)	(0.135)
Hoes*Shannon index	-0.025	0.078	0.033	-0.411***	0.125
	(0.043)	(0.073)	(0.079)	(0.135)	(0.325)
Ploughs*Shannon index	-0.008	0.001	-0.098*	-0.103	0.200*
	(0.018)	(0.033)	(0.059)	(0.107)	(0.104)
Constant	7.046***	6.158***	6.233***	5.814***	6.117***
	(0.176)	(0.317)	(0.194)	(0.261)	(0.422)
Elasticity of Shannon index	0.116***	0.073	0.009	0.258***	-0.079
p-value	0.001	0.419	0.874	0.001	0.745
Fixed effects					
Village-year fixed effects	✓	✓	✓	✓	✓
Number of households	617	148	237	156	76
Number of observations	3702	888	1422	936	456
R-squared a	0.78	0.742	0.65	0.635	0.476

Notes: N. Highlands refers to Northern Highlands. C. Highlands refers to Central highlands.

Table 3A.35: Parametric translog teff only (Battese transformation, balanced sample)

	All	N. Highlands	C. Highlands	Other	Enset
Fertilizer dummy	-0.168*	-0.034	-0.177	-0.270*	0.038
	(0.096)	(0.402)	(0.157)	(0.149)	(0.295)
Oxen dummy	-0.071*	-0.121	-0.011	-0.06	-0.012
	(0.040)	(0.097)	(0.081)	(0.066)	(0.096)
Hoe dummy	-0.026	0.051	-0.048	-0.084	0.075
	(0.037)	(0.086)	(0.070)	(0.054)	(0.119)
Plough dummy	-0.066	0.106	0.014	-0.063	-0.185*
	(0.048)	(0.114)	(0.110)	(0.080)	(0.102)
Shannon index dummy	-0.406***	-0.314**	-0.116	-0.335***	-0.607***
	(0.057)	(0.145)	(0.112)	(0.127)	(0.170)
Area	0.616***	0.474***	0.652***	0.748***	0.376
	(0.072)	(0.165)	(0.187)	(0.198)	(0.237)
Household size	-0.017	-0.028	-0.086	0.420*	-1.465***
	(0.130)	(0.308)	(0.284)	(0.225)	(0.485)
Oxen	0.262	0.285	0.231	-0.127	1.228
	(0.170)	(0.493)	(0.398)	(0.257)	(1.065)
Fertilizer	-0.063	0.182	-0.112	-0.03	-0.331
	(0.057)	(0.397)	(0.089)	(0.085)	(0.227)
Hoes	-0.088	-0.640**	-0.062	0.007	0.805
	(0.123)	(0.317)	(0.263)	(0.191)	(0.541)
Ploughs	-0.031	0.337	-0.099	0.016	-0.511
	(0.099)	(0.242)	(0.193)	(0.152)	(0.645)
Shannon index	0.108	0.474	-0.201	0.699**	0.471**
	(0.101)	(0.417)	(0.281)	(0.316)	(0.223)
Area (square)	0.027**	0.065*	-0.051	-0.101**	0.013
	(0.014)	(0.038)	(0.050)	(0.047)	(0.048)
Household size (square)	0.039	0.071	-0.011	-0.129*	0.370***
	(0.041)	(0.111)	(0.092)	(0.076)	(0.126)
Oxen (square)	-0.048	-0.473	0.065	0.075	-0.192
	(0.077)	(0.356)	(0.244)	(0.103)	(0.488)
Fertilizer (square)	0.029***	-0.086	0.022*	0.021*	0.059**
	(0.008)	(0.077)	(0.013)	(0.011)	(0.030)
Hoes (square)	0.016	-0.092	0.200**	-0.001	-0.572**
	(0.045)	(0.118)	(0.092)	(0.064)	(0.223)
Ploughs (square)	0.01	-0.002	0.022	-0.004	0.222
	(0.028)	(0.061)	(0.050)	(0.042)	(0.172)
Shannon index (square)	0.007	0.095***	-0.01	0.213	0.009
	(0.005)	(0.029)	(0.011)	(0.168)	(0.018)
Area*Household size	-0.083**	-0.103	-0.003	0.079	-0.069
	(0.038)	(0.102)	(0.105)	(0.110)	(0.112)
Area*Oxen	0.148***	0.129	0.063	0.286***	0.326
	(0.055)	(0.121)	(0.148)	(0.090)	(0.308)
Area*Fertilizer	-0.001	-0.02	-0.028	-0.072***	0.022
	(0.010)	(0.050)	(0.024)	(0.022)	(0.038)
Area*Hoes	0.034	0.012	0.098	-0.031	0.363***
	(0.039)	(0.116)	(0.095)	(0.078)	(0.132)
Area*Ploughs	0.019	0.051	-0.041	0.05	-0.01
	(0.030)	(0.072)	(0.067)	(0.070)	(0.133)
Area*Shannon index	-0.001	-0.131	-0.244	0.155	0.206
	(0.032)	(0.132)	(0.166)	(0.130)	(0.221)
Household size*Oxen	0.05	0.169	0.076	0.038	-0.017
	(0.083)	(0.228)	(0.194)	(0.114)	(0.565)
Household size*Fertilizer	-0.030**	0.028	0.032	-0.028	0.048
	(0.014)	(0.106)	(0.027)	(0.025)	(0.061)
Household size*Hoes	0.049	0.373*	0.009	-0.028	0.117
	(0.059)	(0.194)	(0.143)	(0.085)	(0.223)
Household size*Ploughs	0.006	-0.182	0.049	-0.018	-0.044
	(0.049)	(0.130)	(0.100)	(0.083)	(0.204)
Household size*Shannon index	0.046	-0.094	0.148	-0.057	-0.134
	(0.058)	(0.265)	(0.157)	(0.158)	(0.185)
Oxen*Fertilizer	-0.043**	0.089	-0.04	-0.009	-0.136
	(0.018)	(0.105)	(0.035)	(0.028)	(0.112)
Oxen*Hoes	-0.052	-0.129	-0.225*	-0.017	-0.166
	(0.064)	(0.217)	(0.134)	(0.093)	(0.382)
Oxen*Ploughs	0.016	0.052	0.104	-0.051	-0.104
	(0.050)	(0.131)	(0.099)	(0.077)	(0.353)
Oxen*Shannon index	0.063	-0.07	0.114	-0.006	-0.379
	(0.094)	(0.255)	(0.205)	(0.157)	(0.820)
Fertilizer*Hoes	0.017	0.109	-0.005	0.033	0.028
	(0.014)	(0.092)	(0.025)	(0.026)	(0.062)
Fertilizer*Ploughs	0.003	-0.140*	0	0.014	0.062
	(0.011)	(0.079)	(0.019)	(0.020)	(0.074)
Fertilizer*Shannon index	-0.002	-0.145	-0.003	-0.047	0.049
	(0.016)	(0.096)	(0.038)	(0.037)	(0.094)
Hoes*Ploughs	-0.026	0.113	-0.171***	0.003	0.052
	(0.034)	(0.079)	(0.063)	(0.059)	(0.170)
Hoes*Shannon index	0.011	0.054	-0.022	-0.334**	0.076
	(0.057)	(0.085)	(0.138)	(0.140)	(0.400)
Ploughs*Shannon index	-0.043	0.142	-0.02	-0.078	0.325
	(0.033)	(0.096)	(0.104)	(0.118)	(0.299)
Constant	6.033***	5.599***	6.456***	5.294***	6.174***
	(0.572)	(0.480)	(0.381)	(0.281)	(0.646)
Elasticity of Shannon index	0.184***	0.329***	0.009	0.370***	0.200
p-value	0.000	0.004	0.923	0.000	0.473
Fixed effects					
Village-year fixed effects	✓	✓	✓	✓	✓
Number of households	400	85	118	125	72
Number of observations	1882	384	483	712	303
R-squared a	0.766	0.485	0.726	0.692	0.536

Notes: N. Highlands refers to Northern Highlands. C. Highlands refers to Central highlands.

Table 3A.36: Parametric translog no teff (Battese transformation, balanced sample)

	All	N. Highlands	C. Highlands	Other	Enset
Fertilizer dummy	-0.277**	-0.973**	-0.25	-0.553	-0.046
	(0.124)	(0.414)	(0.188)	(0.466)	(0.374)
Oxen dummy	-0.102***	-0.154**	-0.069	-0.296**	0.043
	(0.039)	(0.070)	(0.059)	(0.115)	(0.186)
Hoe dummy	0.000	0.118*	-0.041	-0.039	-0.247
	(0.038)	(0.060)	(0.063)	(0.138)	(0.165)
Plough dummy	-0.06	-0.034	-0.079	-0.024	-0.159
	(0.044)	(0.078)	(0.069)	(0.138)	(0.157)
Shannon index dummy	-0.153***	-0.164	-0.179**	-0.362*	1.494
	(0.052)	(0.101)	(0.090)	(0.207)	(1.254)
Area	0.553***	0.257	0.669***	0.356	0.900**
	(0.078)	(0.232)	(0.128)	(0.349)	(0.367)
Household size	-0.005	0.067	-0.008	0.137	-0.074
	(0.123)	(0.232)	(0.191)	(0.656)	(0.577)
Oxen	0.606***	0.908	0.522**	1.788	-0.102
	(0.190)	(0.731)	(0.245)	(1.401)	(1.253)
Fertilizer	-0.189***	-0.611*	-0.176*	-0.414	0.302
	(0.073)	(0.335)	(0.097)	(0.318)	(0.406)
Hoes	0.193	-0.661	0.601***	-0.133	0.962
	(0.173)	(0.707)	(0.222)	(0.728)	(0.709)
Ploughs	-0.027	0.331	-0.099	0.409	-0.092
	(0.112)	(0.308)	(0.140)	(0.479)	(1.713)
Shannon index	0.044	-0.121	0.238	-0.085	-3.533
	(0.102)	(0.408)	(0.333)	(0.758)	(2.790)
Area (square)	-0.018	-0.075	-0.045*	0.064	-0.016
	(0.016)	(0.057)	(0.027)	(0.076)	(0.052)
Household size (square)	0.019	0.040	0.021	0.032	-0.027
	(0.040)	(0.069)	(0.061)	(0.207)	(0.212)
Oxen (square)	-0.020	-0.210	-0.117	2.776*	-0.964
	(0.094)	(0.586)	(0.104)	(1.586)	(0.678)
Fertilizer (square)	0.036***	0.070	0.042***	0.093*	-0.006
	(0.010)	(0.060)	(0.013)	(0.047)	(0.068)
Hoes (square)	0.005	0.116	0.007	-0.082	0.120
	(0.054)	(0.178)	(0.064)	(0.319)	(0.285)
Ploughs (square)	0.018	-0.013	0.023	0.222	-0.113
	(0.031)	(0.090)	(0.036)	(0.173)	(0.300)
Shannon index (square)	-0.006	0.011	0.106	0.019	-0.187
	(0.007)	(0.017)	(0.128)	(0.027)	(0.250)
Area*Household size	-0.023	0.033	0.025	0.109	-0.328*
	(0.038)	(0.088)	(0.067)	(0.178)	(0.184)
Area*Oxen	0.020	-0.068	0.036	-0.071	0.304
	(0.056)	(0.183)	(0.080)	(0.583)	(0.458)
Area*Fertilizer	0.017	0.066	-0.021	-0.051	0.087
	(0.012)	(0.059)	(0.020)	(0.044)	(0.053)
Area*Hoes	0.083*	0.015	0.193**	-0.068	0.138
	(0.047)	(0.169)	(0.077)	(0.171)	(0.151)
Area*Ploughs	0.000	0.063	-0.047	0.065	-0.107
	(0.034)	(0.086)	(0.051)	(0.159)	(0.599)
Area*Shannon index	0.054**	-0.194	0.229**	-0.054	-0.136
	(0.024)	(0.190)	(0.102)	(0.225)	(0.978)
Household size*Oxen	-0.188**	-0.260	-0.085	-2.053	1.325**
	(0.094)	(0.225)	(0.120)	(1.269)	(0.653)
Household size*Fertilizer	0.018	0.086	0.004	-0.036	-0.075
	(0.016)	(0.061)	(0.025)	(0.074)	(0.151)
Household size*Hoes	-0.007	0.309	-0.069	0.021	-0.693**
	(0.081)	(0.298)	(0.105)	(0.342)	(0.342)
Household size*Ploughs	0.031	-0.093	0.025	-0.143	-0.225
	(0.051)	(0.111)	(0.071)	(0.282)	(0.631)
Household size*Shannon index	-0.044	-0.003	-0.069	0.227	0.123
	(0.030)	(0.183)	(0.132)	(0.373)	(1.693)
Oxen*Fertilizer	-0.021	-0.086	-0.020	0.092	-0.329
	(0.022)	(0.078)	(0.032)	(0.258)	(0.268)
Oxen*Hoes	-0.057	0.070	0.048	0.055	-0.880*
	(0.084)	(0.463)	(0.102)	(0.600)	(0.473)
Oxen*Ploughs	-0.070	-0.402*	-0.058	-0.964	-0.724
	(0.062)	(0.240)	(0.076)	(0.796)	(0.750)
Oxen*Shannon index	-0.060	0.244	-0.095	-0.243*	0.000
	(0.045)	(0.238)	(0.133)	(0.128)	.
Fertilizer*Hoes	-0.009	-0.096	-0.062**	0.053	0.294***
	(0.021)	(0.108)	(0.029)	(0.089)	(0.104)
Fertilizer*Ploughs	0.014	-0.009	0.023	-0.077	0.165
	(0.015)	(0.048)	(0.019)	(0.058)	(0.220)
Fertilizer*Shannon index	0.036**	-0.003	0.021	0.049	-0.129
	(0.017)	(0.086)	(0.034)	(0.099)	(0.657)
Hoes*Ploughs	-0.071*	-0.026	-0.069	-0.128	0.460
	(0.042)	(0.174)	(0.051)	(0.172)	(0.595)
Hoes*Shannon index	-0.114	-0.461	0.127	-0.633	-1.44
	(0.087)	(0.390)	(0.109)	(0.604)	(2.561)
Ploughs*Shannon index	0.020	0.039	-0.150*	-0.045	0.036
	(0.025)	(0.052)	(0.082)	(0.351)	(1.385)
Constant	7.009***	6.694***	6.184***	6.921***	3.954***
	(0.231)	(0.513)	(0.281)	(0.816)	(1.428)
Elasticity of Shannon index	0.003	0.076	0.154	0.273	-3.757
p-value	0.97	0.729	0.375	0.373	0.248
Fixed effects					
Village-year fixed effects	✓	✓	✓	✓	✓
Number of households	419	108	188	57	66
Number of observations	1820	504 f	939	224	153
R-squared a	0.792	0.731	0.611	0.476	0.524

Notes: N. Highlands refers to Northern Highlands. C. Highlands refers to Central highlands.

Table 3A.37: Semi-parametric model: Parametric component (Full sample), Balanced sample

	All	Teff	No teff
Area	0.608***	0.479***	0.689***
	(0.088)	(0.148)	(0.146)
Household size	-0.215	-0.261	-0.285
	(0.143)	(0.356)	(0.264)
Oxen	0.011	0.004	0.004
	(0.009)	(0.021)	(0.014)
Fertilizer	-0.003	-0.005	-0.001
	(0.009)	(0.024)	(0.014)
Hoes	0.003	0.009	0.017
	(0.009)	(0.021)	(0.013)
Ploughs	0.003	0.007	0.023
	(0.011)	(0.029)	(0.018)
Area (square)	-0.003	0.070	-0.210***
	(0.031)	(0.063)	(0.051)
Household size (square)	0.169*	0.192	0.286*
	(0.091)	(0.203)	(0.164)
Oxen (square)	0.050	0.088	-0.057
	(0.063)	(0.237)	(0.101)
Fertilizer (square)	0.011**	-0.017	0.014*
	(0.005)	(0.026)	(0.008)
Hoes (square)	0.033	-0.162*	0.085**
	(0.033)	(0.083)	(0.038)
Ploughs (square)	0.022	0.085**	0.011
	(0.019)	(0.037)	(0.026)
Area*Household size	-0.055	0.025	-0.081
	(0.046)	(0.078)	(0.079)
Area*Oxen	0.000	0.002	0.003
	(0.003)	(0.006)	(0.005)
Area*Fertilizer	-0.001	-0.003	-0.002
	(0.003)	(0.006)	(0.005)
Area*Hoes	0.007***	0.008*	0.000
	(0.003)	(0.005)	(0.005)
Area*Ploughs	-0.001	0.004	-0.005
	(0.003)	(0.005)	(0.006)
Household size*Oxen	-0.003	-0.009	0.003
	(0.005)	(0.011)	(0.008)
Household size*Fertilizer	0.003	0.005	0.004
	(0.004)	(0.012)	(0.007)
Household size*Hoes	0.000	0.010	-0.003
	(0.005)	(0.009)	(0.007)
Household size*Ploughs	-0.008	-0.016	-0.015*
	(0.005)	(0.010)	(0.009)
Oxen*Fertilizer	0.000	-0.002**	0.000
	(0.000)	(0.001)	(0.000)
Oxen*Hoes	0.000	0.000	0.001
	(0.000)	(0.001)	(0.000)
Oxen*Ploughs	-0.001*	0.000	0.000
	(0.000)	(0.001)	(0.001)
Fertilizer*Hoes	0.000	0.002**	-0.001
	(0.000)	(0.001)	(0.000)
Fertilizer*Ploughs	0.001***	0.000	0.001
	(0.000)	(0.001)	(0.001)
Hoes*Ploughs	-0.001*	0.000	-0.001
	(0.000)	(0.001)	(0.001)
Village-year fixed effects	✓	✓	✓
Number of observations	3085	1503	1582
Number of households	617	419	400
R-squared a	0.475	0.567	0.389

Table 3A.38: Semi-parametric model: Parametric component (Northern Highlands), Balanced sample

	All	Teff	No teff
Area	0.439*	0.537*	0.720***
	(0.239)	(0.296)	(0.134)
Household size	0.200	-0.178	-0.009
	(0.269)	(0.600)	(0.196)
Oxen	0.000	0.021	0.016
	(0.017)	(0.036)	(0.012)
Fertilizer	0.000	-0.012	0.003
	(0.018)	(0.030)	(0.012)
Hoes	0.031*	-0.060	0.001
	(0.017)	(0.037)	(0.012)
Ploughs	-0.033	-0.027	-0.012
	(0.023)	(0.039)	(0.016)
Area (square)	-0.007	0.044	0.031
	(0.080)	(0.066)	(0.050)
Household size (square)	-0.146	0.237	0.032
	(0.185)	(0.300)	(0.124)
Oxen (square)	0.089	0.085	0.140*
	(0.102)	(0.211)	(0.082)
Fertilizer (square)	0.000	0.008	0.006
	(0.008)	(0.022)	(0.007)
Hoes (square)	0.048	0.134	0.011
	(0.076)	(0.162)	(0.042)
Ploughs (square)	0.023	0.039	0.015
	(0.037)	(0.136)	(0.028)
Area*Household size	-0.008	-0.096	-0.131*
	(0.122)	(0.136)	(0.067)
Area*Oxen	-0.004	0.000	0.002
	(0.006)	(0.009)	(0.004)
Area*Fertilizer	0.003	-0.004	-0.005
	(0.004)	(0.007)	(0.004)
Area*Hoes	0.004	0.002	0.006
	(0.005)	(0.009)	(0.004)
Area*Ploughs	0.003	-0.008	-0.005
	(0.007)	(0.010)	(0.004)
Household size*Oxen	0.003	-0.012	-0.006
	(0.010)	(0.016)	(0.007)
Household size*Fertilizer	0.001	0.014	0.002
	(0.009)	(0.014)	(0.006)
Household size*Hoes	-0.013	0.026	-0.001
	(0.009)	(0.016)	(0.007)
Household size*Ploughs	0.010	-0.005	-0.002
	(0.011)	(0.017)	(0.007)
Oxen*Fertilizer	0.000	0.002*	0.000
	(0.001)	(0.001)	(0.000)
Oxen*Hoes	0.000	0.001	0.000
	(0.000)	(0.001)	(0.000)
Oxen*Ploughs	-0.001*	-0.002*	0.000
	(0.001)	(0.001)	(0.001)
Fertilizer*Hoes	0.000	0.000	0.000
	(0.001)	(0.001)	(0.000)
Fertilizer*Ploughs	0.001	-0.001	0.001
	(0.001)	(0.001)	(0.000)
Hoes*Ploughs	0.000	-0.001	-0.001**
	(0.001)	(0.001)	(0.001)
Village-year fixed effects	✓	✓	✓
Number of observations	740	413	327
Number of households	148	108	85
R-squared a	0.527	0.442	0.479

Table 3A.39: Semi-parametric model: Parametric component (Central Highlands), Balanced sample

	All	Teff	No teff
Area	0.404	0.732***	0.694**
	(0.288)	(0.197)	(0.309)
Household size	-0.386	-0.269	0.686**
	(0.635)	(0.335)	(0.277)
Oxen	0.046	-0.013	-0.013
	(0.030)	(0.022)	(0.020)
Fertilizer	-0.003	0.015	0.003
	(0.035)	(0.023)	(0.019)
Hoes	0.044	0.024	0.024
	(0.042)	(0.021)	(0.019)
Ploughs	-0.006	-0.015	-0.018
	(0.054)	(0.033)	(0.029)
Area (square)	0.080	-0.209**	-0.178
	(0.106)	(0.105)	(0.146)
Household size (square)	0.349	0.247	-0.402*
	(0.388)	(0.192)	(0.213)
Oxen (square)	0.121	0.083	0.065
	(0.267)	(0.171)	(0.105)
Fertilizer (square)	-0.061**	0.021*	0.000
	(0.026)	(0.012)	(0.009)
Hoes (square)	-0.148*	-0.006	0.044
	(0.085)	(0.062)	(0.082)
Ploughs (square)	0.094*	-0.008	0.019
	(0.050)	(0.045)	(0.040)
Area*Household size	-0.009	-0.087	-0.048
	(0.157)	(0.104)	(0.179)
Area*Oxen	0.006	0.007	0.007
	(0.009)	(0.007)	(0.010)
Area*Fertilizer	-0.007	0.004	-0.015**
	(0.007)	(0.008)	(0.007)
Area*Hoes	-0.004	0.004	-0.001
	(0.009)	(0.007)	(0.009)
Area*Ploughs	0.008	-0.026**	0.002
	(0.009)	(0.011)	(0.011)
Household size*Oxen	-0.018	0.014	0.007
	(0.017)	(0.012)	(0.012)
Household size*Fertilizer	0.014	-0.009	0.005
	(0.018)	(0.012)	(0.010)
Household size*Hoes	0.016	-0.014	-0.010
	(0.017)	(0.013)	(0.010)
Household size*Ploughs	-0.040**	0.003	0.002
	(0.018)	(0.013)	(0.013)
Oxen*Fertilizer	0.001	0.001	-0.001
	(0.001)	(0.001)	(0.001)
Oxen*Hoes	0.000	0.000	0.000
	(0.001)	(0.001)	(0.001)
Oxen*Ploughs	0.003*	0.001	-0.001
	(0.001)	(0.001)	(0.001)
Fertilizer*Hoes	0.005***	0.000	0.000
	(0.001)	(0.001)	(0.001)
Fertilizer*Ploughs	-0.005***	0.001	0.000
	(0.002)	(0.001)	(0.001)
Hoes*Ploughs	-0.001	-0.003***	0.000
	(0.001)	(0.001)	(0.001)
Village-year fixed effects	✓	✓	✓
Number of observations	1185	785	400
Number of households	237	188	118
R-squared a	0.340	0.422	0.562

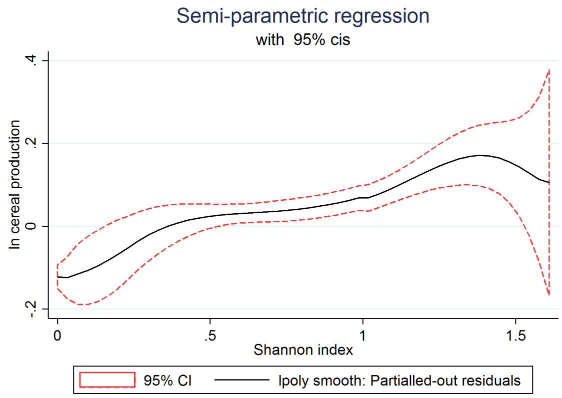
Table 3A.40: Semi-parametric model: Parametric component (Arusi/Bale (Other)), Balanced sample

	All	Teff	No teff
Area	0.981**	0.563***	0.858***
	(0.391)	(0.110)	(0.275)
Household size	-0.563	-0.221	-0.424
	(0.794)	(0.224)	(0.465)
Oxen	0.048	0.004	-0.013
	(0.039)	(0.014)	(0.029)
Fertilizer	-0.011	-0.008	0.014
	(0.043)	(0.014)	(0.045)
Hoes	-0.075	0.011	0.004
	(0.047)	(0.012)	(0.028)
Ploughs	-0.025	0.018	0.013
	(0.045)	(0.016)	(0.035)
Area (square)	0.120	-0.046	0.016
	(0.091)	(0.040)	(0.127)
Household size (square)	0.228	0.186	0.156
	(0.349)	(0.139)	(0.263)
Oxen (square)	0.432	-0.035	-0.053
	(0.261)	(0.110)	(0.412)
Fertilizer (square)	0.004	0.014	-0.008
	(0.025)	(0.009)	(0.046)
Hoes (square)	0.280	0.069	-0.171
	(0.211)	(0.052)	(0.251)
Ploughs (square)	0.003	0.042	0.088
	(0.145)	(0.028)	(0.091)
Area*Household size	-0.281	-0.017	-0.104
	(0.172)	(0.056)	(0.105)
Area*Oxen	-0.003	0.000	0.014
	(0.010)	(0.004)	(0.011)
Area*Fertilizer	-0.015	0.004	0.003
	(0.009)	(0.004)	(0.012)
Area*Hoes	0.004	0.008**	0.008
	(0.012)	(0.004)	(0.009)
Area*Ploughs	-0.002	0.006	0.008
	(0.011)	(0.004)	(0.009)
Household size*Oxen	-0.026	-0.001	-0.007
	(0.016)	(0.007)	(0.012)
Household size*Fertilizer	0.011	0.006	-0.005
	(0.020)	(0.006)	(0.019)
Household size*Hoes	0.032	-0.001	0.011
	(0.019)	(0.006)	(0.012)
Household size*Ploughs	-0.006	-0.014*	-0.009
	(0.021)	(0.008)	(0.012)
Oxen*Fertilizer	0.003**	-0.001*	-0.004***
	(0.001)	(0.000)	(0.001)
Oxen*Hoes	0.001	0.000	0.000
	(0.001)	(0.000)	(0.001)
Oxen*Ploughs	-0.002*	-0.001**	-0.002*
	(0.001)	(0.001)	(0.001)
Fertilizer*Hoes	-0.001	0.001**	0.002**
	(0.001)	(0.000)	(0.001)
Fertilizer*Ploughs	0.001	0.001	0.001
	(0.001)	(0.000)	(0.002)
Hoes*Ploughs	-0.002	0.000	0.000
	(0.001)	(0.001)	(0.001)
Village-year fixed effects	✓	✓	✓
Number of observations	780	190	590
Number of households	156	57	125
R-squared a	0.555	0.487	0.669

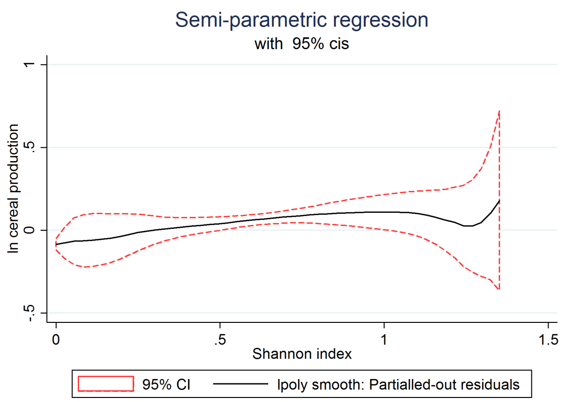
Table 3A.41: Semi-parametric model: Parametric component (Enset), Balanced sample

	All	Teff	No teff
Area	0.703***	0.404	0.369
	(0.188)	(0.377)	(0.526)
Household size	-0.215	-0.769	-1.412
	(0.365)	(0.854)	(1.579)
Oxen	0.009	0.019	-0.017
	(0.019)	(0.038)	(0.056)
Fertilizer	0.001	-0.025	-0.004
	(0.017)	(0.045)	(0.125)
Hoes	0.028*	0.057	-0.032
	(0.017)	(0.035)	(0.077)
Ploughs	0.024	-0.017	0.035
	(0.023)	(0.036)	(0.062)
Area (square)	-0.248***	0.170	-0.011
	(0.059)	(0.159)	(0.115)
Household size (square)	0.258	0.259	1.086
	(0.231)	(0.549)	(0.850)
Oxen (square)	-0.112	0.313	-0.796
	(0.122)	(0.542)	(0.601)
Fertilizer (square)	0.015	0.014	-0.016
	(0.009)	(0.031)	(0.057)
Hoes (square)	0.127***	0.085	-0.134
	(0.048)	(0.202)	(0.352)
Ploughs (square)	0.034	0.018	0.017
	(0.032)	(0.130)	(0.218)
Area*Household size	-0.076	0.022	0.004
	(0.101)	(0.189)	(0.213)
Area*Oxen	0.001	-0.016	0.004
	(0.008)	(0.012)	(0.013)
Area*Fertilizer	-0.006	0.009	0.010
	(0.007)	(0.008)	(0.017)
Area*Hoes	-0.003	0.015	0.003
	(0.006)	(0.011)	(0.017)
Area*Ploughs	0.002	0.015	-0.007
	(0.007)	(0.011)	(0.013)
Household size*Oxen	-0.001	-0.012	0.006
	(0.011)	(0.021)	(0.028)
Household size*Fertilizer	0.004	0.014	0.025
	(0.009)	(0.016)	(0.057)
Household size*Hoes	-0.004	-0.023	0.028
	(0.010)	(0.017)	(0.035)
Household size*Ploughs	-0.019	0.006	-0.018
	(0.012)	(0.024)	(0.031)
Oxen*Fertilizer	0.001	0.000	0.001
	(0.001)	(0.001)	(0.002)
Oxen*Hoes	0.002***	0.000	0.000
	(0.001)	(0.001)	(0.002)
Oxen*Ploughs	-0.001*	-0.002	0.002
	(0.001)	(0.001)	(0.003)
Fertilizer*Hoes	-0.001	0.000	0.002
	(0.001)	(0.001)	(0.003)
Fertilizer*Ploughs	0.001	0.002*	-0.005**
	(0.001)	(0.001)	(0.002)
Hoes*Ploughs	-0.001	0.000	-0.001
	(0.001)	(0.002)	(0.002)
Village-year fixed effects	✓	✓	✓
Number of observations	380	115	265
Number of households	76	66	72
R-squared a	0.395	0.476	0.196

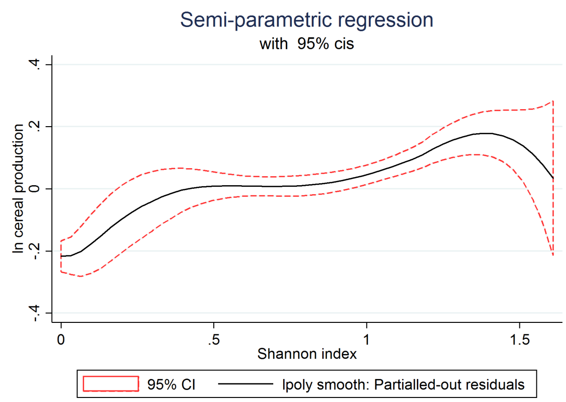
Figure 3A.18: Effect of Shannon index Semi parametric Full sample (Balanced sample)



(a) Full sample

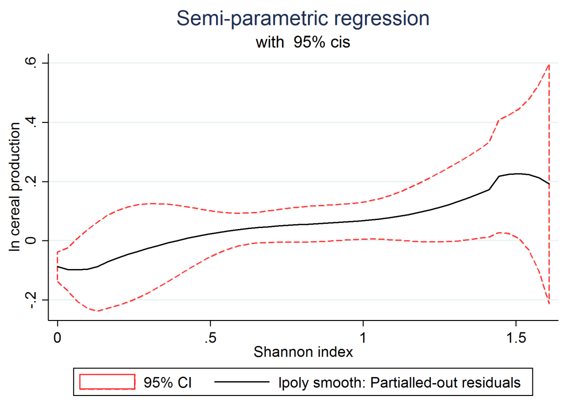


(b) Non teff-producing households

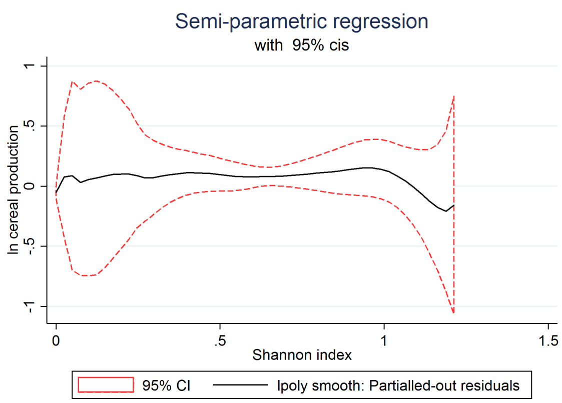


(c) Teff-producing households

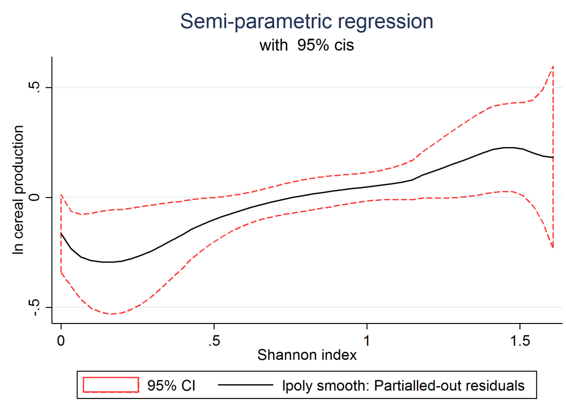
Figure 3A.19: Effect of Shannon index Semi parametric Northern Highlands (Balanced sample)



(a) Full sample

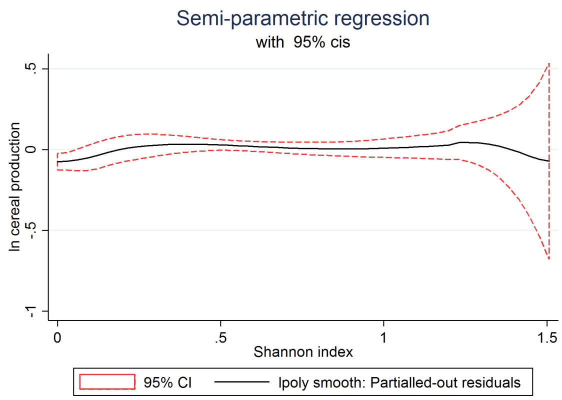


(b) Non teff-producing households

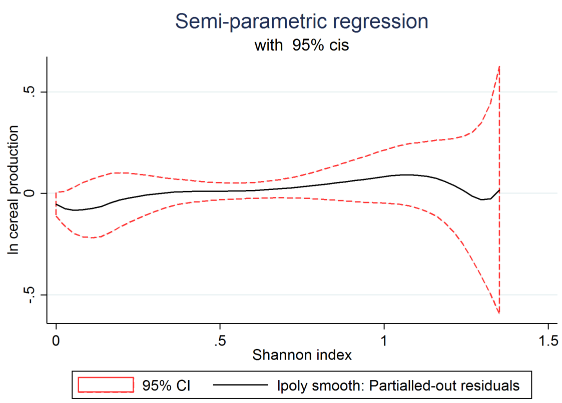


(c) Teff-producing households

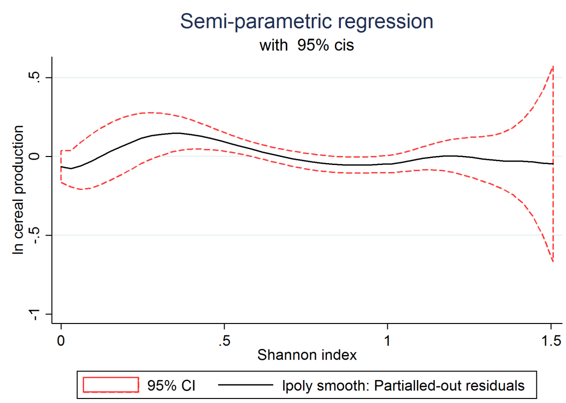
Figure 3A.20: Effect of Shannon index Semi parametric Central Highlands (Balanced sample)



(a) Full sample

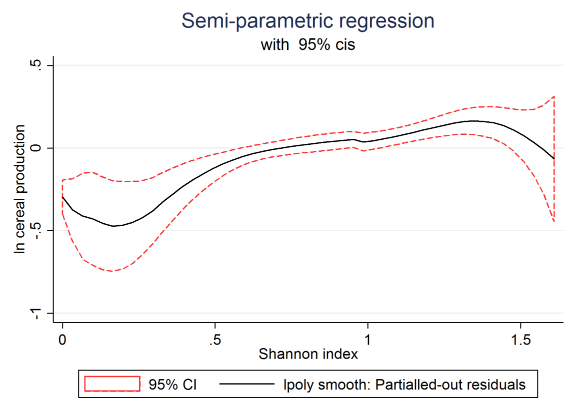


(b) Non teff-producing households

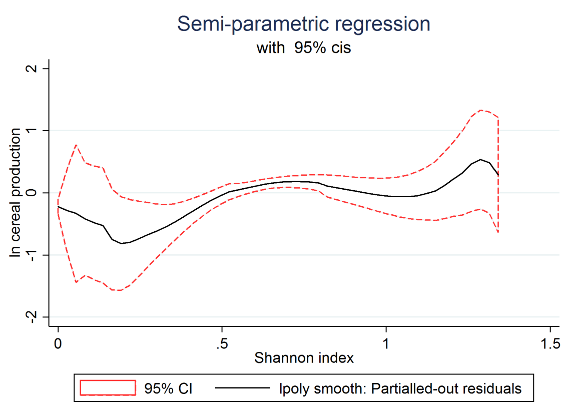


(c) Teff-producing households

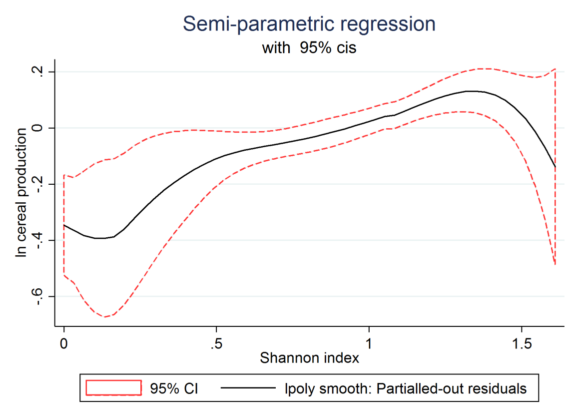
Figure 3A.21: Effect of Shannon index Semi parametric Arussi/Bale (Balanced sample)



(a) Full sample

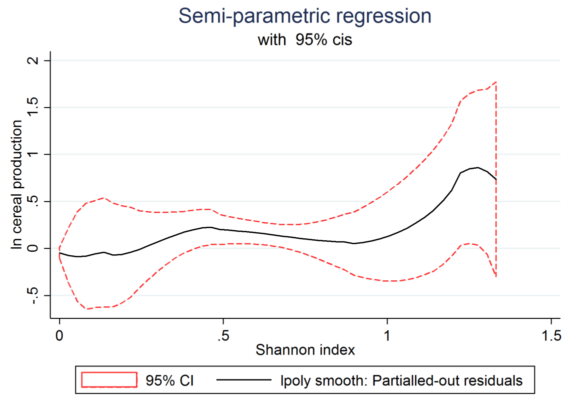


(b) Non teff-producing households

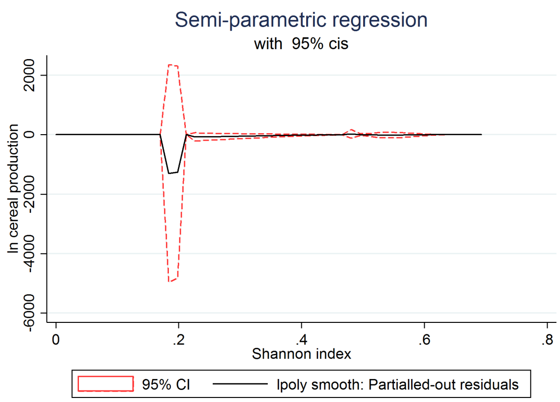


(c) Teff-producing households

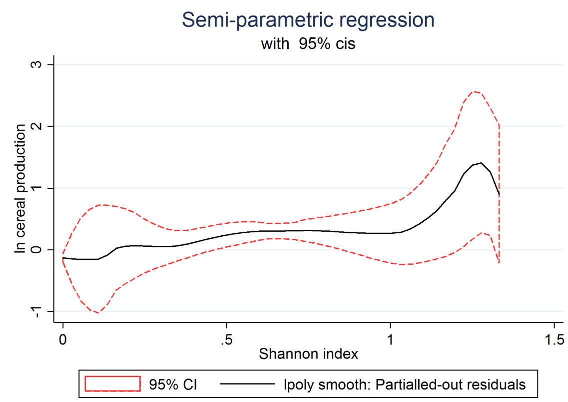
Figure 3A.22: Effect of Shannon index Semi parametric Enset (Balanced sample)



(a) Full sample

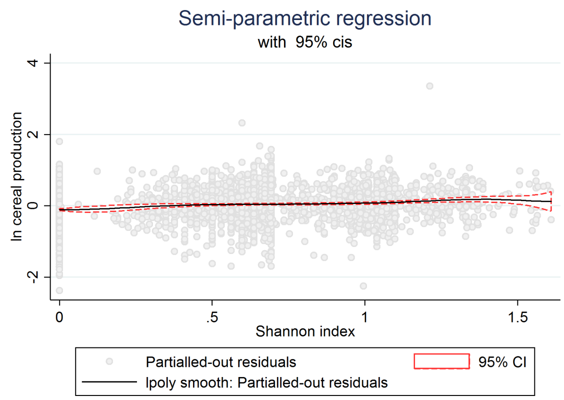


(b) Non teff-producing households

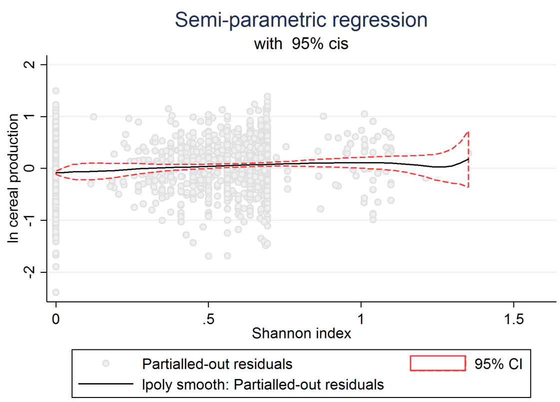


(c) Teff-producing households

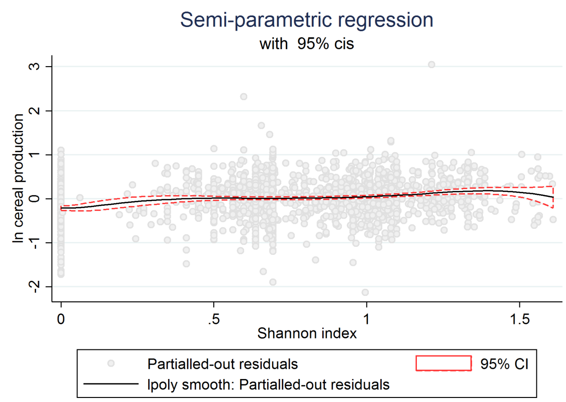
Figure 3A.23: Effect of Shannon index Semi parametric Full sample (Balanced sample, with scatter)



(a) Full sample

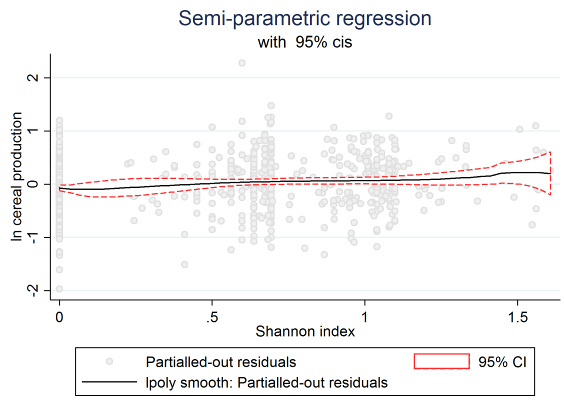


(b) Non teff-producing households

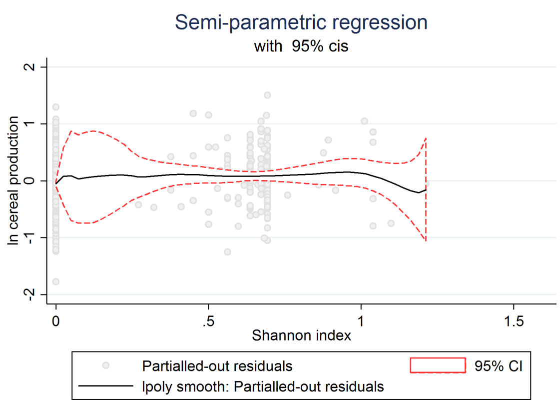


(c) Teff-producing households

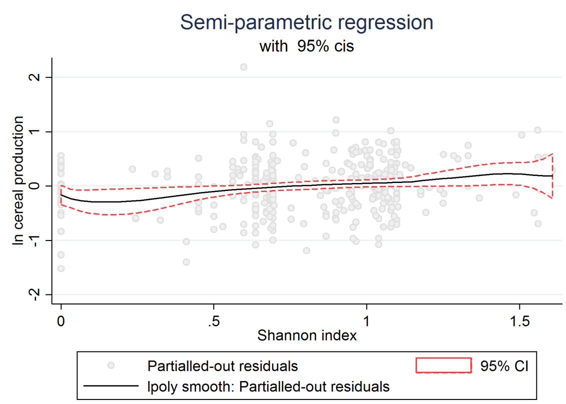
Figure 3A.24: Effect of Shannon index Semi parametric Northern Highlands (Balanced sample, with scatter)



(a) Full sample

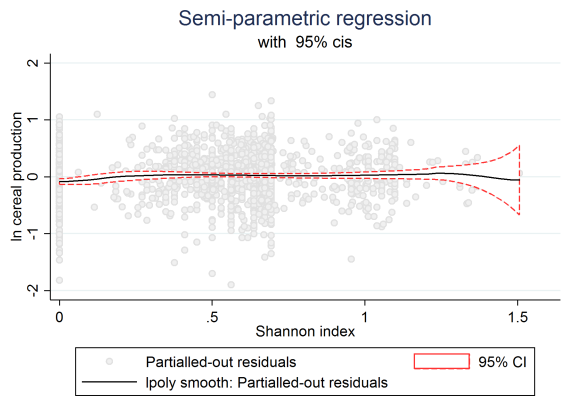


(b) Non teff-producing households

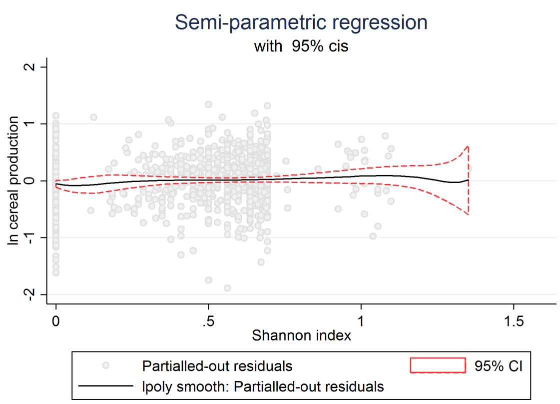


(c) Teff-producing households

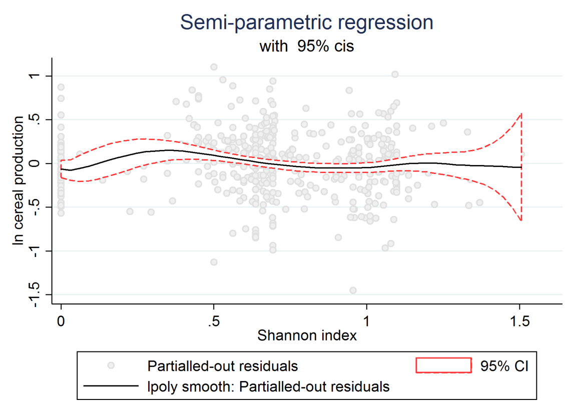
Figure 3A.25: Effect of Shannon index Semi parametric Central Highlands (Balanced sample, with scatter)



(a) Full sample

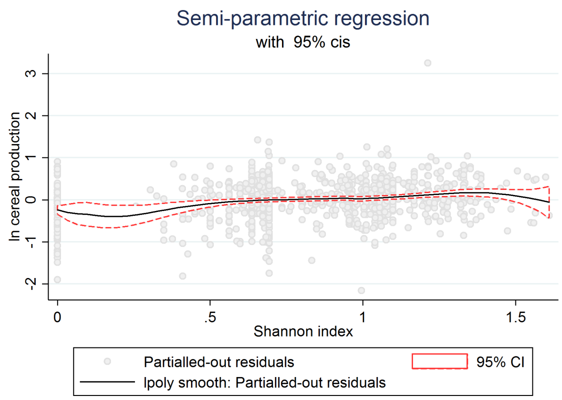


(b) Non teff-producing households

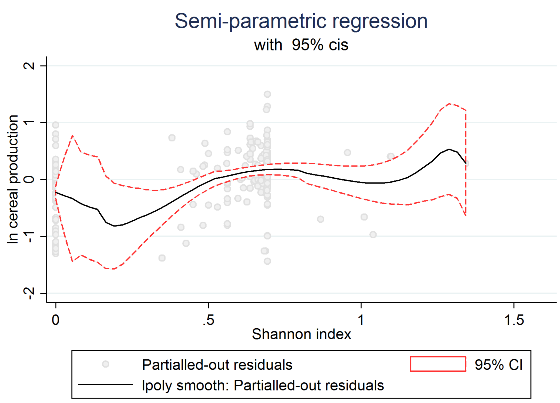


(c) Teff-producing households

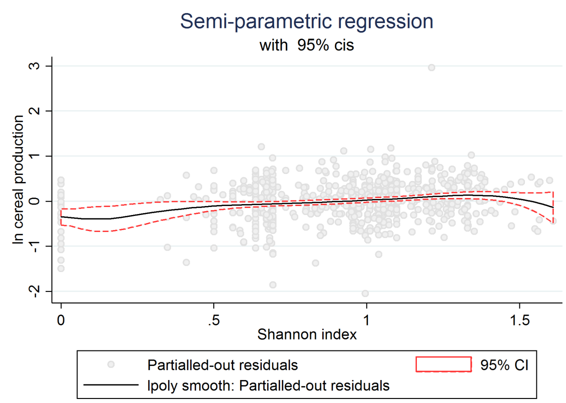
Figure 3A.26: Effect of Shannon index Semi parametric Arussi/Bale (Balanced sample, with scatter)



(a) Full sample

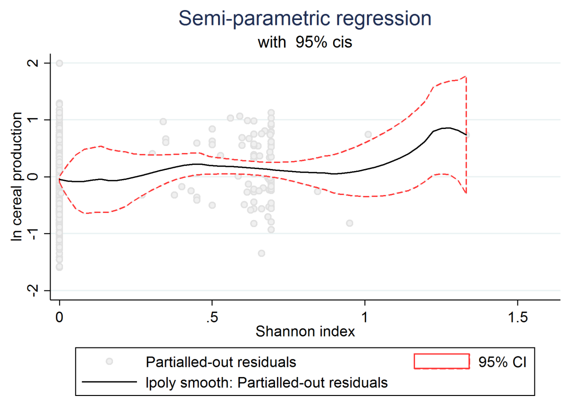


(b) Non teff-producing households

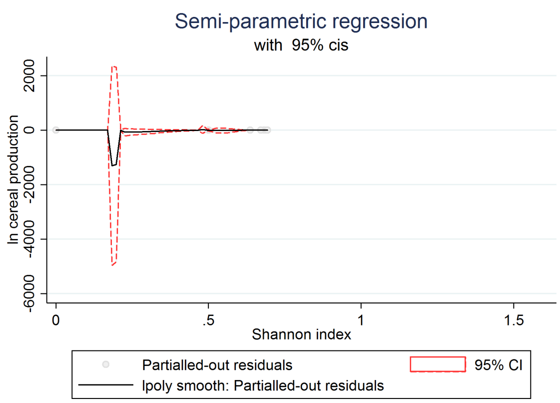


(c) Teff-producing households

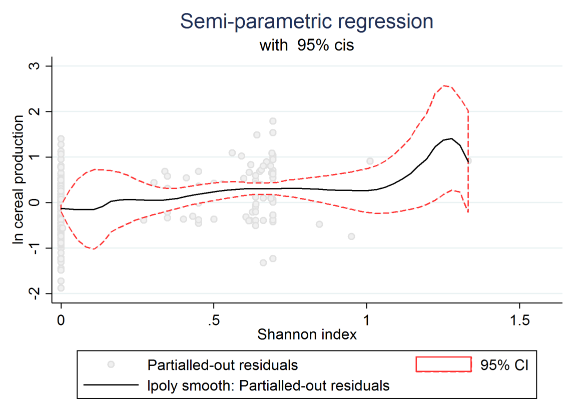
Figure 3A.27: Effect of Shannon index Semi parametric Enset (Balanced sample, with scatter)



(a) Full sample



(b) Non teff-producing households



(c) Teff-producing households

Table 3A.42: Bandwidth choice - (no imputed values)

	All	N. Highlands	C. Highlands	Other	Enset
Main	0.45	0.64	0.54	0.43	0.39
No teff	0.37	0.28	0.41	0.37	0.21
Teff	0.53	0.52	0.45	0.48	0.32

B Appendix B - Data preparation and Battese correction

B.1 Data preparation

This section summarizes the steps involved in the data preparation and spells out the assumptions that were made in order to create the variables used in the paper.

Step 1: Production variables

- **Step 1.1:** We open each of the data files containing the production aggregates and we change the suffix of each variable, such that the production and area variables end in "ha" and "prd". We then generate a year variable which is equal to the year of the wave. We thus end up with six .dta files corresponding to the year 1994, 1995, 1997, 1999, 2004 and 2009.

- **Step 1.2:** We then append the six .dta files obtained from step 1.1 and generate the total cereal area and the total cereal production which sums the total cultivated area and production of six cereals, namely white teff, black teff, barley, wheat, maize and sorghum. Note: Note: In 1995, the production for the belg season was reported. We summed the production of the belg season of 1995 to the production of the year when it was collected (i.e. 1995).

Step 2: Number of oxen and household size

- **Step 2.1:** From the data aggregates we keep, for each year, the number of oxen and the household size and, as in step 1.1, we generate a year variable that takes the value of the year of the wave.

- **Step 2.2:** We then append the 6 data files for oxen and the 6 data files for household size.

Step 3: Fertilizer

The process used for fertilizer is slightly different from the other variables and required .do files. This is because fertilizer data was not included in the aggregates.

- **Step 3.1:** In each raw file, we sum the total quantity (in kgs) used across different crops for each plot. When the data in kgs is not available, we convert the quantity of fertilizer used into kilograms, using the conversion factors provided (this is the case for the first wave). Once, the plot-level quantity of fertilizer is obtained, we sum the quantity across all plots for a given household to obtain the total fertilizer used at the household level.

- **Step 3.2:** We then append each of the files obtained Step 3.1 and substitute any negative values by a missing value.

Step 4: Assets

Since most of the asset values are not available in the aggregate files, our procedure to obtain these values is similar to that of fertilizer.

- **Step 4.1:** For each year we compute the number of hoes and ploughs.
- **Step 4.2:** We append each of the .dta files obtained from step 4.1.

Step 5: Shannon index

- **Step 5.1:** We generate the proportion of cereal area dedicated to a given cereal. This is calculated by dividing the cereal allocated to a given cereal (as per the aggregate files) by the total cereal area.
- **Step 5.2:** We multiply the negative of the variable generated in step 5.1 times the natural logarithm of this variable for each individual crop.
- **Step 5.3:** We sum the values obtained in step 5.2 across all 6 cereals used in the analysis.

Step 6: Imputed values

There are a number of variables that are missing. In some cases, we impute some values so as to keep as many observations as possible in the analysis. We check, however, that our results are not driven by the imputed values.

In the cases of household size and the number of oxen, very few used observations are imputed. From a total of 5,804 observations, we impute four values in the case of household size and one in the case of oxen. For these variables we simply use the lag or lead value of the variables.

In the case of fertilizer, there is a larger number of imputed values. The qfert variable denotes the variable with no imputed values. Conversely, qfert2 includes imputed values. Specifically, out of 5,806 observations, these variables differ from one another in 373 cases, where we have missing values for the quantity of fertilizer. In these cases, again, we use either lags or leads of the quantity of fertilizer used by that household. The vast majority of these (285) occur in 2004.

In the case of hoes and ploughs, there is also a large number (862) of missing observations. Over 95% of these values (844) occur in 1999 because the format in which the data is available in the raw files differs from all other years. As a result, we simply use lags and leads to impute these values.

In the case of cereal production, there are a number of observations (362 out of 5,806) where the households report a non-0 area of cropped cereal but no cereal production. Similarly, there are a number of cases where households report unlikely yields (144). Specifically, we denote "unlikely yields" as cereal yields below 50 kg/ha and yields exceeding 6000 kgs/ha. For these cases, we use the average yield in the peasant-association (among households who do not report an "unlikely yield") and multiply this by the total area cultivated by the farmer. We checked, however, that our results are sensitive to omitting these imputed values.

Step 7: Agro-ecological zones

We use a simplified version of the agro-ecological classification used in Bachewe et al. (2011). Specifically, we merge the Arusi/Bale and the Hararghe agro-ecological zones.

B.2 Battese correction

When a large number of 0 exists for a given variable, the natural logarithm of this variable is not defined. This is a problem if we want to estimate a production function, since using natural logarithms tends to be norm to estimate the typical production functions (Cobb-Douglas and Translog). Typically, practitioners tackle this challenge by either 1) not using households who report 0 values; or 2) substituting the 0 value by a very small number (e.g. 0.0000001). However, Battese (1997) argues that doing this can result in seriously biased estimates of the elasticities of production if the number of 0 observations is very large. The main idea behind this is that households who use a given input may have a different intercept of that of households who do not. Not taking this into account can lead to a biased estimate of the slope parameter.

In practice the procedure requires that an input-use dummy variable[1] be included for all independent variables whose observed values include 0 (fertilizer, number of oxen, number of hoes and number of ploughs). This dummy variable is equal to 1 when the input is not used (observed value of 0), and takes the value of 1 otherwise. In addition to the inclusion of the dummy variable, the method proposed by Battese 1997 requires to transform the input variables such that all 0 values are replaced by a 1.

Algebraically, we can then represent the equations used by equation 1:

$$ln\, y_{it} = \alpha + \sum_{k=1}^{k=K)} \beta_k d_{kit} + \sum_{n=1}^{n=N} \beta_n ln(x_{nit}) 0.5 \sum_{n=1}^{n=N} \sum_{m=1}^{m=N} \beta_{nm}\, lnx_{nit} * lnx_{mit} + \sum_{t=1}^{t=T} \sum_{p=1}^{p=P} d_t * d_p + e_{it} \tag{3B.1}$$

As previously explained, for those inputs where 0-values are observed (hoes, ploughs, oxen, Shannon index, fertilizer) we use the transformation proposed by by Battese (1997) and we use the subscript k . The remaining inputs (household members, land under cereal cultivation) do not undergo any transformation.

The main reason we do not use this correction for our main results is that, in some cases, it conflicts with the fixed effects. In practice, many households either use fertilizer in every period or they do not and a similar rationale applies to ploughs and hoes. As a result, some of these dummies are time invariant for a large number of households.

[1] Consider an input k for which some farmers have a 0 value. Battese (1997) shows that in this case, simply adding a small number may not be the most appropriate solution. Instead, Battese (1997) proposes the inclusion of a dummy variable, d_k which takes a value of 1 when the input is not used (i.e. $d_k = 1$ if k=0 and, conversely, $d_k = 0$ when k¿0). Additionally, for these variables, using the Battese method implies that $k = max(k, d_k)$

Chapter 4

SWC Technology adoption and labour allocation: Implications for impact evaluation and policy. A case study of Ethiopia

A Appendix A - Theoretical model

This section explains the model in more detail. Equations 4A.1-4A.7 follow closely the main text. However, beyond equation 4A.7, this section looks more in-depth at the steps and the assumptions required by the model.

In the model I assume that:

- A household has two members one adult and one child
- Households seek to maximize the household utility subject to a set of constraints
- There is only one non-labour input
- Only children can go to school
- Only adults can work off-farm
- Adult labour farm is strictly positive
- Adult and child leisure are strictly positive
- Schools and Labour markets exist
- Households derive positive levels of utility from children attending school
- For the analysis that will follow, I will focus on the separable case

Algebraically, the constraints can be denoted as follows:

$$MaxU = U(Y_1, Y_2, L_1, L_2, E_2) \tag{4A.1}$$

subject to:

$$p_y(Y_1 + Y_2) + p_e E_2 = p_q Q - w_x X + w_m M_1 \tag{4A.2}$$

$$Q = Q[X(\tau), F_1(\tau), F_2(\tau), \tau], \;\; \tau \geq 0 \tag{4A.3}$$

$$T_1 = F_1(\tau) + M_1 + L_1, \ \ M_1 \geq 0 \tag{4A.4}$$

$$T_2 = F_2(\tau) + E_2 + L_2 \ \ E_2 \geq 0 \tag{4A.5}$$

Where subscript 1 denotes the adult and subscript 2 denotes a child. As previously mentioned, I assume that the utility function depends positively on the amount of leisure and consumption of both members (L_1, L_2, Y_1 and Y_2).

Substituting equation 3 into equation 2, a technology-constrained version of the cash constraint of the outcome can be obtained and is given by the following equation:

$$p_y(Y_1 + Y_2) + p_e E_2 = p_q Q[X(\tau), F_1(\tau), F_2(\tau), \tau] - w_x X(\tau) + w_m M_1 \tag{4A.6}$$

Given these equations, the Lagrangean is given by the following equation:

$$\begin{aligned} \mathcal{L} = U(Y_1, Y_2, L_1, L_2, E_2) + \lambda[p_q Q[X(\tau), F_1(\tau), F_2(\tau), \tau] - w_x X(\tau) + w_m M_1 \\ -p_y(Y_1 + Y_2) - p_e E_2] + \mu[T_1 - L_1 - F_1(\tau) - M_1] + \phi[T_2 - L_2 - F_2(\tau) - E_2] \end{aligned} \tag{4A.7}$$

The following first-order conditions can be derived:

$$\frac{\partial \mathcal{L}}{\partial X} = \lambda[p_q \frac{\partial Q}{\partial X} - w_x] = 0 \tag{4A.8}$$

$$\frac{\partial \mathcal{L}}{\partial F_1} = \lambda p_q \frac{\partial Q}{\partial F_1} - \mu = 0 \tag{4A.9}$$

$$\frac{\partial \mathcal{L}}{\partial F_2} = \lambda p_q \frac{\partial Q}{\partial F_2} - \phi \leq 0; \ \ F_2 \geq 0; \ \ F_2(\lambda p_q - \phi) = 0 \tag{4A.10}$$

$$\frac{\partial \mathcal{L}}{\partial L_1} = \frac{\partial U}{\partial L_1} - \mu = 0 \tag{4A.11}$$

$$\frac{\partial \mathcal{L}}{\partial L_2} = \frac{\partial U}{\partial L_2} - \phi = 0 \tag{4A.12}$$

$$\frac{\partial \mathcal{L}}{\partial Y_1} = \frac{\partial U}{\partial Y_1} - \lambda p_y = 0 \tag{4A.13}$$

$$\frac{\partial \mathcal{L}}{\partial Y_2} = \frac{\partial U}{\partial Y_2} - \lambda p_y = 0 \tag{4A.14}$$

$$\frac{\partial \mathcal{L}}{\partial E_2} = \frac{\partial U}{\partial E_2} - \lambda p_e - \phi \leq 0; \;\; E_2 \geq 0; \;\; E_2(\lambda p_e - \phi) = 0 \tag{4A.15}$$

$$\frac{\partial \mathcal{L}}{\partial M_1} = \lambda w_m - \mu \leq 0; \;\; M_1 \geq 0; \;\; M_1(\lambda w - \mu) = 0 \tag{4A.16}$$

$$\begin{aligned} \frac{\partial \mathcal{L}}{\partial \tau} = \lambda \Big[p_q \Big[\frac{\partial Q}{\partial X}\frac{\partial X}{\partial \tau} + \frac{\partial Q}{\partial F_1}\frac{\partial F_1}{\partial \tau} + \frac{\partial Q}{\partial F_2}\frac{\partial F_2}{\partial \tau} + \frac{\partial Q}{\partial \tau} \Big] - w_x \frac{\partial X}{\partial \tau} \Big] \\ - \mu \frac{\partial F_1}{\partial \tau} - \phi \frac{\partial F_2}{\partial \tau} \leq 0; \;\; \tau \geq 0; \;\; \tau \Big(\frac{\partial \mathcal{L}}{\partial \tau} \Big) = 0 \end{aligned} \tag{4A.17}$$

As made clear in the first part of the Appendix A, I assume that the adult in the household has strictly positive hours of leisure and farm work (equations 4A.9 and 4A.11) hold at equality. Similarly, I assume that children consume a strictly positive amount of leisure (equation 4A.12).

With regards to child labour, the household decision is explained in equation 4A.10. If equation 4A.10 holds at equality, there will be a non-0 level of child labour. However, if equation is an inequality, then there will be no child labour used. Conceptually, this will be the case when the marginal utility of education does not compensate the monetary and time costs of education.

The off-farm work decision is explained by equation 4A.16, which states that there will be a non-0 level of off-farm work when the market wage rate exceeds the marginal product of labour on the farm ($\frac{\mu}{\lambda} = p_q \frac{\partial Q}{\partial F_1}$, from equation 4A.9). When the wage rate is below this rate, however, there will be no off-farm work.

In the separable case, all these equations can be solved recursively (i.e. I can solve jointly $F_1^*, F_2^*, M^*, E^* and X^*$). The optimal input levels can be used to determine the total quantity produced Q^*. The optimal time allocations can then be used to obtain the total off-farm income. The total household income can then be derived.

In the non-separable case, the main difference is that the decision becomes full endogenous and no longer depends on exogenous wages and prices of education.

Based on equation 4A.17, we I can derive a simplified adoption decision as follows:

$$p_q \frac{dQ}{d\tau} \leq w_x (\frac{\partial X}{\partial \tau}) + \frac{\mu}{\lambda} (\frac{\partial F_1}{\partial \tau}) + \frac{\phi}{\lambda} (\frac{\partial F_2}{\partial \tau}) \tag{4A.18}$$

In other words, if equation 4A.18 holds at equality, the household will adopt the technology as the gains from adoption compensate the costs. However, if equation 4A.18 does not hold at equality, the household will not adopt since the gains from adoption are lower than the costs (monetary and otherwise) of adopting.

B Appendix B - data preparation

This appendix details the steps used when compiling the dataset and preparing the dataset. It describes all the relevant steps involved starting from the .dta files downloadable from the IFPRI website to the actual sample used.

Step 1: Preparation plot-level characteristics.

Step 1.1: Generate dummy variables for different levels of perceived plot fertility, slope, depth and erosion. For each category, a different dummy variable was created. In the case of erosion, three dummy variables were created. The first dummy variable takes the value of 1 when there is no perceived erosion on the plot and 0 otherwise. The second takes a value of one when the household perceives there to be mild erosion on the plot and 0 otherwise. Finally, the third dummy variable refers to when severe erosion is perceived on the plot and 0 otherwise.

Step 1.2: Generate the adoption variable. I create a dummy which takes the value of 1 if a soil and water conservation technology is adopted and 0 otherwise. Over 85% of the plots have adopted either bunds (soil or stone bunds) and/or waterways. An additional 10% have adopted grass strips and/or have planted trees.

Step 2: Merging and prepare the plot-level production and input data in the questionnaire. Specifically, for both the Meher and the Belg unit, I undertook the following steps:

Step 2.1: For each farming activity (land preparation, planting, fertilizing, etc), I keep the total reported adult and child labour. To get the total labour, I sum the total reported labour across all the farming activities, from land preparation to post-harvest. I do this for both adult and child labour.

Step 2.2: With regards to crop and production data, I start by creating a dummy variable which takes a value of 1 when either a cereal or a legume is cultivated in a given plot, and 0 otherwise. Specifically, I include the following crops in the analysis: beans, chickpeas, cowpeas, field peas, lentils, barley, maize, millet, oats, teff, wheat, sorghum, dagusa(finger millet).

Step 2.3: I then construct the cultivated area. This is derived by multiplying the total plot area by the reported share of the plot under the cultivation of the crops I include in our sample.

Step 2.4: I then construct the cultivated area. This is derived by multiplying the total plot area by the reported share of the plot under the cultivation of the crops I include in our sample.

Step 3: I construct the household level characteristics. Specifically, I focus on a number of demographic variables such as the number of members in the household and their age bracket as Ill as a number of characteristics of the head of the household (gender, marital status and literacy).

Step 3.1: Using the individual level data I first generate the total household size by summing the number of members in a given household.

Step 3.2: I generate four dummy variables. I generate a dummy variable for children below 6, another for children between 6 and 10, another for children between 11 and 15 and another for household members between 16 and 18. I then collapse the individual dataset into a household level dataset using the household id and obtain the total number of household members in these age brackets.

Step 4: I construct household level variables related to climate information, extension information, credit information and occurrence of previous shocks.

Step 4.1: I create two climate information variables, one relating to temperature and another relating to rainfall. For the temperature variable a value of 1 is assigned if the household has noticed a decrease in rainfall and 0 otherwise. In the case of temperature, I assign a value of 1 if the household has noted an increase in temperature.

Step 4.2: With regards to the extension variables, in addition to the climate extension variable, I also create 4 additional dummy variables which state the source of the extension (i.e. farmer-to-farmer, neighbour, radio and Government[1]). Finally, I also create a variable

[1]Note: In the case of Government Extension, we do not consider the Agricultural Research Centre as Government Extension.

which captures the distance to market. In this case, unfortunately, the data was missing for a number of observations (about 10%). In these cases (missing values), I used the average distance to market reported in the Kebele as an approximation of distance to market.

Step 4.3: I simply create three dummy variables that denote if a given household has witnessed the occurrence of three types of natural shocks, namely drought, flood and hailstorms. In each case, a value of 1 is given if the an occurrence has been observed and a value of 0 is given otherwise.

Step 5: I then turn to the basic facilities and assets. For this part of the analysis there are two types of variables generated. Specifically I create two dummy variables which denote if a given household has a TV and/or radio. Then I also generate a set of dummy variables to denote if the household has access to a set of basic services such as schooling and basic healthcare. For the second set of variables there is a variable which denotes the distance to basic facilities.

C Appendix C - Choosing an instrument

One important aspect in this paper concerns the choice of the instrument used. This is of particular importance since previous studies, using the same dataset, have opted for different instruments. Specifically, these studies have used Government extension, farmer-to-farmer extension, radio information, neighbourhood information and climate information. The decision to use none of these three instruments was based on four criteria. The most important criterion was whether these instruments passed both individually and jointly the falsification test (i.e. were positive in the adoption equation and insignificant in the regression for non-adopters). The second criterion was whether there was evidence that some of these instruments may have violated monotonicity. As explained by Heckman and Vytlacil (2007), one of the key requirements of this type of impact evaluation tool is that the instrument is monotonic (i.e. everyone affected by the instrument is affected in the same direction). The violation of monotonicity would imply that any result we obtain is, essentially uninterpretable. The third criterion was related to the strength of the instrument. As much as possible, I tried to avoid using variables with a low t-statistic in the adoption equation. Finally, the last criterion, which is less important, is whether these variables allow for the inclusion of household fixed effects (i.e. preferably, I use plot-level instruments). The reason for this being that, if we use household-level instruments, I am unable to check for the sensitivity of the results to household fixed effects for the partial adopters sub-sample.

To test for the validity of these instruments, I used the same falsification tests used in the main text (with the same control variables) and I tested the validity of the instruments jointly (and included the no erosion dummy in the equation). In addition to this, I ran six different tests. First, I looked at adoption of SWC technologies as a whole (as in the main text). Second, I looked at the adoption of the two main technologies separately (bunds and waterways). Finally, for each of these three adoption decisions, I ran the falsification tests on both the full sample of plots using adult labour and the sub-sample of plots using child labour only. These results can be obtained upon request.

Below, I provide details for each individual instrument:

1. Climate information provided by extension officers - As shown in columns 1, 3 and 5 of

tables 4C.1 and 4C.2, this variable is not significant for any of the adoption equations. More importantly, the variable had a negative coefficient for adoption of bunds and a positive value in the probit regression adoption of waterways, although neither is significantly different from 0. However, this hints at the possibility of the monotonicity requirement being violated. In addition to this, the variable is often significant in the sub-sample of non-adopters, which is concerning.

2. Radio - For the adult labour sample, this instrument was significant in most of the adoption equations and it consistently had a positive coefficient and had an insignificant coefficient on the labour regressions (Table 4C.1). However, the t-statistic was typically low compared to the erosion perception coefficients. Moreover, this variable was not significant in any of the adoption equations in the child labour sample (table 4C.2). In addition to this, given that this is a household-level variable, using this variable as an instrument would have precluded using household fixed effects as a robustness check.

3. Farmer extension, Government extension and neighbour - These information sources all failed the falsification test in at least one of the robustness checks shown in tables 4C.1 and 4C.2. In the case of farmer extension, the variable displayed an insignificant coefficient in the adoption equation but a significant coefficient in the labour regressions of non-adopters for both child and adult labour. In the cases of Government extension and neighbour, typically these are not very strong predictors of adoption (with the exception of the neighbour variable in column (3) of tables 4C.1 and 4C.2) and both variables display significant coefficients in column (6) of tables 4C.1 and 4C.2). Moreover, as with other potential instruments, these variables were collected at the household level, which precludes the use of household fixed effects as a robustness check.

Table 4C.1: Falsification tests additional instruments (Adult labour)

	All		Bunds		Waterways	
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Variables	Adoption	OLS	Adoption	OLS	Adoption	OLS
Distance to market (km)	0.002	0.027**	0.022	0.027**	-0.002	0.032***
	(0.015)	(0.011)	(0.015)	(0.011)	(0.019)	(0.012)
Hailstorm since 1994	-0.036	0.128	-0.037	0.129	0.147	0.105
	(0.166)	(0.115)	(0.160)	(0.115)	(0.222)	(0.175)
Has TV (1 if yes, 0 if no)	-0.08	0.122	-0.420**	0.124	-0.217	0.045
	(0.181)	(0.133)	(0.175)	(0.133)	(0.221)	(0.162)
Is head of household literate (1 Yes)	-0.097	0.119	0.026	0.118	-0.024	0.013
	(0.121)	(0.073)	(0.127)	(0.073)	(0.155)	(0.093)
At least one flood since 1994	0.041	-0.103	0.127	-0.1	-0.439*	-0.012
	(0.177)	(0.125)	(0.175)	(0.124)	(0.232)	(0.179)
At least on drought since 1994	-0.012	0.021	0.016	0.02	0.116	0.108
	(0.146)	(0.156)	(0.154)	(0.156)	(0.212)	(0.201)
Plot is highly fertile	0.242**	-0.004	0.156	-0.005	-0.114	0.002
	(0.104)	(0.074)	(0.113)	(0.074)	(0.143)	(0.096)
Ln Area plot (ha)	0.051	0.198***	0.084	0.198***	-0.118	0.249***
	(0.060)	(0.047)	(0.063)	(0.047)	(0.087)	(0.062)
Plot is flat	0.038	-0.047	-0.232*	-0.05	0.214	-0.019
	(0.108)	(0.078)	(0.125)	(0.077)	(0.149)	(0.095)
Plot has medium depth	0.352***	0.046	0.201*	0.043	0.299**	0.036
	(0.099)	(0.072)	(0.112)	(0.072)	(0.131)	(0.082)
Household has child under 6	-0.233*	-0.008	-0.360***	-0.006	0.389*	-0.068
	(0.134)	(0.094)	(0.138)	(0.094)	(0.200)	(0.117)
ln Number of children under 6	0.122	-0.019	-0.288*	-0.019	0.331	-0.024
	(0.169)	(0.114)	(0.175)	(0.114)	(0.208)	(0.129)
Household has child aged 6-11	-0.07	0.01	0.065	0.008	-0.265	0.01
	(0.139)	(0.090)	(0.148)	(0.090)	(0.187)	(0.105)
ln Number of children aged 6-11	-0.017	-0.049	0.185	-0.049	0.032	-0.03
	(0.150)	(0.083)	(0.165)	(0.084)	(0.200)	(0.098)
Household has child aged 11-15	0.016	-0.066	0.189	-0.062	0.187	-0.037
	(0.136)	(0.090)	(0.148)	(0.089)	(0.169)	(0.110)
ln Number of children aged 11-15	-0.169	-0.047	0.078	-0.045	-0.397*	-0.059
	(0.160)	(0.117)	(0.169)	(0.117)	(0.225)	(0.147)
ln Number of plots	0.05	-0.046	-0.006	-0.043	0.031	0.04
	(0.138)	(0.088)	(0.147)	(0.087)	(0.171)	(0.100)
ln Number of adults	0.042	0.181*	0.293**	0.180*	0.047	0.214*
	(0.137)	(0.101)	(0.141)	(0.101)	(0.183)	(0.125)
No perceived erosion on plot (1-yes, 0 no)	-1.359***	-0.083	-1.486***	-0.082	-1.184***	-0.028
	(0.116)	(0.107)	(0.134)	(0.107)	(0.161)	(0.135)
Climate information (1 yes, 0 no)	0.123	-0.192*	-0.04	-0.185*	0.395	-0.222
	(0.148)	(0.102)	(0.145)	(0.100)	(0.269)	(0.167)
Radio	0.333**	-0.116	0.012	-0.11	0.416**	-0.093
	(0.145)	(0.125)	(0.150)	(0.124)	(0.193)	(0.129)
Farmer-to-farmer extension (1 yes, 0 no)	-0.052	0.232*	-0.219	0.228*	-0.215	0.735***
	(0.148)	(0.120)	(0.152)	(0.120)	(0.251)	(0.212)
Government extension (1 yes, 0 no)	-0.213	-0.004	0.213	-0.007	-0.215	0.034
	(0.176)	(0.131)	(0.171)	(0.131)	(0.232)	(0.152)
Neighbour (1 yes, 0 no)	-0.077	0.033	-0.470***	0.035	0.257	0.012
	(0.141)	(0.088)	(0.149)	(0.088)	(0.190)	(0.108)
Constant	1.170***	3.159***	-0.213	2.368***	-2.225***	2.286***
	(0.364)	(0.283)	(0.487)	(0.425)	(0.673)	(0.468)
Kebele fixed effects	✓	✓	✓	✓	✓	✓
Number of observations	3208	841	2037	844	1327	605

Number in parentheses denote standard errors. *, **, *** denote statistical significance at the 10%, 5% and 1% level, respectively.
Note: Columns (2), (4) and (6) only use the sub-sample of non-adopters, whereas Columns (1), (3) and (5) use the full sample.

Table 4C.2: Falsification tests additional instruments (Child labour)

	All		Bunds		Waterways	
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Variables	Adoption	OLS	Adoption	OLS	Adoption	OLS
Distance to market (km)	-0.008	-0.009	0.055**	0	0.003	-0.018
	(0.019)	(0.018)	(0.024)	(0.017)	(0.022)	(0.015)
Hailstorm since 1994	-0.382*	-0.032	-0.251	0.027	-0.441	1.396***
	(0.216)	(0.291)	(0.213)	(0.290)	(0.291)	(0.428)
Has TV (1 if yes, 0 if no)	-0.422*	-0.027	-0.455*	0.01	-0.148	0.296
	(0.249)	(0.197)	(0.248)	(0.202)	(0.339)	(0.264)
Is head of household literate (1 Yes)	0.183	-0.215	0.257	-0.199	0.383*	-0.261
	(0.172)	(0.192)	(0.177)	(0.182)	(0.225)	(0.226)
At least one flood since 1994	-0.205	-0.113	0.025	-0.131	-0.435	-0.466
	(0.214)	(0.222)	(0.215)	(0.226)	(0.307)	(0.321)
At least on drought since 1994	-0.168	0.121	-0.422**	0.163	-0.109	0.476
	(0.193)	(0.245)	(0.210)	(0.241)	(0.237)	(0.359)
Plot is highly fertile	0.234	-0.105	0.171	-0.161	0.124	0.086
	(0.158)	(0.142)	(0.154)	(0.132)	(0.195)	(0.113)
Ln Area plot (ha)	-0.011	0.081	-0.029	0.044	-0.243*	0.067
	(0.087)	(0.085)	(0.082)	(0.083)	(0.127)	(0.093)
Plot is flat	-0.339**	0.069	-0.397**	0.104	0.347	0.247
	(0.158)	(0.153)	(0.165)	(0.149)	(0.249)	(0.188)
Plot has medium depth	0.293*	0.036	0.183	0.023	0.731***	-0.177
	(0.160)	(0.152)	(0.151)	(0.149)	(0.219)	(0.149)
Household has child under 6	-0.367**	-0.621***	-0.536***	-0.707***	0.392	-0.438**
	(0.172)	(0.200)	(0.169)	(0.182)	(0.276)	(0.208)
ln Number of children under 6	0.112	-0.709**	-0.678***	-0.817***	-0.15	-1.251***
	(0.231)	(0.280)	(0.257)	(0.265)	(0.276)	(0.260)
Household has child aged 6-11	-0.059	0.07	0.237	0.05	-0.097	-0.428**
	(0.215)	(0.210)	(0.224)	(0.202)	(0.275)	(0.204)
ln Number of children aged 6-11	0.049	0.072	0.086	0.072	0.048	-0.04
	(0.214)	(0.167)	(0.212)	(0.160)	(0.267)	(0.149)
Household has child aged 11-15	0.172	-0.195	0.227	-0.223	0.729**	0.232
	(0.232)	(0.211)	(0.239)	(0.206)	(0.294)	(0.240)
ln Number of children aged 11-15	0.058	0.163	-0.164	0.175	-0.028	0.279
	(0.229)	(0.226)	(0.231)	(0.222)	(0.289)	(0.223)
ln Number of plots	-0.052	0.158	-0.29	0.162	-0.15	0.651***
	(0.228)	(0.224)	(0.220)	(0.206)	(0.244)	(0.199)
ln Number of adults	0.452**	0.087	0.393**	-0.037	0.696**	-0.388*
	(0.196)	(0.289)	(0.185)	(0.271)	(0.308)	(0.220)
No perceived erosion on plot (1-yes, 0 no)	-1.431***	0.049	-1.462***	0.093	-1.395***	-0.034
	(0.182)	(0.180)	(0.193)	(0.184)	(0.304)	(0.239)
Climate information (1 yes, 0 no)	-0.217	-0.637***	-0.139	-0.591***	-0.342	-0.769**
	(0.199)	(0.227)	(0.199)	(0.225)	(0.356)	(0.370)
Radio	0.261	0.312	0.058	0.313	0.094	-0.336
	(0.220)	(0.263)	(0.203)	(0.254)	(0.342)	(0.323)
Farmer-to-farmer extension (1 yes, 0 no)	0.137	0.647**	0.044	0.621**	-0.121	2.860***
	(0.215)	(0.320)	(0.201)	(0.291)	(0.384)	(0.524)
Government extension (1 yes, 0 no)	-0.059	0.026	0.413*	0.015	0.034	-1.408***
	(0.239)	(0.288)	(0.240)	(0.281)	(0.349)	(0.385)
Neighbour (1 yes, 0 no)	-0.345*	0.078	-0.611***	0.089	-0.257	0.395**
	(0.207)	(0.230)	(0.196)	(0.214)	(0.326)	(0.188)
Constant	0.694	2.420***	0.007	0.623	-1.079	0.161
	(0.582)	(0.518)	(0.614)	(0.648)	(0.699)	(0.854)
Kebele fixed effects	✓	✓	✓	✓	✓	✓
Number of observations	1407	280	1048	297	434	174

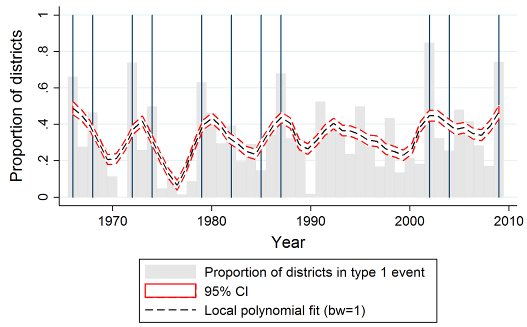
Number in parentheses denote standard errors. *, **, *** denote statistical significance at the 10%, 5% and 1% level, respectively.
Note: Columns (2), (4) and (6) only use the sub-sample of non-adopters, whereas Columns (1), (3) and (5) use the full sample.

Chapter 5

The importance of a comprehensive drought index to estimate drought-induced cereal losses in India

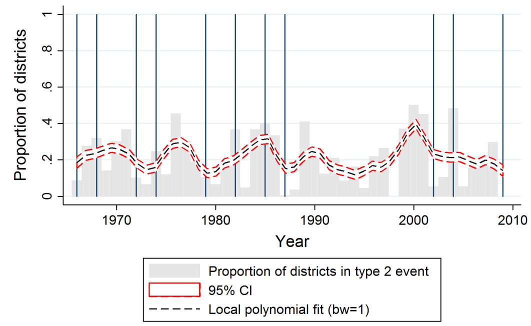
A Appendix A - Additional figures and Tables

Figure 5A.1: Proportion of drought-affected districts
(by type, May-December growing season)



(a)Type 1 events (“hot droughts”)

(below-average rain & above-average temperature)



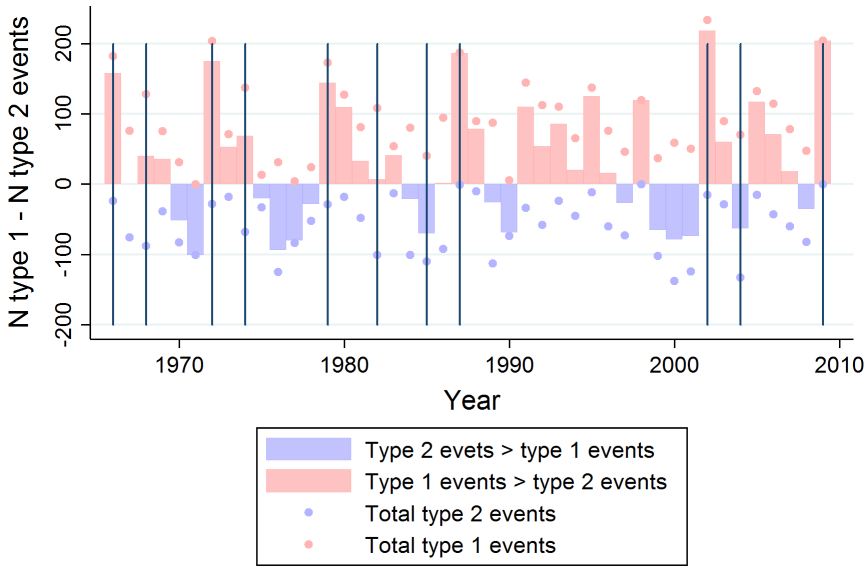
(b)Type 2 events (“cold droughts”)

(below-average rain & below-average temperature)

Notes: Type 1 events denote events where rainfall was below-average and temperature was above average. Conversely, Type 2 events refer to events where both rainfall and temperature were below-average. The rainfall average variable is calculated as the district mean cumulative rainfall from May-December from 1956-2009. The average temperature variable is calculated as the average degree days above the mean season temperature from May-December.

The solid vertical lines represent the years considered by the Indian Government as All-India drought years.

Figure 5A.2: Type 1 droughts in excess of Type 2 droughts
May-December growing season



Notes: The scatter points highlight the total number of droughts (by type) in a given year. In the case of Type 1 droughts (red scatter points) these can be interpreted directly (i.e. 200 means that 200 districts were affects by a Type 1 drought). However, in the case of the Type 2 droughts, these should be interpreted as the negative of the number (i.e. if the observed value is -100, this means there were 100 districts affected by Type 2 droughts).

Bar graphs show the number of affected districts affected by Type 1 droughts in excess of the number affected by Type 2 droughts. As a result a result a value of 50 would mean that there were 50 more districts affected by a Type 1 drought than affected by a Type 2 drought in a given year. The converse applies to a negative number, which highlights a higher number of districts affected by cold droughts in a given year.

The solid vertical lines represent the years considered by the Indian Government as All-India drought years.

Table 5A.1: Full sample robustness checks 1

	Cluster (state)			Squares			Controls		
Variables	1	2	3	4	5	6	7	8	9
Drought index (Type 1)	-0.192***	-0.238***		-0.068	-0.159***		-0.112***	-0.148***	
	(0.049)	(0.056)		(0.042)	(0.045)		(0.016)	(0.018)	
Drought index^2 (Type 1)				-0.201***	-0.126*				
				(0.073)	(0.074)				
Drought index (Type 2)		-0.391***			-0.239**			-0.269***	
		(0.078)			(0.098)			(0.038)	
Drought index^2 (Type 2)					-0.510*				
					(0.296)				
Drought index (2 types)			-0.255***			-0.252***			-0.161***
			(0.055)			(0.040)			(0.018)
Drought index^2 (2 types)						-0.004			
						(0.064)			
Constant	-0.372***	-0.346***	-0.347***	-0.363***	-0.328***	-0.313***	0.612***	0.558***	0.591***
	(0.031)	(0.033)	(0.032)	(0.022)	(0.022)	(0.022)	(0.202)	(0.197)	(0.198)
Time trends	✓	✓	✓	✓	✓	✓	✓	✓	✓
District fixed effects	✓	✓	✓	✓	✓	✓	✓	✓	✓
Year fixed effects	✓	✓	✓	✓	✓	✓	✓	✓	✓
Controls							✓	✓	✓
Number of observations	12100	12100	12100	12100	12100	12100	8888	8888	8888
Number of districts	275	275	275	275	275	275	202	202	202
R-squared a	0.705	0.712	0.711	0.706	0.713	0.711	0.762	0.766	0.765
R-squared w	0.719	0.726	0.725	0.72	0.727	0.725	0.775	0.778	0.777

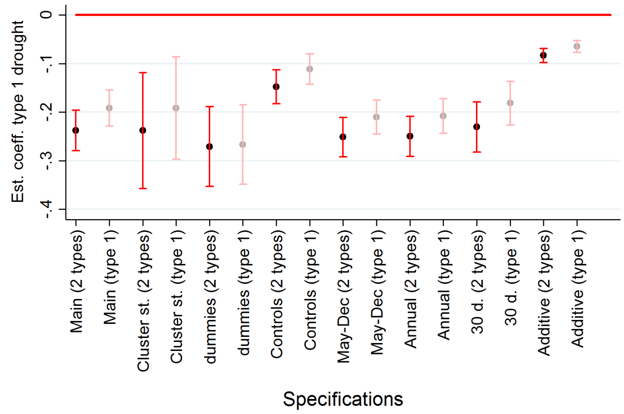
Notes: Values in parentheses denote clustered standard errors at the district level for columns 4-9. For columns 1-3 they denote clustered standard errors at the state level. *, ** and *** denote statistical significance at the 10%, 5% and 1% level, respectively. District trends denote a district-specific quadratic trend. In columns 7-9, we include 4 controls and their squares. These include the proportion of net irrigated area, the total cereal area, the total rural population density (rural population divided by gross cropped area) and fertilizer intensity. In columns 7-9 all districts for which at least one observation is missing for the control variables are dropped and this is the reason behind the decrease in the number of districts.

Table 5A.2: Full sample robustness checks 2

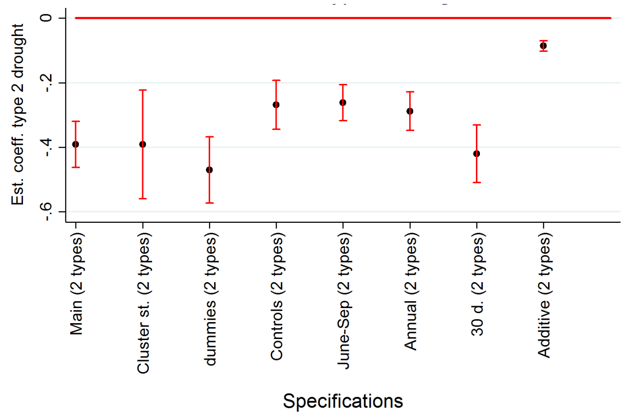
	May-December			Annual			Degree days (30 degrees)			Additive		
Variables	1	2	3	4	5	6	7	8	9	10	11	12
Drought index (Type 1)	-0.210***	-0.251***		-0.208***	-0.250***		-0.182***	-0.230***		-0.065***	-0.083***	
	(0.018)	(0.021)		(0.018)	(0.021)		(0.023)	(0.026)		(0.006)	(0.007)	
Drought index (Type 2)		-0.262***			-0.288***			-0.420***			-0.086***	
		(0.028)			(0.030)			(0.045)			(0.008)	
Drought index (2 types)			-0.253***			-0.254***			-0.264***			-0.084***
			(0.021)			(0.021)			(0.024)			(0.007)
Constant	-0.346***	-0.329***	-0.327***	-0.330***	-0.319***	-0.313***	-0.422***	-0.382***	-0.354***	-0.375***	-0.348***	-0.346***
	(0.023)	(0.022)	(0.021)	(0.023)	(0.023)	(0.022)	(0.024)	(0.024)	(0.023)	(0.021)	(0.021)	(0.021)
Time trends	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
District fixed effects	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Year fixed effects	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Controls												
Number of observationsN	12100	12100	12100	12100	12100	12100	11352	11352	11352	12100	12100	12100
Number of districts	275	275	275	275	275	275	258	258	258	275	275	275
R-squared a	0.711	0.716	0.716	0.71	0.716	0.716	0.704	0.71	0.712	0.704	0.711	0.711
R-squared w	0.725	0.73	0.73	0.724	0.73	0.73	0.718	0.724	0.726	0.719	0.725	0.725

Notes: Values in parentheses denote clustered standard errors at the district level. *, ** and *** denote statistical significance at the 10%, 5% and 1% level, respectively. District trends denote a quadratic trend. In columns 1-6 the drought index is constructed in the same way as the drought index in the paper. The only difference is the growing season used to construct the index. In column 1-3 the May-December period is used, whereas in columns 4-6 annual data is used. In columns 7-9, the index is built over the June-September period, but instead of using the average seasonal temperature for the construction of the hot degree-days variable we use an absolute threshold of 30 degrees. As a result, given that some districts do not experience daily temperatures this high, some districts drop from the sample since in a number of districts the harmful degree-days variable is always 0, which implies the drought index is also equal to 0 and does not vary. Finally, in columns 10-12, instead of multiplying the normalized negative rainfall by the normalized harmful degree-days variable, these two variables are added. In this specification, the average hot degree-days is based on the average June-September daily temperature between 1956-2009, rather than the absolute value of 30 degrees.

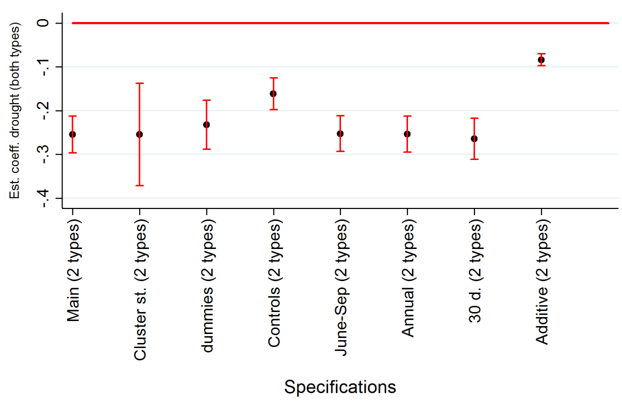
Figure 5A.3: Estimated coefficients and 95% confidence intervals



(a)Coefficient - Type 1 events ("hot droughts")



(b)Coefficient Type 2 events ("cold droughts")



(c)Coefficient combined droughts (all droughts)

In panel (a), the darker scatter plots refer to specifications where the indices for both types of drought were included separately. The lighter scatter dots refer to those specifications where "cold" droughts were omitted.

Table 5A.3: Rice sample robustness checks 1

	Cluster (state)			Squares			Controls		
Variables	1	2	3	4	5	6	7	8	9
Drought index (Type 1)	-0.249***	-0.303***		-0.123	-0.235***		-0.205***	-0.255***	
	(0.045)	(0.052)		(0.078)	(0.080)		(0.020)	(0.023)	
Drought index$\hat{2}$ (Type 1)				-0.206*	-0.109				
				(0.122)	(0.122)				
Drought index (Type 2)		-0.469***			-0.383***			-0.386***	
		(0.080)			(0.112)			(0.039)	
Drought index$\hat{2}$ (Type 2)					-0.281				
					(0.405)				
Drought index (2 types)			-0.323***			-0.336***			-0.271***
			(0.054)			(0.061)			(0.023)
Drought index$\hat{2}$ (2 types)						0.024			
						(0.095)			
Constant	-0.362***	-0.334***	-0.333***	-0.235***	-0.197***	-0.180***	1.193***	1.134***	1.179***
	(0.060)	(0.056)	(0.056)	(0.034)	(0.034)	(0.035)	(0.243)	(0.239)	(0.240)
Time trends	✓	✓	✓	✓	✓	✓	✓	✓	✓
District fixed effects	✓	✓	✓	✓	✓	✓	✓	✓	✓
Year fixed effects	✓	✓	✓	✓	✓	✓	✓	✓	✓
Controls							✓	✓	✓
Number of observations	10560	10560	10560	10560	10560	10560	7832	7832	7832
Number of districts	240	240	240	240	240	240	178	178	178
R-squared a	0.532	0.542	0.541	0.533	0.542	0.541	0.564	0.57	0.57
R-squared w	0.555	0.565	0.563	0.556	0.565	0.563	0.587	0.593	0.592

Notes: Values in parentheses denote clustered standard errors at the district level for columns 4-9. For columns 1-3 they denote clustered standard errors at the state level. *, ** and *** denote statistical significance at the 10%, 5% and 1% level, respectively. District trends denote a district-specific quadratic trend. In columns 7-9, we include 4 controls and their squares. These include the proportion of net irrigated area, the total cereal area, the total rural population density (rural population divided by gross cropped area) and fertilizer intensity. In columns 7-9 all districts for which at least one observation is missing for the control variables are dropped and this is the reason behind the decrease in the number of districts.

Table 5A.4: Rice sample robustness checks 2

	May-December			Annual			Degree days (30 degrees)			Additive		
Variables	1	2	3	4	5	6	7	8	9	10	11	12
Drought index (Type 1)	-0.250***	-0.300***		-0.259***	-0.308***		-0.207***	-0.276***		-0.086***	-0.109***	
	(0.020)	(0.022)		(0.020)	(0.023)		(0.021)	(0.026)		(0.008)	(0.009)	
Drought index (Type 2)		-0.317***			-0.346***			-0.602***			-0.112***	
		(0.028)			(0.031)			(0.068)			(0.009)	
Drought index (2 types)			-0.302***			-0.312***			-0.323***			-0.110***
			(0.021)			(0.023)			(0.026)			(0.008)
Constant	-0.238***	-0.218***	-0.216***	-0.204***	-0.195***	-0.188***	-0.336***	-0.287***	-0.242***	-0.250***	-0.220***	-0.218***
	(0.034)	(0.035)	(0.034)	(0.035)	(0.035)	(0.034)	(0.037)	(0.037)	(0.037)	(0.034)	(0.034)	(0.033)
Time trends	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
District fixed effects	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Year fixed effects	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Controls												
Number of observations	10560	10560	10560	10560	10560	10560	9812	9812	9812	10560	10560	10560
Number of districts	240	240	240	240	240	240	223	223	223	240	240	240
R-squared a	0.538	0.545	0.545	0.538	0.546	0.546	0.528	0.54	0.54	0.531	0.542	0.542
R-squared w	0.561	0.567	0.567	0.561	0.569	0.568	0.552	0.563	0.563	0.554	0.565	0.565

Notes: Values in parentheses denote clustered standard errors at the district level. *, ** and *** denote statistical significance at the 10%, 5% and 1% level, respectively. District trends denote a quadratic trend. In columns 1-6 the drought index is constructed in the same way as the drought index in the paper. The only difference is the growing season used to construct the index. In column 1-3 the May-December period is used, whereas in columns 4-6 annual data is used. In columns 7-9, the index is built over the June-September period, but instead of using the average seasonal temperature for the construction of the hot degree-days variable we use an absolute threshold of 30 degrees. As a result, given that some districts do not experience daily temperatures this high, some districts drop from the sample since in a number of districts the harmful degree-days variable is always 0, which implies the drought index is also equal to 0 and does not vary. Finally, in columns 10-12, instead of multiplying the normalized negative rainfall by the normalized harmful degree-days variable, these two variables are added. In this specification, the average hot degree-days is based on the average June-September daily temperature between 1956-2009, rather than the absolute value of 30 degrees.

Table 5A.5: Wheat sample robustness checks 1

	Cluster (state)			Squares			Controls		
Variables	1	2	3	4	5	6	7	8	9
Drought index (Type 1)	-0.128***	-0.161***		-0.123***	-0.185***		-0.100***	-0.126***	
	(0.028)	(0.031)		(0.039)	(0.039)		(0.018)	(0.018)	
Drought index^2 (Type 1)				-0.007	0.04				
				(0.064)	(0.064)				
Drought index (Type 2)		-0.263***			0.041			-0.183***	
		(0.078)			(0.084)			(0.035)	
Drought index^2 (Type 2)					-1.066***				
					(0.293)				
Drought index (2 types)			-0.174***			-0.226***			-0.133***
			(0.032)			(0.032)			(0.017)
Drought index^2 (2 types)						0.087			
						(0.054)			
Constant	-0.442***	-0.423***	-0.422***	-0.339***	-0.309***	-0.300***	-0.380*	-0.348*	-0.342*
	(0.062)	(0.062)	(0.063)	(0.027)	(0.028)	(0.029)	(0.197)	(0.202)	(0.202)
Time trends	✓	✓	✓	✓	✓	✓	✓	✓	✓
District fixed effects	✓	✓	✓	✓	✓	✓	✓	✓	✓
Year fixed effects	✓	✓	✓	✓	✓	✓	✓	✓	✓
Controls							✓	✓	✓
Number of observations	8756	8756	8756	8756	8756	8756	6776	6776	6776
Number of districts	199	199	199	199	199	199	154	154	154
R-squared a	0.713	0.716	0.716	0.713	0.717	0.716	0.761	0.763	0.763
R-squared w	0.727	0.731	0.73	0.727	0.731	0.73	0.774	0.775	0.775

Notes: Values in parentheses denote clustered standard errors at the district level for columns 4-9. For columns 1-3 they denote clustered standard errors at the state level. *, ** and *** denote statistical significance at the 10%, 5% and 1% level, respectively. District trends denote a district-specific quadratic trend. In columns 7-9, we include 4 controls and their squares. These include the proportion of net irrigated area, the total cereal area, the total rural population density (rural population divided by gross cropped area) and fertilizer intensity. In columns 7-9 all districts for which at least one observation is missing for the control variables are dropped and this is the reason behind the decrease in the number of districts.

Table 5A.6: Wheat sample robustness checks 2

	May-December			Annual			Degree days (30 degrees)			Additive		
Variables	1	2	3	4	5	6	7	8	9	10	11	12
Drought index (Type 1)	-0.141***	-0.162***		-0.143***	-0.167***		-0.112***	-0.142***		-0.045***	-0.058***	
	(0.014)	(0.015)		(0.014)	(0.016)		(0.014)	(0.015)		(0.006)	(0.006)	
Drought index (Type 2)		-0.124***			-0.161***			-0.251***			-0.059***	
		(0.021)			(0.022)			(0.032)			(0.007)	
Drought index (2 types)			-0.157***			-0.166***			-0.171***			-0.058***
			(0.014)			(0.015)			(0.016)			(0.005)
Constant	-0.323***	-0.312***	-0.319***	-0.315***	-0.308***	-0.309***	-0.361***	-0.334***	-0.312***	-0.345***	-0.323***	-0.323***
	(0.028)	(0.027)	(0.027)	(0.028)	(0.027)	(0.027)	(0.028)	(0.028)	(0.028)	(0.027)	(0.027)	(0.028)
Time trends	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
District fixed effects	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Year fixed effects	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Controls												
Number of observations	8756	8756	8756	8756	8756	8756	8712	8712	8712	8756	8756	8756
Number of districts	199	199	199	199	199	199	198	198	198	199	199	199
R-squared a	0.716	0.717	0.717	0.715	0.717	0.717	0.712	0.715	0.716	0.712	0.716	0.716
R-squared w	0.73	0.731	0.731	0.73	0.732	0.732	0.727	0.729	0.73	0.727	0.73	0.73

Notes: Values in parentheses denote clustered standard errors at the district level. *, ** and *** denote statistical significance at the 10%, 5% and 1% level, respectively. District trends denote a quadratic trend. In columns 1-6 the drought index is constructed in the same way as the drought index in the paper. The only difference is the growing season used to construct the index. In column 1-3 the May-December period is used, whereas in columns 4-6 annual data is used. In columns 7-9, the index is built over the June-September period, but instead of using the average seasonal temperature for the construction of the hot degree-days variable we use an absolute threshold of 30 degrees. As a result, given that some districts do not experience daily temperatures this high, some districts drop from the sample since in a number of districts the harmful degree-days variable is always 0, which implies the drought index is also equal to 0 and does not vary. Finally, in columns 10-12, instead of multiplying the normalized negative rainfall by the normalized harmful degree-days variable, these two variables are added. In this specification, the average hot degree-days is based on the average June-September daily temperature between 1956-2009, rather than the absolute value of 30 degrees.

Table 5A.7: Maize sample robustness checks 1

	Cluster (state)			Squares			Controls		
Variables	1	2	3	4	5	6	7	8	9
Drought index (Type 1)	-0.138**	-0.118		0.181***	0.250***		-0.094***	-0.057*	
	(0.057)	(0.072)		(0.063)	(0.065)		(0.028)	(0.031)	
Drought index^2 (Type 1)				-0.520***	-0.585***				
				(0.102)	(0.102)				
Drought index (Type 2)		0.156			1.140***			0.264***	
		(0.147)			(0.155)			(0.060)	
Drought index^2 (Type 2)					-3.322***				
					(0.461)				
Drought index (2 types)			-0.084			0.336***			-0.017
			(0.082)			(0.056)			(0.031)
Drought index^2 (2 types)						-0.712***			
						(0.087)			
Constant	-0.141	-0.152	-0.154	-0.209***	-0.224***	-0.241***	0.182	0.242	0.13
	(0.094)	(0.090)	(0.087)	(0.050)	(0.051)	(0.051)	(0.183)	(0.182)	(0.184)
Time trends	✓	✓	✓	✓	✓	✓	✓	✓	✓
District fixed effects	✓	✓	✓	✓	✓	✓	✓	✓	✓
Year fixed effects	✓	✓	✓	✓	✓	✓	✓	✓	✓
Controls							✓	✓	✓
Number of observations	7656	7656	7656	7656	6248	6248	6248		
Number of districts	174	174	174	174	174	174	142	142	142
R-squared a	0.398	0.398	0.396	0.4	0.405	0.403	0.414	0.417	0.413
R-squared w	0.428	0.429	0.426	0.431	0.436	0.433	0.446	0.448	0.444

Notes: Values in parentheses denote clustered standard errors at the district level for columns 4-9. For columns 1-3 they denote clustered standard errors at the state level. *, ** and *** denote statistical significance at the 10%, 5% and 1% level, respectively. District trends denote a district-specific quadratic trend. In columns 7-9, we include 4 controls and their squares. These include the proportion of net irrigated area, the total cereal area, the total rural population density (rural population divided by gross cropped area) and fertilizer intensity. In columns 7-9 all districts for which at least one observation is missing for the control variables are dropped and this is the reason behind the decrease in the number of districts.

Table 5A.8: Maize sample robustness checks 2

	May-December			Annual			Degree days (30 degrees)			Additive		
Variables	1	2	3	4	5	6	7	8	9	10	11	12
Drought index (Type 1)	-0.113***	-0.085***		-0.108***	-0.081***		-0.113***	-0.094***		-0.038***	-0.025**	
	(0.022)	(0.026)		(0.022)	(0.026)		(0.029)	(0.033)		(0.009)	(0.010)	
Drought index (Type 2)		0.168***			0.177***			0.154**			0.058***	
		(0.044)			(0.042)			(0.068)			(0.014)	
Drought index (2 types)			-0.053**			-0.050*			-0.081**			0.004
			(0.027)			(0.026)			(0.032)			(0.010)
Constant	-0.219***	-0.233***	-0.276***	-0.217***	-0.224***	-0.277***	-0.231***	-0.248***	-0.254***	-0.231***	-0.252***	-0.328***
	(0.047)	(0.047)	(0.046)	(0.049)	(0.049)	(0.047)	(0.051)	(0.050)	(0.049)	(0.051)	(0.051)	(0.049)
Time trends	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
District fixed effects	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Year fixed effects	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Controls												
Number of observations	7656	7656	7656	7656	7656	7656	7612	7612	7612	7656	7656	7656
Number of districts	174	174	174	174	174	174	173	173	173	174	174	174
R-squared a	0.397	0.399	0.395	0.397	0.399	0.395	0.397	0.397	0.396	0.396	0.399	0.395
R-squared w	0.428	0.43	0.426	0.428	0.429	0.426	0.427	0.428	0.427	0.427	0.429	0.425

Notes: Values in parentheses denote clustered standard errors at the district level. *, ** and *** denote statistical significance at the 10%, 5% and 1% level, respectively. District trends denote a quadratic trend. In columns 1-6 the drought index is constructed in the same way as the drought index in the paper. The only difference is the growing season used to construct the index. In column 1-3 the May-December period is used, whereas in columns 4-6 annual data is used. In columns 7-9, the index is built over the June-September period, but instead of using the average seasonal temperature for the construction of the hot degree-days variable we use an absolute threshold of 30 degrees. As a result, given that some districts do not experience daily temperatures this high, some districts drop from the sample since in a number of districts the harmful degree-days variable is always 0, which implies the drought index is also equal to 0 and does not vary. Finally, in columns 10-12, instead of multiplying the normalized negative rainfall by the normalized harmful degree-days variable, these two variables are added. In this specification, the average hot degree-days is based on the average June-September daily temperature between 1956-2009, rather than the absolute value of 30 degrees.

Table 5A.9: Millet sample robustness checks 1

	Cluster (state)			Squares			Controls		
Variables	1	2	3	4	5	6	7	8	9
Drought index (Type 1)	-0.240**	-0.287**		-0.011	-0.091		-0.151***	-0.183***	
	(0.098)	(0.111)		(0.075)	(0.082)		(0.033)	(0.038)	
Drought index^2 (Type 1)				-0.370***	-0.309**				
				(0.123)	(0.125)				
Drought index (Type 2)		-0.381*			0.035			-0.243***	
		(0.200)			(0.154)			(0.087)	
Drought index^2 (Type 2)					-1.416***				
					(0.444)				
Drought index (2 types)			-0.297**			-0.175**			-0.190***
			(0.112)			(0.079)			(0.040)
Drought index^2 (2 types)						-0.205*			
						(0.115)			
Constant	-0.671***	-0.647***	-0.647***	-0.737***	-0.704***	-0.687***	0.712**	0.691**	0.702**
	(0.049)	(0.057)	(0.056)	(0.041)	(0.041)	(0.041)	(0.306)	(0.302)	(0.306)
Time trends	✓	✓	✓	✓	✓	✓	✓	✓	✓
District fixed effects	✓	✓	✓	✓	✓	✓	✓	✓	✓
Year fixed effects	✓	✓	✓	✓	✓	✓	✓	✓	✓
Controls							✓	✓	✓
Number of observations	7172	7172	7172	7172	7172	7172	5588	5588	5588
Number of districts	163	163	163	163	163	163	127	127	127
R-squared a	0.429	0.434	0.434	0.431	0.435	0.434	0.502	0.504	0.504
R-squared w	0.459	0.463	0.463	0.46	0.465	0.463	0.529	0.531	0.531

Notes: Values in parentheses denote clustered standard errors at the district level for columns 4-9. For columns 1-3 they denote clustered standard errors at the state level. *, ** and *** denote statistical significance at the 10%, 5% and 1% level, respectively. District trends denote a district-specific quadratic trend. In columns 7-9, we include 4 controls and their squares. These include the proportion of net irrigated area, the total cereal area, the total rural population density (rural population divided by gross cropped area) and fertilizer intensity. In columns 7-9 all districts for which at least one observation is missing for the control variables are dropped and this is the reason behind the decrease in the number of districts.

Table 5A.10: Millet sample robustness checks 2

	May-December			Annual			Degree days (30 degrees)			Additive		
Variables	1	2	3	4	5	6	7	8	9	10	11	12
Drought index (Type 1)	-0.262***	-0.295***		-0.256***	-0.295***		-0.244***	-0.275***		-0.078***	-0.095***	
	(0.036)	(0.041)		(0.037)	(0.042)		(0.047)	(0.055)		(0.013)	(0.015)	
Drought index (Type 2)		-0.205***			-0.266***			-0.278***			-0.074***	
		(0.049)			(0.053)			(0.099)			(0.017)	
Drought index (2 types)			-0.286***			-0.292***			-0.311***			-0.088***
			(0.041)			(0.042)			(0.051)			(0.014)
Constant	-0.709***	-0.692***	-0.702***	-0.691***	-0.679***	-0.683***	-0.756***	-0.729***	-0.696***	-0.743***	-0.716***	-0.732***
	(0.039)	(0.039)	(0.039)	(0.040)	(0.040)	(0.040)	(0.041)	(0.041)	(0.042)	(0.042)	(0.041)	(0.042)
Time trends	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
District fixed effects	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Year fixed effects	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Controls												
Number of observations	7172	7172	7172	7172	7172	7172	6952	6952	6952	7172	7172	7172
Number of districts	163	163	163	163	163	163	158	158	158	163	163	163
R-squared a	0.436	0.438	0.438	0.434	0.438	0.438	0.429	0.431	0.435	0.428	0.431	0.431
R-squared w	0.465	0.467	0.467	0.463	0.467	0.467	0.459	0.461	0.464	0.457	0.461	0.46

Notes: Values in parentheses denote clustered standard errors at the district level. *, ** and *** denote statistical significance at the 10%, 5% and 1% level, respectively. District trends denote a quadratic trend. In columns 1-6 the drought index is constructed in the same way as the drought index in the paper. The only difference is the growing season used to construct the index. In column 1-3 the May-December period is used, whereas in columns 4-6 annual data is used. In columns 7-9, the index is built over the June-September period, but instead of using the average seasonal temperature for the construction of the hot degree-days variable we use an absolute threshold of 30 degrees. As a result, given that some districts do not experience daily temperatures this high, some districts drop from the sample since in a number of districts the harmful degree-days variable is always 0, which implies the drought index is also equal to 0 and does not vary. Finally, in columns 10-12, instead of multiplying the normalized negative rainfall by the normalized harmful degree-days variable, these two variables are added. In this specification, the average hot degree-days is based on the average June-September daily temperature between 1956-2009, rather than the absolute value of 30 degrees.

Table 5A.11: Sorghum sample robustness checks 1

	Cluster (state)			Squares			Controls		
Variables	1	2	3	4	5	6	7	8	9
Drought index (Type 1)	-0.159*	-0.188*		0.119	0.082		-0.097***	-0.114***	
	(0.074)	(0.086)		(0.094)	(0.105)		(0.028)	(0.031)	
Drought index$\hat{2}$ (Type 1)				-0.453***	-0.429***				
				(0.149)	(0.156)				
Drought index (Type 2)		-0.239			0.392**			-0.122**	
		(0.135)			(0.185)			(0.060)	
Drought index$\hat{2}$ (Type 2)					-2.063***				
					(0.527)				
Drought index (2 types)			-0.195*			0.008			-0.115***
			(0.089)			(0.099)			(0.031)
Drought index$\hat{2}$ (2 types)						-0.344**			
						(0.146)			
Constant	-0.652***	-0.637***	-0.636***	-0.737***	-0.716***	-0.699***	-0.022	-0.059	-0.056
	(0.060)	(0.066)	(0.067)	(0.050)	(0.049)	(0.049)	(0.207)	(0.205)	(0.205)
Time trends	✓	✓	✓	✓	✓	✓	✓	✓	✓
District fixed effects	✓	✓	✓	✓	✓	✓	✓	✓	✓
Year fixed effects	✓	✓	✓	✓	✓	✓	✓	✓	✓
Controls							✓	✓	✓
Number of observations	6908	6908	6908	6908	6908	6908	6380	6380	6380
Number of districts	157	157	157	157	157	157	145	145	145
R-squared a	0.335	0.337	0.337	0.337	0.34	0.338	0.366	0.367	0.367
R-squared w	0.369	0.371	0.371	0.371	0.374	0.373	0.4	0.4	0.4

Notes: Values in parentheses denote clustered standard errors at the district level for columns 4-9. For columns 1-3 they denote clustered standard errors at the state level. *, ** and *** denote statistical significance at the 10%, 5% and 1% level, respectively. District trends denote a district-specific quadratic trend. In columns 7-9, we include 4 controls and their squares. These include the proportion of net irrigated area, the total cereal area, the total rural population density (rural population divided by gross cropped area) and fertilizer intensity. In columns 7-9 all districts for which at least one observation is missing for the control variables are dropped and this is the reason behind the decrease in the number of districts.

Table 5A.12: Sorghum sample robustness checks 2

	May-December			Annual			Degree days (30 degrees)			Additive		
Variables	1	2	3	4	5	6	7	8	9	10	11	12
Drought index (Type 1)	-0.198***	-0.215***		-0.214***	-0.228***		-0.132***	-0.158***		-0.050***	-0.059***	
	(0.030)	(0.036)		(0.033)	(0.038)		(0.036)	(0.042)		(0.011)	(0.013)	
Drought index (Type 2)		-0.102**			-0.105*			-0.232***			-0.042***	
		(0.047)			(0.054)			(0.085)			(0.016)	
Drought index (2 types)			-0.201***			-0.214***			-0.197***			-0.053***
			(0.036)			(0.038)			(0.039)			(0.013)
Constant	-0.703***	-0.697***	-0.717***	-0.671***	-0.671***	-0.699***	-0.772***	-0.753***	-0.720***	-0.750***	-0.741***	-0.758***
	(0.049)	(0.048)	(0.047)	(0.048)	(0.048)	(0.046)	(0.049)	(0.048)	(0.047)	(0.049)	(0.048)	(0.045)
Time trends	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
District fixed effects	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Year fixed effects	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Controls												
Number of observations	6908	6908	6908	6908	6908	6908	6732	6732	6732	6908	6908	6908
Number of districts	157	157	157	157	157	157	153	153	153	157	157	157
R-squared a	0.34	0.341	0.34	0.341	0.342	0.341	0.338	0.339	0.341	0.334	0.335	0.335
R-squared w	0.374	0.375	0.374	0.375	0.376	0.375	0.372	0.374	0.375	0.368	0.369	0.369

Notes: Values in parentheses denote clustered standard errors at the district level. *, ** and *** denote statistical significance at the 10%, 5% and 1% level, respectively. District trends denote a quadratic trend. In columns 1-6 the drought index is constructed in the same way as the drought index in the paper. The only difference is the growing season used to construct the index. In column 1-3 the May-December period is used, whereas in columns 4-6 annual data is used. In columns 7-9, the index is built over the June-September period, but instead of using the average seasonal temperature for the construction of the hot degree-days variable we use an absolute threshold of 30 degrees. As a result, given that some districts do not experience daily temperatures this high, some districts drop from the sample since in a number of districts the harmful degree-days variable is always 0, which implies the drought index is also equal to 0 and does not vary. Finally, in columns 10-12, instead of multiplying the normalized negative rainfall by the normalized harmful degree-days variable, these two variables are added. In this specification, the average hot degree-days is based on the average June-September daily temperature between 1956-2009, rather than the absolute value of 30 degrees.

Table 5A.13: Barley sample robustness checks 1

	Cluster (state)			Squares			Controls		
Variables	1	2	3	4	5	6	7	8	9
Drought index (Type 1)	-0.013	-0.032		-0.046	-0.085*		-0.007	-0.025	
	(0.035)	(0.048)		(0.048)	(0.049)		(0.027)	(0.028)	
Drought index$\hat{2}$ (Type 1)				0.054	0.087				
				(0.076)	(0.075)				
Drought index (Type 2)		-0.152			-0.111			-0.137***	
		(0.078)			(0.132)			(0.045)	
Drought index$\hat{2}$ (Type 2)					-0.175				
					(0.455)				
Drought index (2 types)			-0.051			-0.136***			-0.042
			(0.049)			(0.043)			(0.027)
Drought index$\hat{2}$ (2 types)						0.149**			
						(0.070)			
Constant	-0.291***	-0.280***	-0.280***	-0.348***	-0.325***	-0.313***	-0.223**	-0.242**	-0.210**
	(0.048)	(0.052)	(0.049)	(0.040)	(0.040)	(0.038)	(0.095)	(0.095)	(0.093)
Time trends	✓	✓	✓	✓	✓	✓	✓	✓	✓
District fixed effects	✓	✓	✓	✓	✓	✓	✓	✓	✓
Year fixed effects	✓	✓	✓	✓	✓	✓	✓	✓	✓
Controls							✓	✓	✓
Number of observations	3432	3432	3432	3432	3432	3432	3432	3432	3432
Number of districts	78	78	78	78	78	78	78	78	78
R-squared a	0.767	0.768	0.767	0.767	0.768	0.767	0.768	0.768	0.768
R-squared w	0.78	0.781	0.78	0.78	0.781	0.781	0.781	0.782	0.782

Notes: Values in parentheses denote clustered standard errors at the district level for columns 4-9. For columns 1-3 they denote clustered standard errors at the state level. *, ** and *** denote statistical significance at the 10%, 5% and 1% level, respectively. District trends denote a district-specific quadratic trend. In columns 7-9, we include 4 controls and their squares. These include the proportion of net irrigated area, the total cereal area, the total rural population density (rural population divided by gross cropped area) and fertilizer intensity. In columns 7-9 all districts for which at least one observation is missing for the control variables are dropped and this is the reason behind the decrease in the number of districts.

Table 5A.14: Barley sample robustness checks 2

	May-December			Annual			Degree days (30 degrees)			Additive		
Variables	1	2	3	4	5	6	7	8	9	10	11	12
Drought index (Type 1)	-0.071***	-0.067***		-0.070***	-0.073***		-0.011	-0.033		-0.006	-0.013	
	(0.022)	(0.023)		(0.022)	(0.023)		(0.027)	(0.028)		(0.009)	(0.009)	
Drought index (Type 2)		0.019			-0.016			-0.173***			-0.032***	
		(0.031)			(0.038)			(0.045)			(0.010)	
Drought index (2 types)			-0.055**			-0.067***			-0.047*			-0.020***
			(0.022)			(0.022)			(0.026)			(0.008)
Constant	-0.288***	-0.292***	-0.304***	-0.287***	-0.285***	-0.292***	-0.351***	-0.327***	-0.319***	-0.348***	-0.331***	-0.313***
	(0.038)	(0.038)	(0.038)	(0.038)	(0.038)	(0.038)	(0.041)	(0.041)	(0.039)	(0.040)	(0.039)	(0.037)
Time trends	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
District fixed effects	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Year fixed effects	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Controls												
Number of observations	3432	3432	3432	3432	3432	3432	3432	3432	3432	3432	3432	3432
Number of districts	78	78	78	78	78	78	78	78	78	78	78	78
R-squared a	0.768	0.768	0.767	0.768	0.768	0.768	0.767	0.768	0.767	0.767	0.767	0.767
R-squared w	0.781	0.781	0.781	0.781	0.781	0.781	0.78	0.781	0.78	0.78	0.781	0.781

Notes: Values in parentheses denote clustered standard errors at the district level. *, ** and *** denote statistical significance at the 10%, 5% and 1% level, respectively. District trends denote a quadratic trend. In columns 1-6 the drought index is constructed in the same way as the drought index in the paper. The only difference is the growing season used to construct the index. In column 1-3 the May-December period is used, whereas in columns 4-6 annual data is used. In columns 7-9, the index is built over the June-September period, but instead of using the average seasonal temperature for the construction of the hot degree-days variable we use an absolute threshold of 30 degrees. As a result, given that some districts do not experience daily temperatures this high, some districts drop from the sample since in a number of districts the harmful degree-days variable is always 0, which implies the drought index is also equal to 0 and does not vary. Finally, in columns 10-12, instead of multiplying the normalized negative rainfall by the normalized harmful degree-days variable, these two variables are added. In this specification, the average hot degree-days is based on the average June-September daily temperature between 1956-2009, rather than the absolute value of 30 degrees.

B Appendix B - Data preparation

B.1 Data and Variables

Building the dataset

We start with the raw data file, which already includes cumulative monthly rainfall data at the district level.

Generating the rainfall variable

We generate three rainfall variables, which represent cumulative rainfall over three distinct periods, namely:

- A short Monsoon period (June-September), used in our main results
- An extended Monsoon period (May-December), used as a robustness check.
- An annual rainfall measure (January-December), used as a robustness check.

For each of the three cumulative rainfall variables we then define a long-term average rainfall measure for each district. To do this, we take the average total cumulative rainfall over the growing season for each district over the period 1956-2009. For our main specification, we define the growing season as June-September (see above).

For a given district, the general formula used is the following:

$$TR_{it} = \sum_{m=1}^{N} R_{mit} \tag{5B.1}$$

Where the total rainfall in a given growing season for a given district i in a given year t, is equal to the sum of the monthly cumulative rainfall over the months (m to N) included in the growing season. To calculate the long-term average rainfall, we use the following formula:

$$LTAR_i = \frac{1}{54} \sum_{t=1956}^{T=2009} TR_{it} \tag{5B.2}$$

Where the long-term average rainfall for a given district i is simply calculated as the average total rainfall in that district over the 1956-2009 period.

Generating temperature variables

We opt for a measure of hot degree days (HDD) to capture accumulated heat over the growing season (June-September, in our main specification). This captures the number of degree-days above a reference temperature over a given time period. We use two alternative specifications for generating this variable.

In our main specification, we compute HDD based on the average temperature over the monsoon period (June-September). We test the sensitivity of results to alternative growing periods (May-December and Annual, respectively).

Our first step is to define the average daily temperature over the growing season for each district between 1956 and 2009. For any given district, HDD is estimated as:

$$HDD_{it} = \sum_{m=1}^{M} \sum_{d=1}^{D} (DT_{imd} - DTA_i) \tag{5B.3}$$

Our long-term average HDD is then calculated as follows:

$$LTAHDD_i = \frac{1}{54} \sum_{t=1956}^{T=2009} HDD_{it} \tag{5B.4}$$

where d and m represent a given day and month included in the growing season and N and M respectively represent the total numbers of days in a given month and the total number of months in the growing season; DT denotes the average daily temperature in district i in day d of month m; and, DTA represents the average growing season daily temperature for a given district over the 1956-2009 period. Next, we create $LTAHDD_i$, which is simply the average cumulative degree-days above the mean daily temperature experienced by district i over the 1956-2009 period.

In addition, we create alternative cumulative degree-day variables, where 30 degrees is used as a base temperature (instead of the average temperature over the growing season). We do this for the three alternative growing seasons. We have:

$$HDD30_{it} = \sum_{m=1}^{M} \sum_{d=1}^{D} (DT_{imd} - 30) \tag{5B.5}$$

There are two main reasons why we use the district average as our reference temperature. The first has to do with the fact that we often pool a number of cereals together in our regressions. Given that there is no unique reference temperature for cereals, we prefer to use the district mean temperature. The second reason relates to sample size. Some districts may not have many days with an average daily temperature above 30 degrees. Thus, these districts have to be dropped from our sample since they have an invariant drought index.

Data inputting for controls used in the robustness check

In an attempt to gauge the sensitivity of our results to the inclusion of additional controls, we include a number of variables which could ostensibly be related to observed yields. These include area under cultivation, fertilizer, rural population density and proportion of irrigated area. For the latter three variables, there are a number of missing observations. For instance, in the case of rural population, the values are only recorded every 10 years when a census is performed. In other cases, there are also a number of missing observations. It should be stressed, however, that the imputations discussed below do not affect our main results since we use them only as a robustness check. We now discuss the assumptions underlying the imputation of each variable.

In the case of rural population we have data for 1971, 1981, 1991 and 2001. As such, between two waves of the census (e.g. between 1981 and 1991), we assume an exponential growth in between two waves. In the case of the pre-1971 and post-2001 data, we assume the growth rate of the subsequent and previous period, respectively, i.e. for the pre-1971 data, we assume the growth rate witnessed between 1971 and 1981. Similarly, for the post-2001 data, we assume the growth rate witnessed between 1991 and 2001. There are five occurrences where this process predicts impossible values (i.e. negative population). For these five we replace the impossible value by a missing value. Since we confine our sample to a balanced sample for all of our robustness checks, these observations are not used.

For the remaining variables, fertilizer and irrigation, we use linear interpolation (using the Stata command *ipol*) when the missing observation is between two values. In order to reduce the number of missing observations, we use linear extrapolation when they are either before the first or after the last observation (by using the Stata option *epolate* within the *ipolate* command). In the case of fertilizer we initially have 2,691 missing observations. However, the majority of these occur outside of our sample period (1966-2009). Only 270 observations occur within our sample period and are either interpolated or extrapolated. Out of these, the method produces 30 impossible (negative) values. In these cases, we simply replace the variable by a missing observation. This ensures that these impossible values do not affect our robustness checks.

We then carry out a similar exercise for the proportion of area under irrigation. First, we define the proportion of net irrigated area as the ratio of net irrigated area to net cropped area. Generating this variable results in five observations which have impossible (above 1) values. In three of these cases, since the values are below 1.05 we replace them by 1. We replace the two values that exceed 1.05 with a missing observation. Yet, after creating this variable, there are still 1,090 missing observations. Most of these occur due to missing data on net irrigated area. As such, we use the interpolation command with the extrapolation option and replace the (38) impossible (negative) values by missing values. For the remaining missing values we interpolate (with the extrapolate option) the proportion of net irrigated area and replace the negative values with a missing observation.

Generating additional variables (excluding drought indices)

We generate a number of additional variables:

- Rural population per hectare; obtained by dividing the rural population by gross cropped area
- Total cereal quantity produced; obtained by summing the quantity produced of each individual type of cereal
- Total cereal area; obtained by summing the areas devoted to each individual cereal
- Cereal yield; obtained by dividing the total quantity of cereal by total cereal area
- Individual cereal yield; obtained for each cereal by dividing total production by the

total area devoted to a particular cereal

Generating drought indices

Crucial to our analysis is the construction of a novel drought index. For our purposes, we develop four drought indices. Below we describe the steps we carry out for each one.

Yu-Babcock index

We denote: total rainfall over the growing season TR_{it}; the mean of total rainfall over the growing season over 1956-2009 $LTAR_i$; and, the standard deviation of TR_{it} as $sdTR_i$. We then obtain the standardized variable using the following formula:

$$ZTR_{it} = \frac{TR_it - LTAR_i}{sdTR_i} \tag{5B.6}$$

We proceed analogously for our HDD_{it} measure. Let: HDD_{it} be cumulative degree days over the growing season; $LTAHDD_i$ be long-term average cumulative degree days in the growing season; and, $sdHDD_i$ be the standard deviation of HDD_{it}. We compute the standardized variable:

$$ZHDD_{it} = (HDD_{it} - LTAHDD_i)/(sdHDD_i) \tag{5B.7}$$

Following this, we use the following to compute the Yu-Babcock index:

$$BYU_it = -max(0, ZHDD_{it}) * min(0, ZTR_{it}) \tag{5B.8}$$

Normalized indices

For the remaining indices, we use a normalized variable between 0 and 1, rather than a standardized value. We construct a variable, MTR_{it}, which is simply the negative of TR_{it} (i.e. $MTR_{it} = -TR_{it}$). The following is estimated to obtain NTR_{it} and $NHDD_{it}$:

$$NTR_{it} = \frac{MTR_{it} - MTR_i^{min})}{(MTR_i^{max} - MTR_i^{min})} \tag{5B.9}$$

$$NHDD_{it} = \frac{(HDD_{it} - HDD_i^{min})}{(HDD_i^{max} - HDD_i^{min})} \tag{5B.10}$$

We differ from Yu and Babcock (2010) in creating a normalized version of the rain and temperature variables such that they vary strictly between 0 and 1, with 1 indicating the most extreme value (the highest temperature and lowest rainfall) and 0 indicating the lowest value. From these two variables, we then create a normalized rainfall-temperature index $NRTI_{it}$, which is simply a product of these variables:

$$NRTI_{it} = NTR_{it} * NHDD_{it} \tag{5B.11}$$

From this, we obtain three additional indices. First:

$$DI1_{it} = \begin{cases} NRTI_{it} \text{ if } ZTR_{it} < 0 \; and ZHDD_{it} > 0; \\ 0 \text{ otherwise} \end{cases} \tag{5B.12}$$

This is equivalent to a normalized version of the Yu-Babcock (2010) index. It only takes a non-zero value for events where rainfall deficiency and temperature are above average.

Second, we create our cold drought index analogously, using the following:

$$DI2_{it} = \begin{cases} NRTI_{it} \text{ if } ZTR_{it} < 0 \; and ZHDD_{it} < 0; \\ 0 \text{ otherwise} \end{cases} \tag{5B.13}$$

This is the category omitted by Yu and Babcock. It only takes a non-zero value for events where rainfall deficiency is above-average and temperature is below average.

Finally, we create a third index, which combines $DI1_{it}$ and $DI2_{it}$:

$$DI12_{it} = \begin{cases} NRTI_{it} \text{ if } ZTR_{it} < 0; \\ 0 \text{ otherwise} \end{cases} \tag{5B.14}$$

This index takes non-zero values for all events where precipitation is below average.

The three main strengths of this index are that it: (i) defines all potential dry events; (ii) takes into account both temperature and rainfall; and, (iii) is increasing in temperature and rainfall deficiency. The main strength vis--vis the Yu and Babcocks index is that, by using the normalized negative of rainfall, we are able to construct an index that accounts for all potential types of drought without running into the problem of negative values that emerges from the interaction of the standardized variables.

Our index, however, still has four potential drawbacks. First, the normalization process is bounded between 0 and 1, which means that if a given district has a very large outlier in a given year but records lower values in other years then this would indicate a low value in the drought index thus masking what might have been a very bad drought year. This problem is less likely to arise in the standardized index.

The second potential weakness arises from the multiplicative nature of the index. Thus, whenever temperature is close to 0 this can lead to a very low value of the drought index despite very deficient rainfall. Note, however, that this problem is only likely to arise for the $DI2_it$ index, and also applies to Yu and Babcock's index.

Third, similar to their index, our index does not take into account intra-seasonal deficiencies in rainfall, which have been shown to have important impacts on agricultural productivity, e.g. Fishman (2016).

Finally, similar to most drought indices, our index does not take into account (rare) multi-year droughts because this would require an index with memory that takes into account soil moisture conditions. That said, since drought in India is mainly driven by variation in the annual monsoon, we argue that using an annual measure of monsoon rainfall is of greater relevance when estimating drought impact in our setting.

To ensure that the multiplicative relationship is not driving our results we also create a series of additive indices, which conceptually are very similar to our multiplicative indices. Specifically, the normalized additive rainfall temperature index, $NARTI_{it}$, is constructed as:

$$NARTI_{it} = NTR_{it} + NHDD_{it} \tag{5B.15}$$

The only difference is that $NRTI_{it}$ is the product of rainfall and temperature while $NARTI_{it}$ is additive. From the latter, we have the following:

$$ADDI1_{it} = \begin{cases} NARTI_{it} \text{ if } ZTR_{it} < 0 \textit{ and } ZHDD_{it} > 0; \\ 0 \text{ otherwise} \end{cases} \tag{5B.16}$$

$$ADDI2_{it} = \begin{cases} NARTI_{it} \text{ if } ZTR_{it} < 0 \textit{ and } ZHDD_{it} < 0; \\ 0 \text{ otherwise} \end{cases} \tag{5B.17}$$

$$ADDI12_{it} = \begin{cases} NARTI_{it} \text{ if } ZTR_{it} < 0; \\ 0 \text{ otherwise} \end{cases} \tag{5B.18}$$

where $ADDI1_{it}$, $ADDI2_{it}$ and $ADDI12_{it}$ are the additive equivalents to $DI1_{it}$, $DI2_{it}$ and $DI12_{it}$.

As a robustness check, we construct each of these indices for three distinct periods (i.e. June-September, May-December, and January-December) for our rain and temperature variables. We also inspect the correlations among all the indices. They are very high.

Determining the sample and generating trends

After developing the drought indices, we create a data file which includes only the observations between 1966 and 2009, i.e. our sample period. This choice is purely driven by data availability. Prior to 1966, our dependent variables (production and yields) are missing from the ICRISAT dataset and, hence, would have resulted in districts being dropped. Prior to starting our analysis, we also dropped any districts for which at least one observation is missing in order to keep a balanced panel. We then generate district-specific quadratic trends using the following:

$$trend = t - 1965 \tag{5B.19}$$

$$trend_s q = trend^2 \tag{5B.20}$$

where t denotes the year.

C Appendix C - Cost estimates methodology

As made clear in the main text, the cost estimates generated in this paper are based purely on yield losses, without taking into account any potential changes in the cultivated area. Specifically, our cost estimates are derived using a series of seven steps. We detail all the assumptions and steps used throughout and discuss their relative strengths and weaknesses.

Step 1 - Obtain a national estimate of crop prices and aggregate cereal price for each year:

Crop prices: We generate a national weighted average of crop price by year (using the **egen** command and the user-written option *wtmean*), where the weight is determined by area of land under cultivation. For millet the process is slightly different since there are two kinds of millet in our sample (pearl millet and finger millet). As a result, we first generate, for each year, a weighted average of millet prices at the district-level. We then sum the total area under millet production (area under pearl millet + area under finger millet) and use this to establish a national weighted average millet price for a given year. Note that the **egen** command automatically adjusts the computation for missing data. As a result, districts that do not report prices for a given year are not included in the weighted average.

We then use 2008 crop prices to estimate prices (and costs) in USD: aggregate cereal price index (24.147 USD/quintal); rice (29.947 USD/quintal); wheat (22.360 USD/quintal); maize (16.125 USD/quintal); barley (19.089 USD/quintal); sorghum (18.88 USD/quintal); and, millet (17.5 USD/quintal). These prices are obtained by calculating the weighted average of crop-specific prices in India for 2008 (in Rupees) and converting this by the weighted averages of the 2008 monthly exchange rates extracted from this link.

All of the tables are also constructed using nominal yearly prices in Rupees and are available from the authors upon request.

Weaknesses and strengths of the assumptions

National prices. For any given year, there are large differences in prices across districts. It could be argued that prices at the district- or state-level may be more appropriate. However, there are issues with missing price data at the district-level and, to a lesser extent, at the state-level even for cases where there is a non-zero quantity reported. This is the main reason why we opt for national prices.

Using fixed prices in USD: Using a fixed price throughout the sample period implies that the estimates of costs will vary depending on the chosen year since the choice of the year will, by definition drive both the exchange rate and the price level. Yet, output losses in the early periods are made comparable to losses in later periods since they are given the same value. Using nominal prices could lead to the economic cost of drought artificially increasing over time as nominal prices in most cereals have trended upwards over the sample period. In any case, we have also performed this exercise using nominal prices in rupees and the results are available from the authors upon request.

Step 2 - Estimate the regression of interest

We estimate the following linear regression in which the coefficients for the two types of droughts are estimated separately, and there are: (i) no dummy variables; (ii) no controls; (iii) district-specific quadratic trends; (iv) district fixed effects; and, (v) year fixed effects.

$$ln(y_{itc}) = \boldsymbol{\alpha}_i + \boldsymbol{\beta}_t + \boldsymbol{\delta}_{i1} * t + \boldsymbol{\delta}_{i2} * t^2 + \theta_1 DI1_{it} + \theta_2 DI2_{it} + \epsilon_{it} \tag{5C.1}$$

Step 3 - Estimate the yield losses

After Stata has generated the output for the regression in Step 2, we operationalise the following steps:

- **Step 3.1** - Predict the natural logarithm of yield for drought when $DI12_{it} > 0$ (i.e. when the given district is drought affected). We do this by using the predict command following the estimation of the regression before replacing observations not affected by drought with an empty observation. We denote this variable $lyhat_d$. Note that, to limit potential biases in the estimates of overall costs, we remove districts with implausible predicted yields, which we define as yields below 100 kg/ha and above 5 tonnes/ha). This assumption, however, affects very few observations, specifically 25 predicted values out of over 6,000 events in the full sample.

- **Step 3.2** - Predict the natural logarithm of the yield variable under no drought (i.e. $DI12_{it} = 0$;or $DI1_{it} = 0$ and $DI2_{it} = 0$). We rename the variables $DI1_{it} = 0$ and $DI2_{it} = 0$ (e.g. they temporarily become $DI1original_{it}$ and $DI2original_{it}$) and create two new temporary variables: $DI1_{it} = 0$ and $DI2_{it} = 0$. We then use the predict command to obtain predicted yield and a variable denoted $lyhat_{nd}$. The temporary $DI1_{it}$ and $DI2_{it}$ variables are deleted, and $DI1original_{it}$ and $DI2original_{it}$ are, respectively, renamed $DI1_{it}$ and $DI2_{it}$ once again. We replace $lyhat_d$ with an empty observation for every case where $DI12_{it} = 0$ (non-drought affected case). Note that when we estimate the predicted values using dummy variables, we also switch the dummy variable equal to zero when we replace the index coefficient with zero.

- **Step 3.3** - Obtain yield values. All our predicted values are in logs. We thus convert these variables into levels and denote these variables $yhat_nd$ and $yhat_d$.

- **Step 3.4** - Obtain predicted yield losses by simply subtracting the predicted yield under no drought (Step 3.2) by the actual predicted yield (Step 3.1) for all cases where $DI12_{it} > 0$. Formally, we calculate $ylosses = yhat_nd - yhat_d$.

- **Step 3.5** - Obtain predicted yield losses by drought type by simply subtracting the predicted yield under no drought by the actual predicted yield for each type of drought separately. Thus, we estimate: $ylosses_1 = yhat_{nd} - yhat_d$ if $DI1_{it} > 0$; and, $ylosses_2 = yhat_{nd} - lyhat_d$ if $DI2_{it} > 0$. Note the two types of drought are mutually exclusive (i.e. it is impossible for a district to simultaneously have a hot and a cold drought).

Step 4 - Estimate district-level production losses

This requires three further steps:

- **Step 4.1** - Convert land area to ha. As highlighted in the supporting documentation, the land-use data is in 000s of ha. As a result we simply multiply cereal area by 1,000 to derive the cereal area in ha. Note that we do not model potential land-use changes as a response to a drought event, which is likely to happen. In other words, we exclude the possibility that land under cereal production might decline in a drought year given our focus on developing an inclusive drought index and estimating the marginal effects of drought on agricultural production.

- **Step 4.2** - Convert yield losses to 1,000t/ha. Currently, our yield losses are in t/ha. We thus convert the yield losses to 1,000t/ha by dividing *ylosses* by 1,000.
- **Step 4.3** - Get the total district production losses (in 1,000t). Obtain the product of the variable obtained in Step 4.1 by that obtained in Step 4.2.

Step 5 - Estimate the district-level cost of production losses

To do this we perform two further steps:

- **Step 5.1** - Convert price data to million USD/1,000t. For the results shown in the paper, our price data are in USD per quintal (as explained in Step 3.1) and our production loss data (estimated in Step 4.3) are in 1,000t. To obtain the price data in million USD per 1,000t we divide our price level by 100. Note, a quintal is 100kg. To convert it into 1,000t (1,000,000kg) we multiply the price data by 10,000. However, since we want the data in million USD rather than USD, we divide this by 1,000,000. Thus, $price * 10,000/1,000,000 = price/100$.
- **Step 5.2** - Obtain total value of production losses. After obtaining prices in million USD/1,000t we multiply the variable derived in Step 5.1 by the variable derived in Step 4.3 to obtain the total value of production losses in USD millions. Note, for our estimates in rupees, we apply the exact same procedure using yearly nominal prices.

Step 6 - Estimate total yearly production losses

To obtain this measure in 1,000t we sum estimated total production losses of each affected district in a given year. We use the *total* function of the *egen* command. Note that the value in the table represents the unweighted average yearly loss. In other words, we do not weight this mean by the number of affected districts in a given year.

Step 7 - Estimate total yearly production costs

To obtain this measure in millions of rupees, we simply sum the estimated total value of the production losses of each affected district in a given year. We use the *egen* command with the *total* function. Note again that the value in the table represents the unweighted average yearly loss. In other words, we do not weight this mean by the number of affected districts in a given year.

Chapter 6

Threshold effects of extreme rainfall events and the evolution of drought impacts on Indian agriculture

A Appendix A - Additional tables and graphs

Table 6A.1: Unit root tests (Full sample and agro-ecological zones)

				LLC (Levin-Lin-Chu test)				IPS (Im-Pesaran-Shin)	
	N	T	Lags	Statistic	Statistic adj.	p-value	Lags (LR var)	Statistic	p-value
All									
Yield (levels)	275	44	0.804	-17.917	-8.183	0.000	11.000	-1.681	0.046
De-trended yield (ln)	275	44	0.313	-57.184	-41.112	0.000	11.000	-54.969	0.000
De-meaned yield (ln)	275	44	0.800	-25.312	-15.825	0.000	11.000	-9.475	0.000
Aez 1 - Arid areas									
Yield (levels)	23	44	0.652	-7.056	-4.605	0.000	11.000	-5.147	0.000
De-trended yield (ln)	23	44	0.217	-13.395	-10.276	0.000	11.000	-18.759	0.000
De-meaned yield (ln)	23	44	0.739	-9.233	-6.706	0.000	11.000	-7.020	0.000
Aez 2 - Semi-arid areas									
Yield (levels)	123	44	0.797	-11.648	-5.012	0.000	11.000	0.628	0.735
De-trended yield (ln)	123	44	0.285	-40.140	-29.082	0.000	11.000	-35.407	0.000
De-meaned yield (ln)	123	44	0.780	-16.797	-10.684	0.000	11.000	-4.949	0.000
Aez 3 - Sub-humid									
Yield (levels)	111	44	0.874	-11.221	-4.994	0.000	11.000	-0.832	0.203
De-trended yield (ln)	111	44	0.279	-39.521	-29.192	0.000	11.000	-39.715	0.000
De-meaned yield (ln)	111	44	0.865	-15.821	-9.432	0.000	11.000	-5.782	0.000
Aez 5 - Humid areas									
Yield (levels)	18	44	0.611	-3.824	-1.301	0.097	11.000	-0.343	0.366
De-trended yield (ln)	18	44	0.222	-18.200	-13.971	0.000	11.000	-15.254	0.000
De-meaned yield (ln)	18	44	0.611	-5.386	-3.012	0.001	11.000	-1.804	0.036

Notes: N refers to the total number of observations. T refers to the number of time periods and lags refers to the average number of lags as chosen by the AIC. LR var refers to the long-run variance and it was estimated with a Bartlett kernel with 11 lags (the default). The null of the test is that panels contain a unit root. As a result, a rejection of the null provides some evidence that the series may be stationary (at least for some of the panels). Finally, note that the first three columns (N, T and Lags) are common across the two tests.

Table 6A.2: Unit root tests (by crop)

				LLC (Levin-Lin-Chu test)				IPS (Im-Pesaran-Shin)	
	N	T	Lags	Statistic	Statistic adj.	p-value	Lags (LR var)	Statistic	p-value
Barley									
Yield (levels)	78	44	0.833	-11.325	-4.471	0.000	11.000	-1.875	0.030
De-trended yield (ln)	78	44	0.346	-42.248	-32.058	0.000	11.000	-33.909	0.000
De-meaned yield (ln)	78	44	0.808	-14.456	-7.741	0.000	11.000	-5.614	0.000
Maize									
Yield (levels)	174	44	0.477	-34.720	-20.987	0.000	11.000	-22.980	0.000
De-trended yield (ln)	174	44	0.207	-56.965	-43.457	0.000	11.000	-47.978	0.000
De-meaned yield (ln)	174	44	0.483	-38.858	-25.882	0.000	11.000	-27.108	0.000
Millet									
Yield (levels)	163	44	0.620	-33.506	-20.650	0.000	11.000	-19.581	0.000
De-trended yield (ln)	163	44	0.264	-58.883	-46.122	0.000	11.000	-48.399	0.000
De-meaned yield (ln)	163	44	0.534	-39.567	-27.734	0.000	11.000	-26.153	0.000
Rice									
Yield (levels)	240	44	0.708	-25.958	-14.666	0.000	11.000	-15.683	0.000
De-trended yield (ln)	240	44	0.400	-56.621	-39.947	0.000	11.000	-50.487	0.000
De-meaned yield (ln)	240	44	0.679	-33.195	-21.868	0.000	11.000	-24.599	0.000
Sorghum									
Yield (levels)	157	44	0.522	-38.260	-24.597	0.000	11.000	-26.033	0.000
De-trended yield (ln)	157	44	0.236	-59.653	-47.117	0.000	11.000	-49.028	0.000
De-meaned yield (ln)	157	44	0.414	-43.777	-31.504	0.000	11.000	-32.617	0.000
Wheat									
Yield (levels)	199	44	0.774	-20.255	-10.955	0.000	11.000	-5.678	0.000
De-trended yield (ln)	199	44	0.337	-50.990	-35.187	0.000	11.000	-42.951	0.000
De-meaned yield (ln)	199	44	0.774	-27.275	-17.038	0.000	11.000	-12.672	0.000

Notes: N refers to the total number of observations. T refers to the number of time periods and lags refers to the average number of lags as chosen by the AIC. LR var refers to the long-run variance and it was estimated with a Bartlett kernel with 11 lags (the default). The null of the test is that panels contain a unit root. As a result, a rejection of the null provides some evidence that the series may be stationary (at least for some of the panels). Finally, note that the first three columns (N, T and Lags) are common across the two tests.

Table 6A.3: Robustness check - controls (full sample and agro-ecological zones)

	Full Sample	Arid	Semi-arid	Sub-humid	Humid
		Threshold test			
P-value					
Single	0	0.023	0	0.001	0.501
Double	0	0.094	0	0.014	0.345
Triple	0.519	0.54	0.587	0.816	0.839
		Threshold Location			
γ_1	0.589	0.708	0.497	0.803	
	[0.580,0.596]	[0.673,0.727]	[0.483,0.510]	[0.761,0.806]	
γ_2	0.797	1.462	0.746	0.953	
	[0.789,0.780]	[1.362,1.491]	[0.741,0.748]	[0.944,0.955]	
γ_3					
		β - Rainfall-Temperature Index			
Rain< γ_1	-0.426***	-0.657***	-0.465***	-0.120***	-0.259**
	(0.050)	(0.167)	(0.070)	(0.036)	(0.088)
γ_1 < Rain < γ_2	-0.198***	-0.218*	-0.220***	-0.023	
	(0.025)	(0.109)	(0.035)	(0.033)	
γ_2 < Rain < γ_3	0.002	1.266	0.036	0.105**	
	(0.029)	(0.741)	(0.037)	(0.043)	
Rain > γ_3					
Constant	0.039*	-0.140*	0.014	0.034	0.201***
	(0.020)	(0.073)	(0.024)	(0.030)	(0.052)
District fixed effects	✓	✓	✓	✓	✓
Year fixed effects	✓	✓	✓	✓	✓
District-specific trends					
Controls	✓	✓	✓	✓	✓
Grid	300	300	300	300	
Observations	8888	748	4840	2992	308
N districts	202	17	110	68	7
R-squared	0.293	0.521	0.339	0.362	0.462

*, **, *** denote statistical significance at the 10%, 5% and 1% level, respectively. Numbers in parentheses represent clustered standard errors at the district level. All numbers in the table were rounded to 3 decimal places. This specifications uses a Balanced sample, which is a requirement for the threshold regression. The dependent variable is de-trended cereal yield where a district-specific quadratic trend was used to de-trend the variable. Controls include de-trended natural logarithms of: total cereal area, fertilizer, proportion of irrigated area and rural population per ha.

Table 6A.4: Robustness check - controls (by crop)

	Barley	Maize	Millet	Rice	Sorghum	Wheat
			Threshold test - P-value			
Single	0.747	0	0	0	0	0
Double	0.053	0.002	0	0	0	0.057
Triple	0.801	0.318	0.712	0.51	0.609	0.658
			Threshold Location			
γ_1		0.577	0.513	0.742	0.586	0.745
		[0.554,0.585]	[0.504,0.528]	[0.731,0.746]	[0.579,0.595]	[0.725, 0.748]
γ_2		0.891	0.79	0.953	0.82	0.956
		[0.867,0.893]	[0.785,0.793]	[0.948,0.956]	[0.815,0.822]	[0.947,0.962]
γ_3						
			β - Rainfall-Temperature Index			
Rain$< \gamma_1$	-0.132***	-0.172**	-0.810***	-0.384***	-0.544***	-0.242***
	(0.043)	(0.079)	(0.133)	(0.045)	(0.085)	(0.032)
$\gamma_1 <$ Rain $< \gamma_2$		0.213***	-0.205***	-0.134***	-0.006	-0.174***
		(0.053)	(0.053)	(0.032)	(0.044)	(0.027)
$\gamma_2 <$ Rain $< \gamma_3$		0.390***	0.157***	0.090**	0.301***	-0.042
		(0.066)	(0.050)	(0.044)	(0.055)	(0.039)
Rain $> \gamma_3$						
Constant	0.046	-0.268***	-0.065*	0.110***	-0.061	0.188***
	(0.030)	(0.048)	(0.039)	(0.030)	(0.053)	(0.023)
District fixed effects	✓	✓	✓	✓	✓	✓
Year fixed effects	✓	✓	✓	✓	✓	✓
District-specific trends						
Controls	✓	✓	✓	✓	✓	✓
Grid		300	300	300	300	300
Observations	3432	6248	5588	7832	6380	6776
N districts	78	142	127	178	145	154
R-squared	0.179	0.122	0.214	0.256	0.119	0.255

*, **, *** denote statistical significance at the 10%, 5% and 1% level, respectively. Numbers in parentheses represent clustered standard errors at the district level. All numbers in the table were rounded to 3 decimal places. This specifications uses a Balanced sample, which is a requirement for the threshold regression. The dependent variable is de-trended yield for each individual cereal, where a district-specific quadratic trend was used to de-trend the variable. Controls include de-trended natural logarithms of: total cereal area, fertilizer, proportion of irrigated area and rural population per ha.

Table 6A.5: Robustness check - De-meaned yield (full sample and agro-ecological zones)

	Full Sample	Arid	Semi-arid	Sub-humid	Humid
			Threshold test		
P-value					
Single	0	0.193	0	0	0.015
Double	0	0.179	0	0	0.647
Triple	0.402	0.422	0.516	0.48	0.782
			Threshold Location		
γ_1	0.517		0.394	0.73	1.138
	[0.492,0.530]		.	[0.726,0.734]	[1.124,1.142]
γ_2	0.81		0.743	0.939	
	[0.805,0.811]		[0.739,0.746]	[0.934,0.941]	
γ_3					
			β - Rainfall-Temperature Index		
Rain$< \gamma_1$	-0.544***	-0.702***	-0.817***	-0.214***	-0.119*
	(0.070)	(0.157)	(0.172)	(0.031)	(0.066)
$\gamma_1 <$ Rain $< \gamma_2$	-0.260***		-0.317***	-0.079***	0.361
	(0.023)		(0.035)	(0.029)	(0.232)
$\gamma_2 <$ Rain $< \gamma_3$	-0.009		0.022	0.093***	
	(0.025)		(0.035)	(0.034)	
Rain $> \gamma_3$					
Constant	-0.570***	-0.552***	-0.609***	-0.590***	-0.364***
	(0.016)	(0.102)	(0.019)	(0.024)	(0.040)
District fixed effects	✓	✓	✓	✓	✓
Year fixed effects	✓	✓	✓	✓	✓
District-specific trends	✓	✓	✓	✓	✓
Controls					
Grid	300		300	300	300
Observations	12100	1012	5412	4884	792
N districts	275	23	123	111	18
R-squared	0.737	0.656	0.788	0.802	0.754

*, **, *** denote statistical significance at the 10%, 5% and 1% level, respectively. Numbers in parentheses represent clustered standard errors at the district level. All numbers in the table were rounded to 3 decimal places. This specifications uses a Balanced sample, which is a requirement for the threshold regression. The dependent variable is de-meaned natural logarithm of cereal yield which allows us to use district-specific quadratic trends as a control.

Table 6A.6: Robustness check - de-meaned yield (by crop)

	Barley	Maize	Millet	Rice	Sorghum	Wheat
			Threshold test - P-value			
Single	0.511	0	0	0	0	0
Double	0.093	0	0	0	0	0
Triple	0.585	0.558	0.679	0.575	0.602	0.556
			Threshold Location			
γ_1		0.576	0.515	0.588	0.607	0.782
		[0.569,0.583]	[0.504,0.555]	[0.574,0.597]	[0.598,0.615]	[0.787,0.800]
γ_2		0.921	0.784	0.81	0.819	0.958
		[0.914,0.923]	[0.780,0.788]	[0.808,0.812]	[0.814,0.821]	[0.952,0.960]
γ_3						
			β - Rainfall-Temperature Index			
Rain$< \gamma_1$	-0.075*	-0.376***	-0.847***	-0.603***	-0.526***	-0.208***
	(0.038)	(0.075)	(0.122)	(0.068)	(0.072)	(0.025)
$\gamma_1 <$ Rain $< \gamma_2$		0.103**	-0.201***	-0.326***	-0.002	-0.084***
		(0.044)	(0.050)	(0.027)	(0.047)	(0.026)
$\gamma_2 <$ Rain $< \gamma_3$		0.304***	0.164***	-0.057**	0.309***	0.056*
		(0.062)	(0.051)	(0.028)	(0.053)	(0.032)
Rain $> \gamma_3$						
Constant	-0.601***	-0.338***	-0.400***	-0.556***	-0.388***	-0.764***
	(0.034)	(0.031)	(0.027)	(0.023)	(0.032)	(0.025)
District fixed effects	✓	✓	✓	✓	✓	✓
Year fixed effects	✓	✓	✓	✓	✓	✓
District-specific trends	✓	✓	✓	✓	✓	✓
Controls						
Grid		300	300	300	300	300
Observations	3432	7656	7172	10560	6908	8756
N districts	78	174	163	240	157	199
R-squared	0.78	0.442	0.496	0.576	0.405	0.733

*, **, *** denote statistical significance at the 10%, 5% and 1% level, respectively. Numbers in parentheses represent clustered standard errors at the district level. All numbers in the table were rounded to 3 decimal places. This specifications uses a Balanced sample, which is a requirement for the threshold regression. The dependent variable is de-meaned natural logarithm of the yield for each individual cereal.

Table 6A.7: Robustness check - annual growing season (full sample and agro-ecological zones)

	Full Sample	Arid	Semi-arid	Sub-humid	Humid
			Threshold test		
P-value					
Single	0	0.036	0	0	0.168
Double	0	0.225	0	0	0.386
Triple	0.544	0.844	0.584	0.646	0.62
			Threshold Location		
γ_1	0.501	0.749	0.503	0.733	
	[0.471,0.515]	[0.733,0.753]	[0.489, 0.517]	[0.728,0.737]	
γ_2	0.766		0.789	0.906	
	[0.762,0.771]		[0.774,0.791]	[0.896,0.907]	
γ_3					
			β - Rainfall-Temperature Index		
Rain$< \gamma_1$	-0.652***	-0.762***	-0.692***	-0.258***	-0.222**
	(0.084)	(0.182)	(0.095)	(0.029)	(0.081)
$\gamma_1 <$ Rain $< \gamma_2$	-0.337***	-0.186	-0.301***	-0.091***	
	(0.023)	(0.167)	(0.033)	(0.025)	
$\gamma_2 <$ Rain $< \gamma_3$	-0.088***		-0.05	0.048**	
	(0.020)		(0.034)	(0.022)	
Rain $> \gamma_3$					
Constant	0.073***	0.03	0.074***	0.056***	0.074
	(0.018)	(0.102)	(0.024)	(0.019)	(0.045)
District fixed effects	✓	✓	✓	✓	✓
Year fixed effects	✓	✓	✓	✓	✓
District-specific trends					
Controls					
Grid	300	300	300	300	
Observations	12100	1012	5412	4884	792
N districts	275	23	123	111	18
R-squared	0.149	0.28	0.193	0.214	0.117

*, **, *** denote statistical significance at the 10%, 5% and 1% level, respectively. Numbers in parentheses represent clustered standard errors at the district level. All numbers in the table were rounded to 3 decimal places. This specifications uses a Balanced sample, which is a requirement for the threshold regression. The dependent variable is de-trended cereal yield where a district-specific quadratic trend was used to de-trend the variable. The growing season used for computing the index used in this robustness check covers the months of January-December

Table 6A.8: Robustness check - annual growing season (by crop)

	Barley	Maize	Millet	Rice	Sorghum	Wheat
			Threshold test - P-value			
Single	0.649	0	0	0	0	0
Double	0.788	0	0	0	0	0.018
Triple	0.771	0.21	0.454	0.596	0.077	0.652
			Threshold Location			
γ_1		0.595	0.456	0.737	0.63	0.766
		[0.578,0.605]	[0.434,0.468]	[0.728,0.740]	[0.620,0.636]	[0.762,0.770]
γ_2		0.804	0.766	0.892	0.764	0.936
		[0.798,0.807]	[0.761,0.769]	[0.886,0.894]	[0.760,0.767]	[0.917,0.938]
γ_3					0.852	
					[0.834,0.853]	
			β - Rainfall-Temperature Index			
Rain$< \gamma_1$	-0.169***	-0.278***	-0.951***	-0.511***	-0.480***	-0.244***
	(0.035)	(0.063)	(0.164)	(0.040)	(0.070)	(0.027)
$\gamma_1 <$ Rain $< \gamma_2$		0.101**	-0.292***	-0.267***	-0.122**	-0.121***
		(0.041)	(0.050)	(0.028)	(0.053)	(0.029)
$\gamma_2 <$ Rain $< \gamma_3$		0.334***	0.033	-0.057*	0.119***	-0.044
		(0.048)	(0.039)	(0.030)	(0.046)	(0.033)
Rain $> \gamma_3$					0.290***	
					(0.044)	
Constant	0.069**	-0.224***	-0.019	0.174***	-0.044	0.180***
	(0.034)	(0.039)	(0.034)	(0.021)	(0.042)	(0.019)
District fixed effects	✓	✓	✓	✓	✓	✓
Year fixed effects	✓	✓	✓	✓	✓	✓
District-specific trends						
Controls						
Grid		300	300	300	300	300
Observations	3432	7656	7172	10560	6908	8756
N districts	78	174	163	240	157	199
R-squared	0.166	0.111	0.141	0.179	0.116	0.088

*, **, *** denote statistical significance at the 10%, 5% and 1% level, respectively. Numbers in parentheses represent clustered standard errors at the district level. All numbers in the table were rounded to 3 decimal places. This specifications uses a Balanced sample, which is a requirement for the threshold regression. The dependent variable is de-trended yield for each individual cereal, where a district-specific quadratic trend was used to de-trend the variable. The growing season used for computing the index used in this robustness check covers the months of January-December

Table 6A.9: Robustness check - May-December growing season (full sample and agro-ecological zones)

	Full Sample	Arid	Semi-arid	Sub-humid	Humid
		Threshold test			
P-value					
Single	0	0.057	0	0	0.21
Double	0	0.107	0	0	0.145
Triple	0.738	0.82	0.553	0.267	0.698
		Threshold Location			
γ_1	0.581	0.719	0.489	0.738	
	[0.567,0.591]	[0.712,0.721]	[0.472,0.501]	[0.729,0.742]	
γ_2	0.81	1.388	0.703	0.879	
	[0.802,0.812]	[1.360,1.399]	[0.693,0.706]	[0.869,0.880]	
γ_3					
		β - Rainfall-Temperature Index			
Rain $< \gamma_1$	-0.540***	-0.632***	-0.697***	-0.253***	-0.241**
	(0.054)	(0.176)	(0.098)	(0.028)	(0.085)
$\gamma_1 <$ Rain $< \gamma_2$	-0.272***	-0.047	-0.371***	-0.123***	
	(0.021)	(0.160)	(0.037)	(0.029)	
$\gamma_2 <$ Rain $< \gamma_3$	-0.072***	1.985***	-0.112***	0.002	
	(0.022)	(0.511)	(0.032)	(0.022)	
Rain $> \gamma_3$					
Constant	0.066***	-0.059	0.072***	0.061***	0.071
	(0.018)	(0.106)	(0.022)	(0.020)	(0.046)
District fixed effects	✓	✓	✓	✓	✓
Year fixed effects	✓	✓	✓	✓	✓
District-specific trends					
Controls					
Grid	300	300	300	300	
Observations	12100	1012	5412	4884	792
N districts	275	23	123	111	18
R-squared	0.146	0.289	0.189	0.211	0.117

*, **, *** denote statistical significance at the 10%, 5% and 1% level, respectively. Numbers in parentheses represent clustered standard errors at the district level. All numbers in the table were rounded to 3 decimal places. This specifications uses a Balanced sample, which is a requirement for the threshold regression. The dependent variable is de-trended cereal yield where a district-specific quadratic trend was used to de-trend the variable. The growing season used for computing the index used in this robustness check covers the months of May-December

Table 6A.10: Robustness check - May-December growing season (by crop)

	Barley	Maize	Millet	Rice	Sorghum	Wheat
			Threshold test - P-value			
Single	0.672	0	0	0	0	0
Double	0.173	0	0	0	0	0.012
Triple	0.282	0.33	0.587	0.512	0.592	0.511
			Threshold Location			
γ_1		0.581	0.458	0.761	0.577	0.758
		[0.571,0.590]	[0.441,0.501]	[0.740,0.764]	[0.564,0.608]	[0.736,0.761]
γ_2		0.816	0.721	0.899	0.727	0.93
		[0.809,0.818]	[0.712,0.724]	[0.894,0.901]	[0.724,0.731]	[0.889,0.932]
γ_3						
			β - Rainfall-Temperature Index			
Rain< γ_1	-0.153***	-0.301***	-0.906***	-0.465***	-0.580***	-0.248***
	(0.036)	(0.068)	(0.142)	(0.035)	(0.079)	(0.027)
γ_1 < Rain < γ_2		0.091**	-0.333***	-0.221***	-0.225***	-0.143***
		(0.040)	(0.055)	(0.026)	(0.056)	(0.028)
γ_2 < Rain < γ_3		0.305***	-0.027	-0.039	0.128***	-0.062*
		(0.049)	(0.038)	(0.028)	(0.043)	(0.034)
Rain > γ_3						
Constant	0.058*	-0.215***	-0.013	0.146***	-0.025	0.179***
	(0.034)	(0.038)	(0.033)	(0.020)	(0.041)	(0.018)
District fixed effects	✓	✓	✓	✓	✓	✓
Year fixed effects	✓	✓	✓	✓	✓	✓
District-specific trends						
Controls						
Grid		300	300	300	300	300
Observations	3432	7656	7172	10560	6908	8756
N districts	78	174	163	240	157	199
R-squared	0.164	0.11	0.139	0.174	0.11	0.088

*, **, *** denote statistical significance at the 10%, 5% and 1% level, respectively. Numbers in parentheses represent clustered standard errors at the district level. All numbers in the table were rounded to 3 decimal places. This specifications uses a Balanced sample, which is a requirement for the threshold regression. The dependent variable is de-trended yield for each individual cereal, where a district-specific quadratic trend was used to de-trend the variable. The growing season used for computing the index used in this robustness check covers the months of May-December,

Table 6A.11: Robustness check - additive RTI (full sample and agro-ecological zones)

	Full Sample	Arid	Semi-arid	Sub-humid	Humid
			Threshold test		
P-value					
Single	0	0.001	0	0	0.041
Double	0	0.068	0	0	0.367
Triple	0.854	0.579	0.59	0.293	0.388
			Threshold Location		
γ_1	0.581	0.719	0.489	0.738	0.873
	[0.482, 0.591]	[0.719,0.721]	[0.472,0.501]	[0.729,0.742]	[0.867,0.876]
γ_2	0.81	1.388	0.8	0.879	
	[0.802, 0.813]	[1.357,1.399]	[0.790,0.802]	[0.869,0.880]	
γ_3					
			β - Rainfall-Temperature Index		
Rain< γ_1	-0.248***	-0.208**	-0.293***	-0.112***	-0.059**
	(0.025)	(0.079)	(0.044)	(0.014)	(0.028)
γ_1 < Rain < γ_2	-0.112***	0.072	-0.102***	-0.052***	-0.012
	(0.010)	(0.070)	(0.016)	(0.014)	(0.036)
γ_2 < Rain < γ_3	-0.019*	0.490***	0.005	-0.006	
	(0.010)	(0.149)	(0.016)	(0.013)	
Rain > γ_3					
Constant	0.056***	-0.214*	0.028	0.066***	0.022
	(0.021)	(0.117)	(0.027)	(0.025)	(0.059)
District fixed effects	✓	✓	✓	✓	✓
Year fixed effects	✓	✓	✓	✓	✓
District-specific trends					
Controls					
Grid	300	300	300	300	300
Observations	12100	1012	5412	4884	792
N districts	275	23	123	111	18
R-squared	0.153	0.311	0.188	0.209	0.111

*, **, *** denote statistical significance at the 10%, 5% and 1% level, respectively. Numbers in parentheses represent clustered standard errors at the district level. All numbers in the table were rounded to 3 decimal places. This specifications uses a Balanced sample, which is a requirement for the threshold regression. The dependent variable is de-trended cereal yield where a district-specific quadratic trend was used to de-trend the variable. The index used in this robustness check is an additive, rather than a multiplicative relation between rainfall and temperature for the June-September growing season.

Table 6A.12: Robustness check - additive RTI (by crop)

	Barley	Maize	Millet	Rice	Sorghum	Wheat
			Threshold test - P-value			
Single	0.452	0	0	0	0	0
Double	0.212	0	0	0	0	0.002
Triple	0.647	0.686	0.571	0.51	0.494	0.468
			Threshold Location			
γ_1		0.638	0.458	0.704	0.577	0.758
		[0.627,0.644]	[0.441,0.471]	[0.701, 0.708]	[0.564,0.685]	[0.749,0.761]
γ_2		1.558	0.715	0.899	0.791	0.959
		[1.538,1.583]	[0.709,0.718]	[0.894,0.901]	[0.783,0.793]	[0.933,0.961]
γ_3						
			β - Rainfall-Temperature Index			
Rain< γ_1	-0.083***	-0.064**	-0.394***	-0.237***	-0.190***	-0.112***
	(0.019)	(0.030)	(0.068)	(0.021)	(0.037)	(0.014)
γ_1 < Rain < γ_2		0.101***	-0.124***	-0.117***	0.006	-0.063***
		(0.025)	(0.029)	(0.013)	(0.025)	(0.014)
γ_2 < Rain < γ_3		-0.380***	0.029	-0.033**	0.143***	-0.029*
		(0.101)	(0.021)	(0.014)	(0.024)	(0.016)
Rain > γ_3						
Constant	0.082**	-0.239***	-0.065	0.164***	-0.143***	0.188***
	(0.035)	(0.049)	(0.040)	(0.025)	(0.053)	(0.022)
District fixed effects	✓	✓	✓	✓	✓	✓
Year fixed effects	✓	✓	✓	✓	✓	✓
District-specific trends						
Controls						
Grid		300	300	300	300	300
Observations	3432	7656	7172	10560	6908	8756
N districts	78	174	163	240	157	199
R-squared	0.163	0.11	0.144	0.179	0.112	0.087

*, **, *** denote statistical significance at the 10%, 5% and 1% level, respectively. Numbers in parentheses represent clustered standard errors at the district level. All numbers in the table were rounded to 3 decimal places. This specifications uses a Balanced sample, which is a requirement for the threshold regression. The dependent variable is de-trended yield for each individual cereal, where a district-specific quadratic trend was used to de-trend the variable.The index used in this robustness check is an additive, rather than a multiplicative relation between rainfall and temperature for the June-September growing season.

Table 6A.13: Time results - F-tests of joint significance

	Full sample		Arid		Semi-arid		Sub-humid		Humid	
Specification	F-value	p-value	F-value	p-value	F-value	p-value	F-value	p-value	F-value	p-value
Linear	0.493	0.483	0.155	0.698	5.045	0.026	0.577	0.449	**3.611**	**0.075**
Quadratic	0.249	0.780	0.383	0.686	3.046	0.051	5.932	0.004	1.988	0.168
Cubic	**7.275**	**0.000**	1.980	0.146	**6.622**	**0.000**	**7.653**	**0.000**	1.629	0.220

Values in bold denote the selected specification for the parametric fit graphs. When no value is in bold it means that the interactions with time where not statistically significant at the conventional levels.

Table 6A.14: Time results - F-tests of joint significance

	Barley		Maize		Millet		Rice		Sorghum		Wheat	
Specification	F-value	p-value	F-value	p-value	F-value	p-value	F-value	p-value	F-value	p-value	F-value	p-value
Linear	0.869	0.354	**20.627**	**0.000**	0.271	0.604	**31.375**	**0.000**	20.264	0.000	2.647	0.105
Quadratic	**14.010**	**0.000**	11.053	0.000	0.750	0.474	16.555	0.000	11.865	0.000	12.175	0.000
Cubic	9.353	0.000	7.384	0.000	1.158	0.328	12.702	0.000	**10.228**	**0.000**	**10.035**	**0.000**

Values are approximated to three decimal values. Values in bold denote the selected specification for the parametric fit graphs. When no value is in bold it means that the interactions with time where not statistically significant at the conventional levels. In the crop regressions with the exception of Barley, it is important to notice that the difference in p-values between specifications is often very small. In fact, in all cases (with the exception from Barley) more than one specification is significant at the 1% level and the difference in p-value cannot be seen from the three decimal value approximation.

Table 6A.15: Parametric time results - Full sample

	Full sample			
Variables	No trend	Linear	Quadratic	Cubic
Dummy variable[1]	-0.011	-0.011	-0.011	-0.011
	(0.009)	(0.009)	(0.009)	(0.009)
NRTIq12	-0.232***	-0.248***	-0.255***	-0.121*
	(0.028)	(0.038)	(0.050)	(0.065)
NRTIq12*trend		0.001	0.002	-0.033***
		(0.001)	(0.005)	(0.011)
NRTIq12*trend^2			0	0.002***
			(0.000)	(0.000)
NRTIq12*trend^3				-0.000***
				(0.000)
Constant	-0.300***	-0.295***	-0.293***	-0.325***
	(0.015)	(0.017)	(0.021)	(0.023)
District fixed effects	✓	✓	✓	✓
Year fixed effects	✓	✓	✓	✓
District trends	✓	✓	✓	✓
Controls				
Number of observations	12100	12100	12100	12100
Number of districts	275	275	275	275
R-squared adjusted	0.711	0.711	0.711	0.712

*, **, *** denote statistical significance at the 10%, 5% and 1% level, respectively. Numbers in parentheses represent clustered standard errors at the district level. All numbers in the table were rounded to 3 decimal places. This specifications uses a Balanced sample The dependent variable is the natural logarithm of cereal yield. NRTIq12 refers only to the values of the NRTI variable when rainfall for the growing season is below its long-term average.

[1] This dummy variable is equal to 1 if the rainfall in that given grrowing season was below its long-term average and is equal to 0 otherwise.

Table 6A.16: Parametric time results - arid and semi-arid areas

	Arid				Semi-arid			
Variables	No trend	Linear	Quadratic	Cubic	No trend	Linear	Quadratic	Cubic
Dummy variable[1]	-0.136**	-0.134**	-0.137**	-0.134**	0.020**	0.019*	0.019*	0.021**
	(0.050)	(0.050)	(0.052)	(0.051)	(0.010)	(0.010)	(0.010)	(0.010)
NRTIq12	-0.347**	-0.423	-0.578*	-0.036	-0.286***	-0.210***	-0.243***	-0.073
	(0.162)	(0.256)	(0.301)	(0.382)	(0.038)	(0.055)	(0.072)	(0.092)
NRTIq12*trend		0.003	0.024	-0.116		-0.003**	0.001	-0.043***
		(0.007)	(0.029)	(0.087)		(0.001)	(0.006)	(0.015)
NRTIq12*trend^2			0	0.007			0	0.002***
			(0.001)	(0.004)			(0.000)	(0.001)
NRTIq12*trend^3				-0.000*				-0.000***
				(0.000)				(0.000)
Constant	-0.784***	-0.776***	-0.757***	-0.808***	-0.286***	-0.308***	-0.299***	-0.339***
	(0.099)	(0.099)	(0.106)	(0.111)	(0.019)	(0.021)	(0.024)	(0.026)
District fixed effects	✓	✓	✓	✓	✓	✓	✓	✓
Year effects	✓	✓	✓	✓	✓	✓	✓	✓
District trends	✓	✓	✓	✓	✓	✓	✓	✓
Controls								
Number of observations	1012	1012	1012	1012	5412	5412	5412	5412
Number of districts	23	23	23	23	123	123	123	123
R-squared adjusted	0.632	0.632	0.631	0.633	0.756	0.756	0.756	0.757

*, **, *** denote statistical significance at the 10%, 5% and 1% level, respectively. Numbers in parentheses represent clustered standard errors at the district level. All numbers in the table were rounded to 3 decimal places. This specifications uses a Balanced sample The dependent variable is the natural logarithm of cereal yield. NRTIq12 refers only to the values of the NRTI variable when rainfall for the growing season is below its long-term average.

[1] This dummy variable is equal to 1 if the rainfall in that given grrowing season was below its long-term average and is equal to 0 otherwise.

Table 6A.17: Parametric time results - sub-humid and humid areas

	Semi-humid				Humid			
Variables	No trend	Linear	Quadratic	Cubic	No trend	Linear	Quadratic	Cubic
Dummy variable[1]	-0.018**	-0.018**	-0.018**	-0.019**	0.03	0.033*	0.032	0.034*
	(0.008)	(0.008)	(0.008)	(0.008)	(0.019)	(0.019)	(0.019)	(0.019)
NRTIq12	-0.126***	-0.111***	-0.230***	-0.103*	-0.180**	-0.379***	-0.462**	-0.28
	(0.023)	(0.033)	(0.048)	(0.059)	(0.064)	(0.098)	(0.190)	(0.228)
NRTIq12*trend		-0.001	0.014***	-0.018*		0.007*	0.017	-0.028
		(0.001)	(0.004)	(0.010)		(0.004)	(0.016)	(0.032)
NRTIq12*trend^2			-0.000***	0.001***			0	0.002
			(0.000)	(0.001)			(0.000)	(0.001)
NRTIq12*trend^3				-0.000***				0
				(0.000)				(0.000)
Constant	-0.324***	-0.329***	-0.289***	-0.325***	0.152***	0.211***	0.236***	0.190***
	(0.023)	(0.024)	(0.022)	(0.023)	(0.025)	(0.029)	(0.053)	(0.062)
District fixed effects	✓	✓	✓	✓	✓	✓	✓	✓
Year effects	✓	✓	✓	✓	✓	✓	✓	✓
District trends	✓	✓	✓	✓	✓	✓	✓	✓
Controls								
Number of observations	4884	4884	4884	4884	792	792	792	792
Number of districts	111	111	111	111	18	18	18	18
R-squared adjusted	0.785	0.785	0.786	0.786	0.72	0.722	0.722	0.723

*, **, *** denote statistical significance at the 10%, 5% and 1% level, respectively. Numbers in parentheses represent clustered standard errors at the district level. All numbers in the table were rounded to 3 decimal places. This specifications uses a Balanced sample The dependent variable is the natural logarithm of cereal yield. NRTIq12 refers only to the values of the NRTI variable when rainfall for the growing season is below its long-term average.

[1] This dummy variable is equal to 1 if the rainfall in that given grrowing season was below its long-term average and is equal to 0 otherwise.

Table 6A.18: Parametric time results - barley and maize

	Barley				Maize			
Variables	No trend	Linear	Quadratic	Cubic	No trend	Linear	Quadratic	Cubic
Dummy variable[1]	-0.022	-0.023*	-0.026*	-0.026*	0.169***	0.168***	0.168***	0.168***
	(0.014)	(0.014)	(0.014)	(0.014)	(0.018)	(0.018)	(0.018)	(0.018)
NRTIq12	-0.004	-0.05	-0.302***	-0.331***	-0.417***	-0.222***	-0.304***	-0.294**
	(0.046)	(0.076)	(0.089)	(0.120)	(0.046)	(0.060)	(0.082)	(0.120)
NRTIq12*trend		0.002	0.039***	0.047**		-0.008***	0.002	0
		(0.002)	(0.007)	(0.023)		(0.002)	(0.008)	(0.023)
NRTIq12*trend^2			-0.001***	-0.001			0	0
			(0.000)	(0.001)			(0.000)	(0.001)
NRTIq12*trend^3				0				0
				(0.000)				(0.000)
Constant	-0.256***	-0.243***	-0.177***	-0.171***	-0.223***	-0.291***	-0.265***	-0.268***
	(0.032)	(0.033)	(0.033)	(0.038)	(0.032)	(0.035)	(0.041)	(0.046)
District fixed effects	✓	✓	✓	✓	✓	✓	✓	✓
Year fixed effects	✓	✓	✓	✓	✓	✓	✓	✓
District trends	✓	✓	✓	✓	✓	✓	✓	✓
Controls								
Number of observations	3432	3432	3432	3432	7656	7656	7656	7656
Number of districts	78	78	78	78	174	174	174	174
R-squared adjusted	0.767	0.767	0.77	0.769	0.406	0.407	0.408	0.407

*, **, *** denote statistical significance at the 10%, 5% and 1% level, respectively. Numbers in parentheses represent clustered standard errors at the district level. All numbers in the table were rounded to 3 decimal places. This specifications uses a Balanced sample The dependent variable is the natural logarithm of the yield of a given cereal. NRTIq12 refers only to the values of the NRTI variable when rainfall for the growing season is below its long-term average.

[1] This dummy variable is equal to 1 if the rainfall in that given grrowing season was below its long-term average and is equal to 0 otherwise.

Table 6A.19: Parametric time results - millet and sorghum

	Sorghum				Millet			
Variables	No trend	Linear	Quadratic	Cubic	No trend	Linear	Quadratic	Cubic
Dummy variable[1]	0.059***	0.057***	0.056**	0.057***	0.038**	0.037**	0.038**	0.039**
	(0.022)	(0.022)	(0.022)	(0.022)	(0.017)	(0.017)	(0.017)	(0.017)
NRTIq12	-0.310***	-0.086	-0.196**	-0.076	-0.371***	-0.340***	-0.256**	-0.165
	(0.050)	(0.071)	(0.093)	(0.121)	(0.058)	(0.084)	(0.118)	(0.133)
NRTIq12*trend		-0.009***	0.005	-0.026		-0.001	-0.012	-0.036*
		(0.002)	(0.008)	(0.020)		(0.002)	(0.010)	(0.019)
NRTIq12*trend^2			-0.000*	0.001			0	0.002
			(0.000)	(0.001)			(0.000)	(0.001)
NRTIq12*trend^3				-0.000*				0
				(0.000)				(0.000)
Constant	-0.640***	-0.718***	-0.681***	-0.716***	-0.650***	-0.659***	-0.682***	-0.704***
	(0.030)	(0.034)	(0.037)	(0.044)	(0.025)	(0.030)	(0.040)	(0.042)
District fixed effects	✓	✓	✓	✓	✓	✓	✓	✓
Year fixed effects	✓	✓	✓	✓	✓	✓	✓	✓
District trends	✓	✓	✓	✓	✓	✓	✓	✓
Controls								
Number of observations	6908	6908	6908	6908	7172	7172	7172	7172
Number of districts	157	157	157	157	163	163	163	163
R-squared adjusted	0.338	0.34	0.34	0.34	0.434	0.434	0.434	0.434

*, **, *** denote statistical significance at the 10%, 5% and 1% level, respectively. Numbers in parentheses represent clustered standard errors at the district level. All numbers in the table were rounded to 3 decimal places. This specifications uses a Balanced sample The dependent variable is the natural logarithm of the yield of a given cereal. NRTIq12 refers only to the values of the NRTI variable when rainfall for the growing season is below its long-term average.

[1] This dummy variable is equal to 1 if the rainfall in that given grrowing season was below its long-term average and is equal to 0 otherwise.

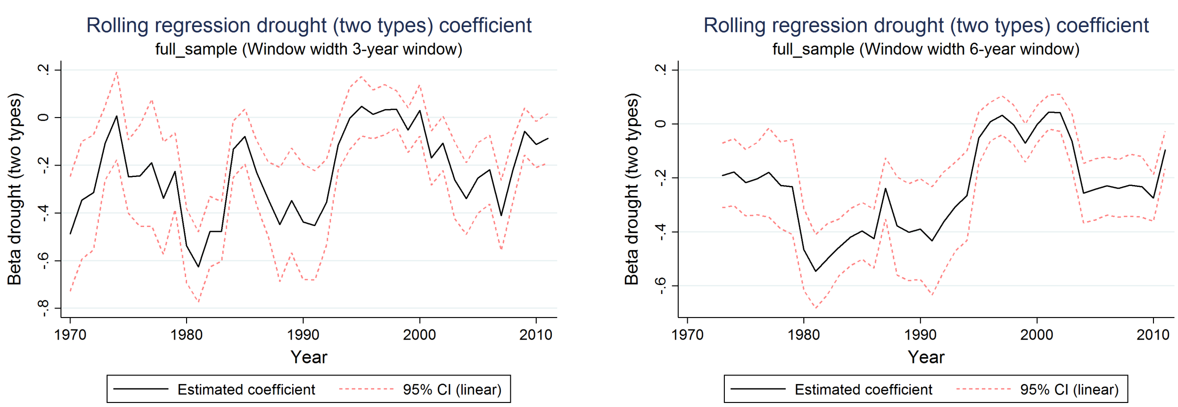
Table 6A.20: Parametric time results - rice and wheat

	Rice				Wheat			
Variables	No trend	Linear	Quadratic	Cubic	No trend	Linear	Quadratic	Cubic
Dummy variable[1]	-0.033***	-0.031***	-0.031***	-0.031***	-0.016**	-0.016**	-0.017**	-0.017**
	(0.010)	(0.011)	(0.011)	(0.011)	(0.008)	(0.008)	(0.008)	(0.008)
NRTIq12	-0.257***	-0.448***	-0.500***	-0.354***	-0.143***	-0.097**	-0.241***	-0.185**
	(0.029)	(0.054)	(0.066)	(0.073)	(0.024)	(0.040)	(0.057)	(0.079)
NRTIq12*trend		0.008***	0.014***	-0.023*		-0.002	0.017***	0.002
		(0.001)	(0.005)	(0.014)		(0.001)	(0.005)	(0.014)
NRTIq12*trend^2			0	0.002***			-0.000***	0
			(0.000)	(0.001)			(0.000)	(0.001)
NRTIq12*trend^3				-0.000***				0
				(0.000)				(0.000)
Constant	-0.280***	-0.223***	-0.208***	-0.243***	-0.318***	-0.333***	-0.287***	-0.303***
	(0.023)	(0.025)	(0.026)	(0.025)	(0.025)	(0.027)	(0.027)	(0.030)
District fixed effects	✓	✓	✓	✓	✓	✓	✓	✓
Year fixed effects	✓	✓	✓	✓	✓	✓	✓	✓
District trends	✓	✓	✓	✓	✓	✓	✓	✓
Controls								
Number of observations	10560	10560	10560	10560	8756	8756	8756	8756
Number of districts	240	240	240	240	199	199	199	199
R-squared adjusted	0.541	0.543	0.543	0.543	0.716	0.716	0.717	0.717

*, **, *** denote statistical significance at the 10%, 5% and 1% level, respectively. Numbers in parentheses represent clustered standard errors at the district level. All numbers in the table were rounded to 3 decimal places. This specifications uses a Balanced sample The dependent variable is the natural logarithm of the yield of a given cereal. NRTIq12 refers only to the values of the NRTI variable when rainfall for the growing season is below its long-term average.

[1] This dummy variable is equal to 1 if the rainfall in that given grrowing season was below its long-term average and is equal to 0 otherwise.

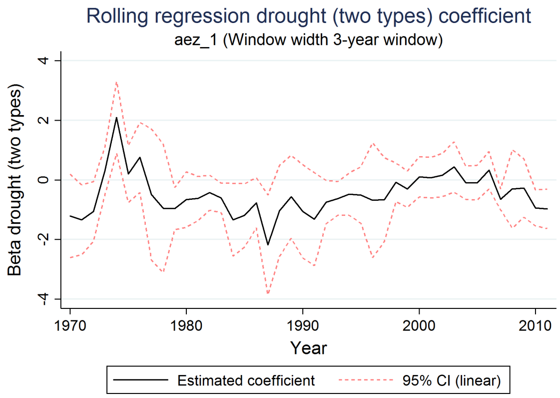
Figure 6A.1: Rolling regressions - Additional windows (Full sample)



(a) Full sample - rolling regression (3-year window)

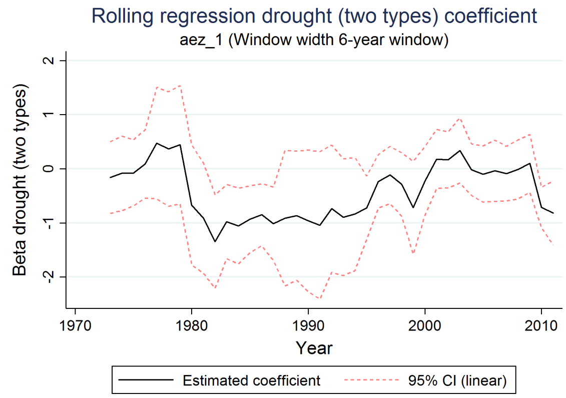
(b) Full sample - rolling regression (6-year window)

Figure 6A.2: Rolling regressions - Additional windows (Arid and Semi-arid areas)



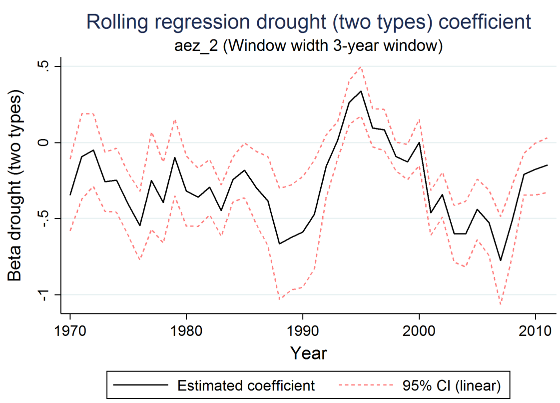
(a) Arid areas - rolling regression

(3-year window)



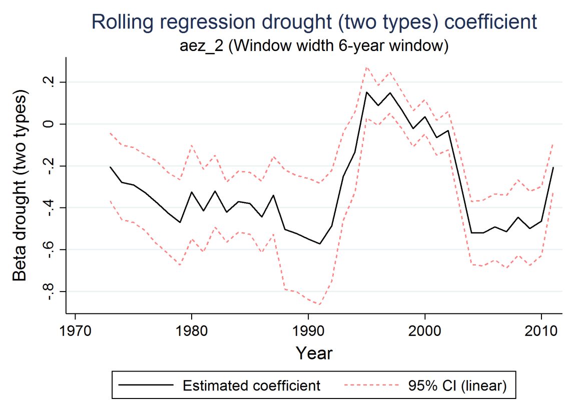
(b) Arid areas - rolling regression

(6-year window)



(c) Semi-arid areas - rolling regression

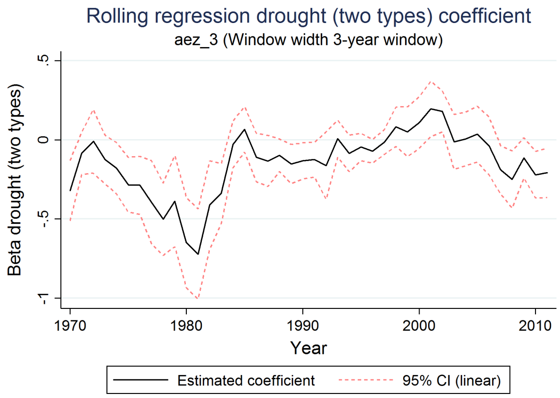
(3-year window)



(d) Semi-arid areas - rolling regression

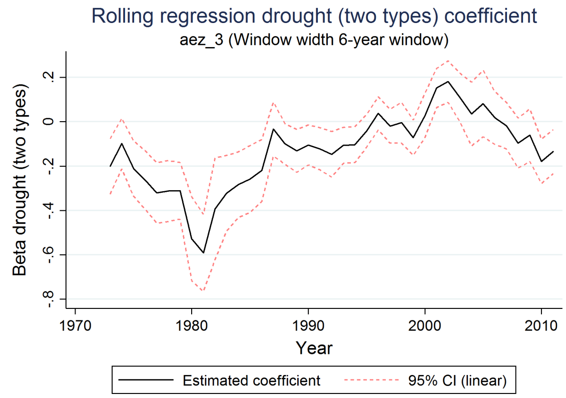
(6-year window)

Figure 6A.3: Rolling regressions - Additional windows (Sub-humid and humid areas)



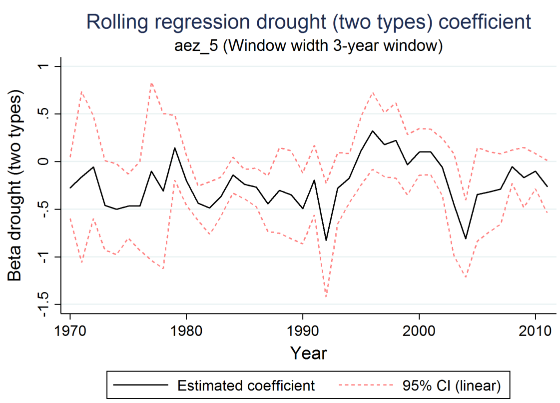
(a) Sub-humid areas - rolling regression

(3-year window)



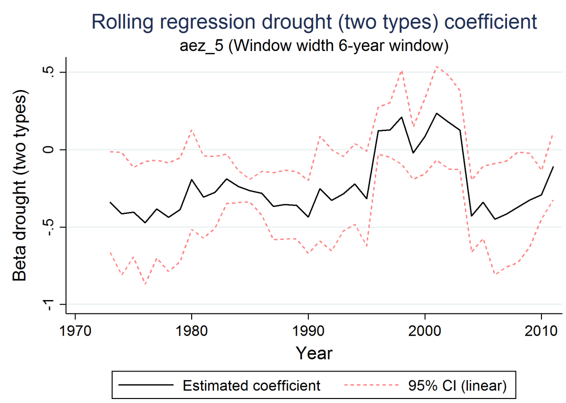
(b) Sub-humid areas - rolling regression

(6-year window)



(c) Humid areas - rolling regression

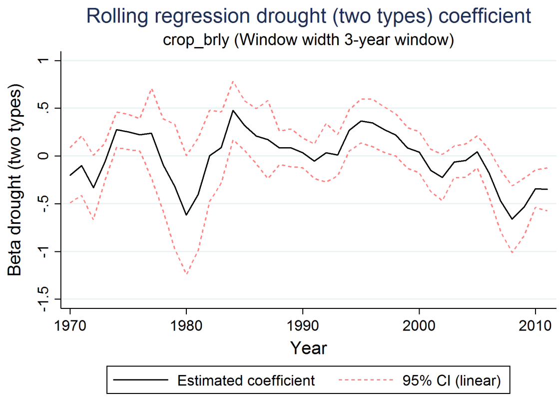
(3-year window)



(d) Humid areas - rolling regression

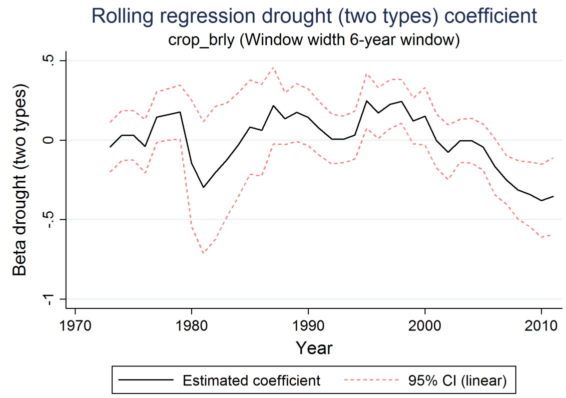
(6-year window)

Figure 6A.4: Rolling regressions - Additional windows (Barley, Maize and Millet)



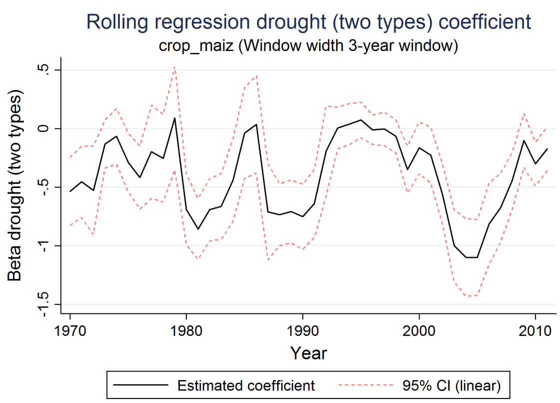
(a) Barley - rolling regression

(3-year window)



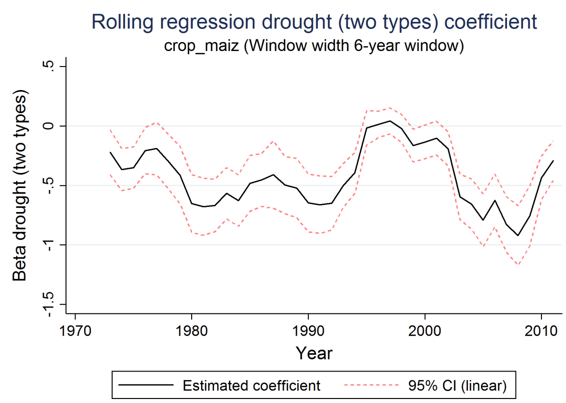
(b) Barley - rolling regression

(6-year window)



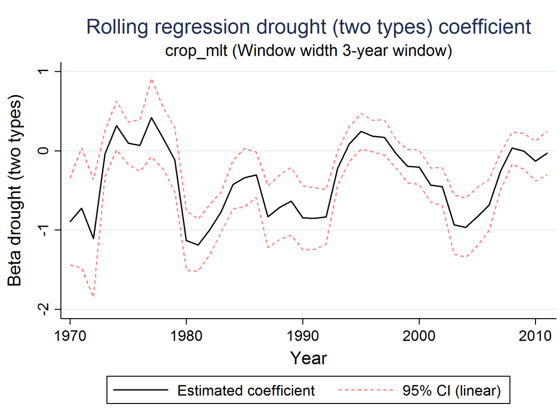
(c) Maize - rolling regression

(3-year window)



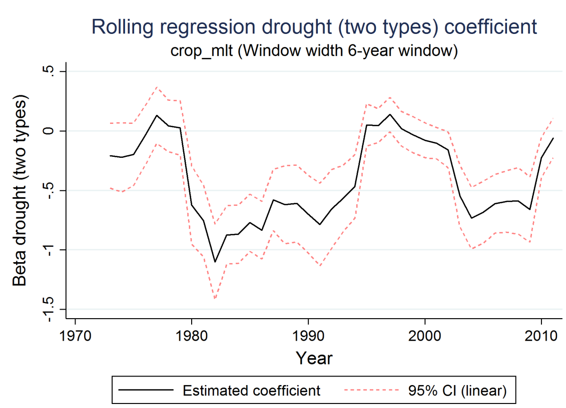
(d) Maize - rolling regression

(6-year window)



(e) Millet - rolling regression

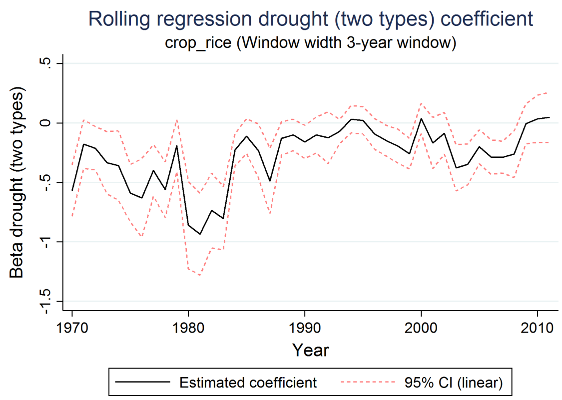
(3-year window)



(f) Millet - rolling regression

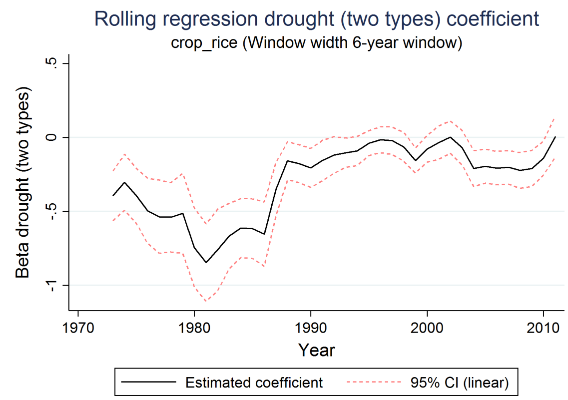
(6-year window)

Figure 6A.5: Rolling regressions - Additional windows (Rice, Sorrghum and Wheat)



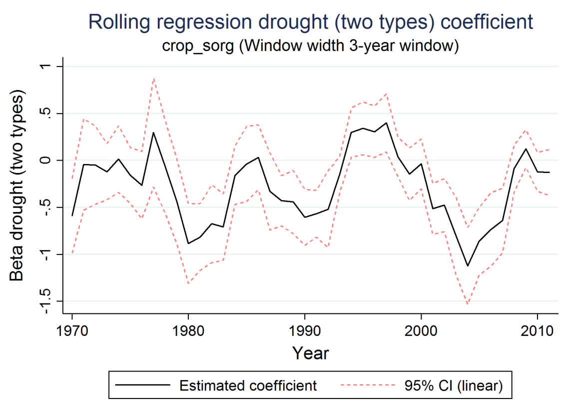
(a) Rice - rolling regression

(3-year window)



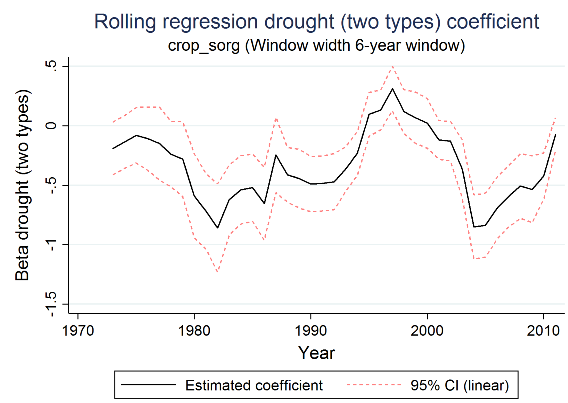
(b) Rice - rolling regression

(6-year window)



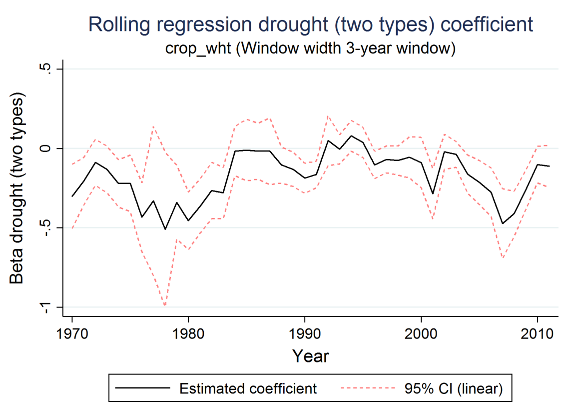
(c) Sorghum - rolling regression

(3-year window)



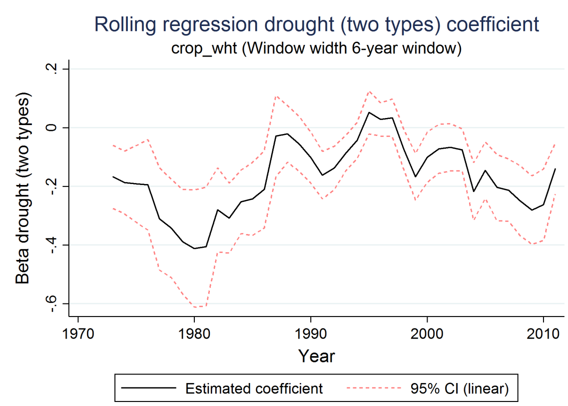
(d) Sorghum - rolling regression

(6-year window)



(e) Wheat - rolling regression

(3-year window)



(f) Wheat - rolling regression

(6-year window)