Do agricultural input subsidies have dynamic causal effects on aggregate district and disaggregate farm household level outcomes? Evidence from Malawi

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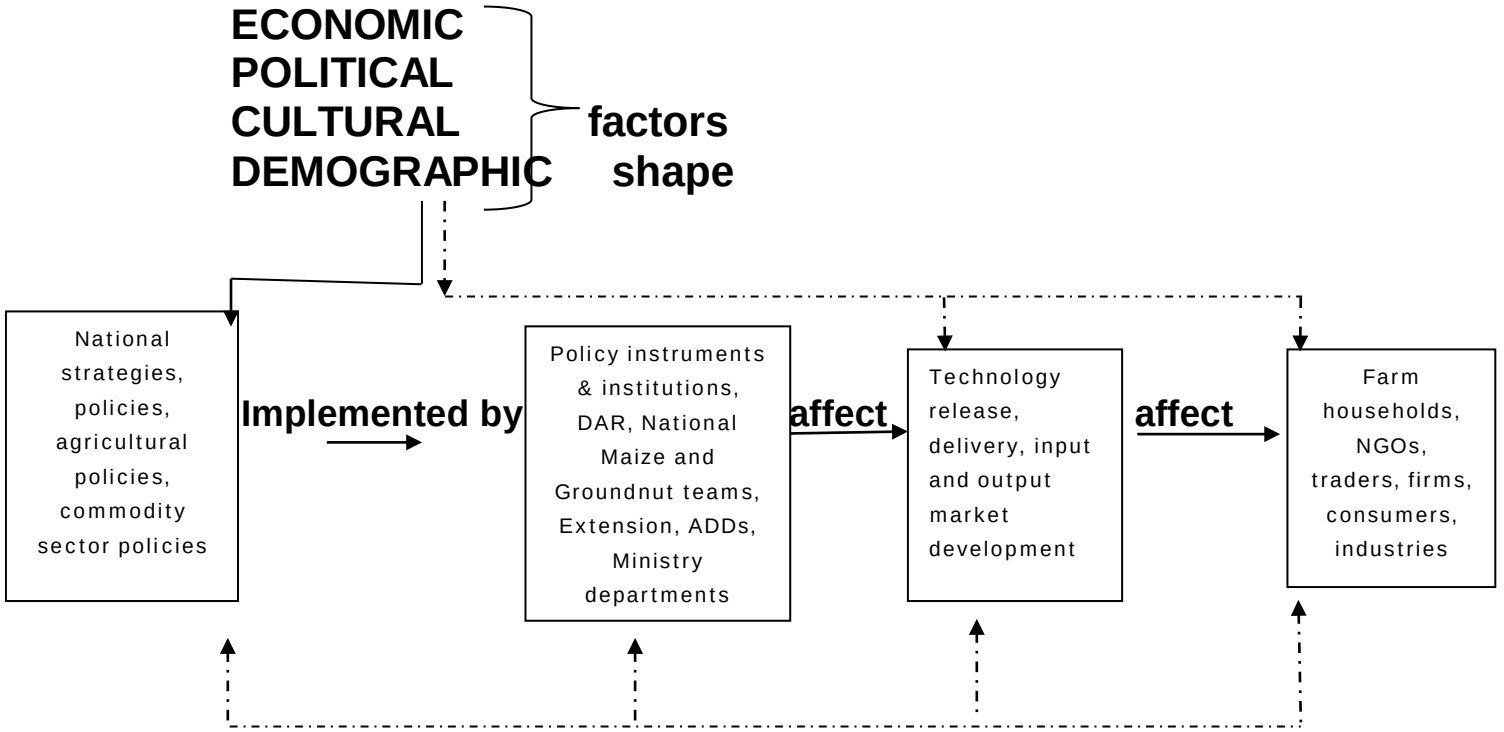
Introduction

- Smart agricultural input subsidies adopted by governments in SSA
- Controversy in literature
- Evaluate dynamic and distributional causal effects of agricultural input subsidies in Malawi using methods in treatment effects literature

Evolution of AIS in Malawi,1992/93-2012/2013

Dimension	Drought Relief	SP	TIP	AIS
Years	1992/93; 1994/95; 1995/96	1998/99;1999/00	2000/01-2004/05	2005/06-20012/13
Driving forces	Offset food aid	Adverse SAPs	Good harvests	Reduce food aid; input supply system
Objectives	Access drought households	Access all farm households	Target poorest households	Reduce prices of fertilizers and seeds
Pack composition and size	2-5 kg seed, 10-50 kg basal (0.2 ha)	Seed (2 kg of hybrids, OPV, rice sorghum or millet), 10 kg basal if hybrid or 5 kg if OPV maize; 5 kg urea; (0.1 ha)	5 Kg maize OPV seed; 1 Kg legume seed; 12.5 Kg basal; 12.5 Kg urea	Seed and fertilizer for 0.5 ha at subsidized price; legume seed voucher
Households	300,000-783,000	2,300-2,870,000	1,000,000-2,000,000	2,500,000-3,926,000
Selection	Geographic	Indicator	Community	Community and self-targeting
Cost	US$ 20	US$ 9 -10	US$ 5 -17	US$ 20-72

Conceptual framework: Public-policy impact chain: Austin (1990)



Hypotheses, Methods 1

- Input subsidy programs have dynamic causal effects on district level aggregate area planted to seed of improved varieties, area planted, yield, and prices in representative markets for maize and groundnuts

- time-series intervention analysis

- $y_t = a_0 + a_1 y_{t-1} + a_2 y_{t-2} + .. + a_p y_{t-p} + c_0 z_t + \varepsilon_t \, (1)$

- But assumptions
  - coefficients invariant to intervention
  - Intervention pure jump

- So
  - Estimate appropriate ARIMA (p, d, q) models
  - Diagnostic checks of the estimated equations (ACF, PACF, unit roots, structural breaks)

Hypotheses, Methods 2

- Impact of input subsidy programs on district level aggregate outcomes evolves in a path-dependent way in which past behavior affects current behavior (dynamic effect)
- Estimate dynamic panel model as an autoregressive equation of order p
- $y_{it} = \gamma_1 y_{i,t-1} + .. + \gamma_p y_{i,t-p} + x'_{it}\beta + \alpha_i + \varepsilon_{it}, t = p+1, ...T \ (2)$
- Estimate FD equation using the Arellano-Bond instrumental variables and generalized method-of-moments (GMM-IV) estimator
- But
  - Many instruments sample size small
  - no autocorrelation idiosyncratic errors in the levels equation
- So
  - alternative models to check the robustness of the results to identifying assumptions
  - restrict lags of dependent variable
  - test for assumption Arellano and Bond statistics

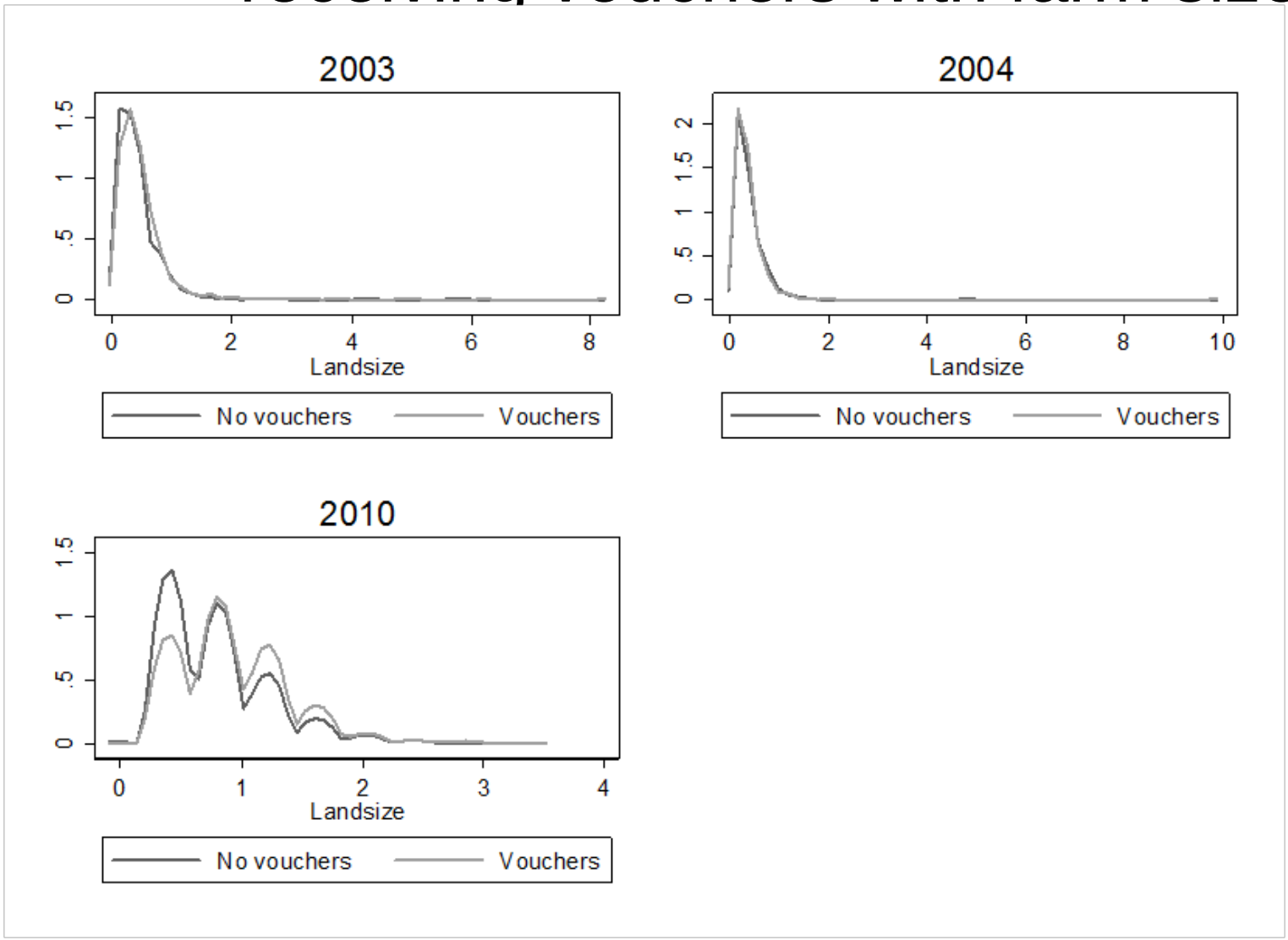
Hypotheses, Methods 3

- Agricultural input subsidy programs have impact on the distribution of outcomes at the farm household level
- Estimate effect on quantiles of distribution of outcomes in baseline and follow up surveys using quantile differences-in-differences
- $y_i = \beta_0 + \beta_1 * year_i + \beta_2 treated_i + \beta_3 year_i * treated_i + \beta_k x_{k,i} + e_i \ (4)$
- But
  - Unobserved confounding factors vary over time and selection bias
- So
  - with and without covariates

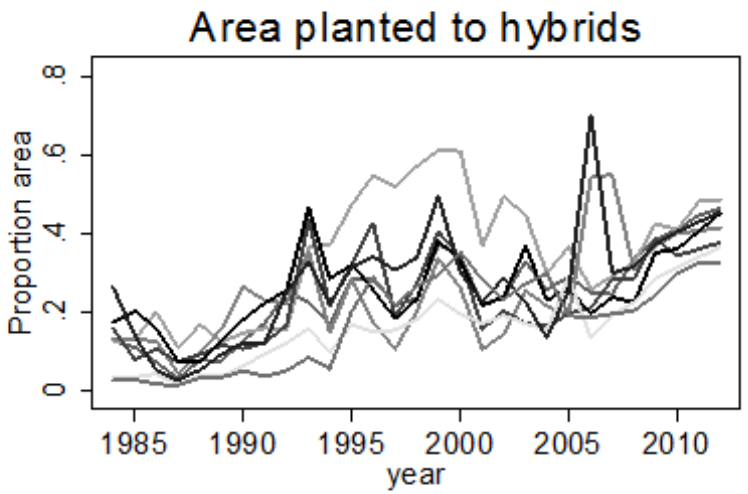
Data

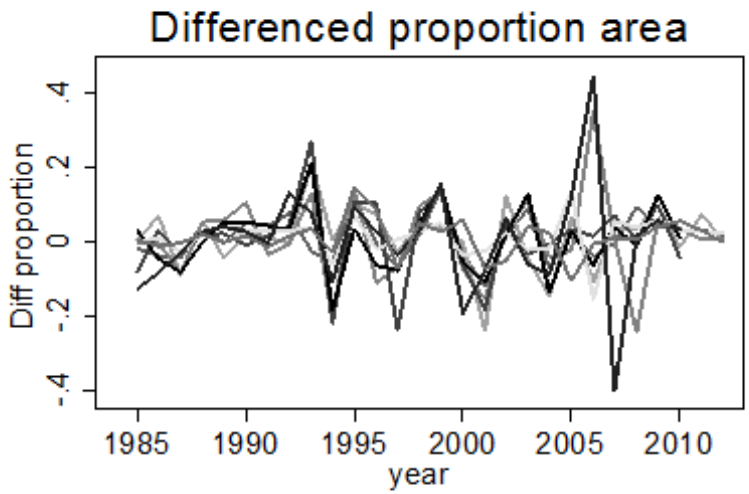
- Aggregate district level variables Ministry of Agriculture and Food Security (1984 to 2012) data bases
- Farm household data NSO IH2 and IH3
- Reliability of official area, yield and production data under debate
- Use data from different sources, e.g. other farm surveys
- Focus group discussions and questionnaire interviews
- Triangulate modeling and survey results and literature review

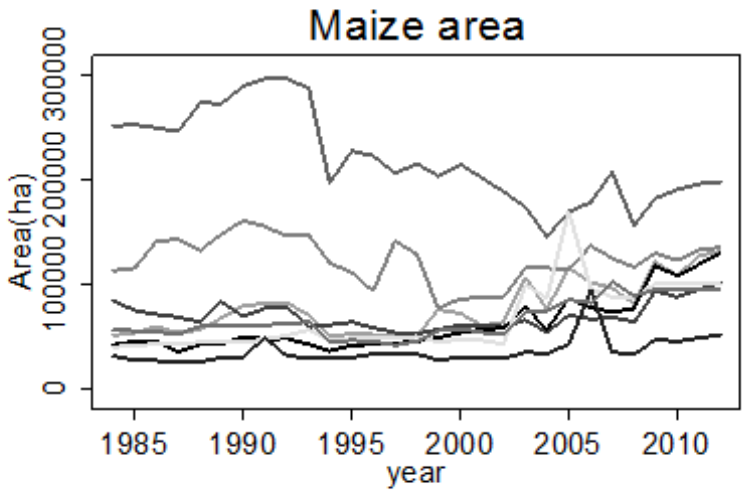
Kernel density receiving or not receiving vouchers with farm size

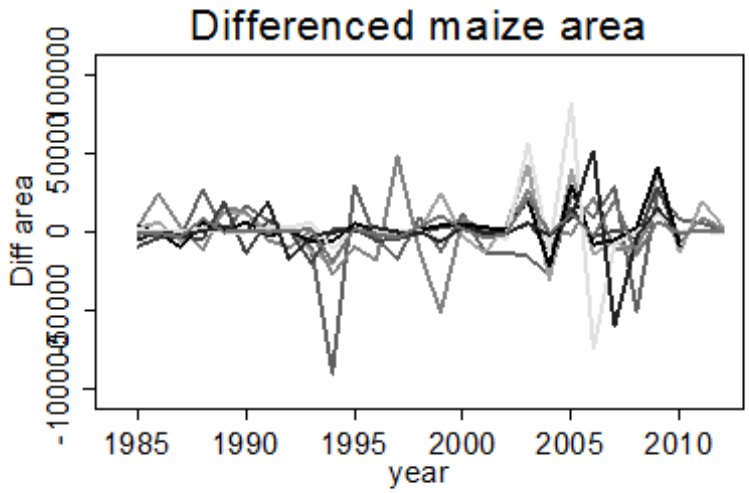


Time series plots: area planted to hybrids and maize area and differenced series for major producing districts









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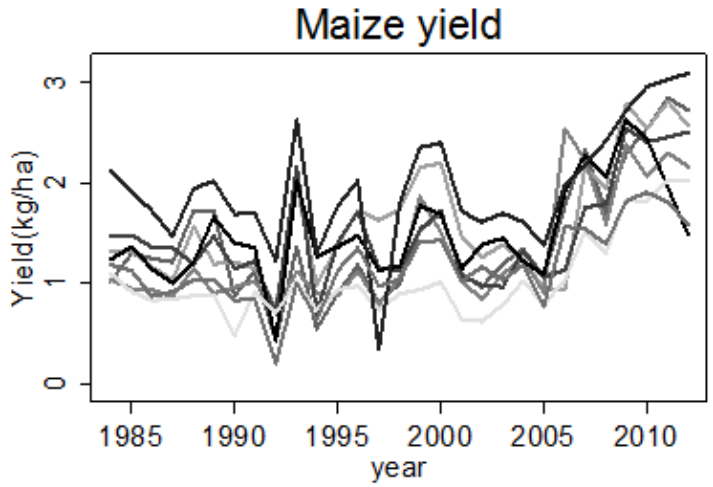
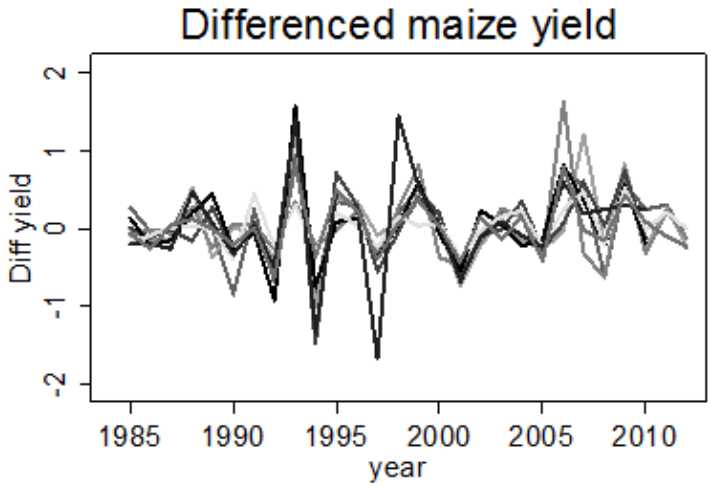
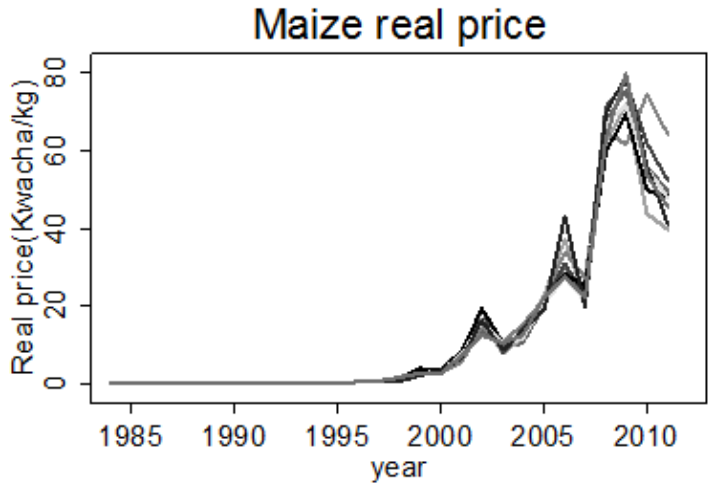
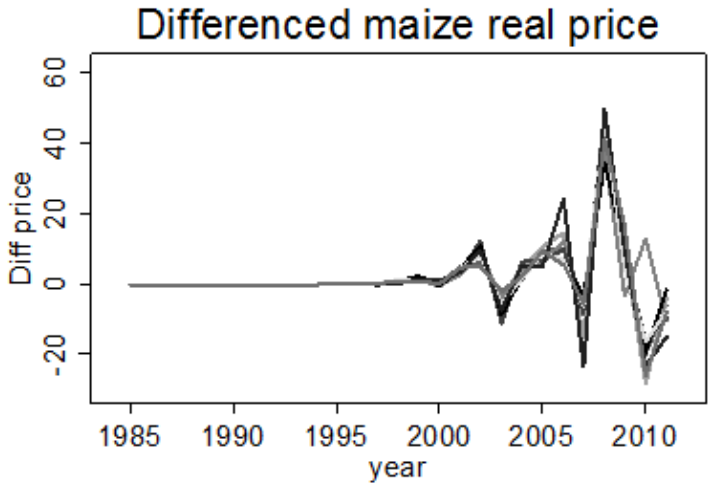
Time series plots: maize yield and prices and differenced series for major producing districts

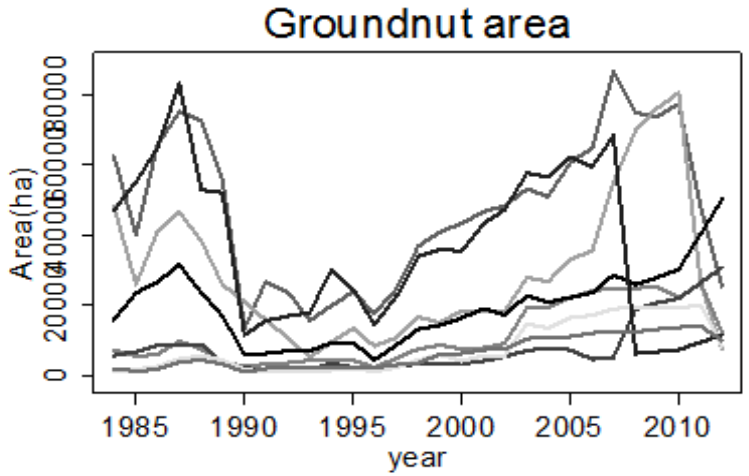


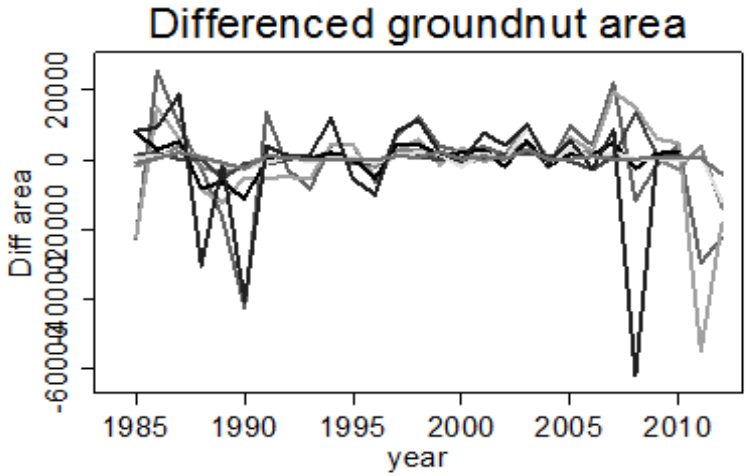


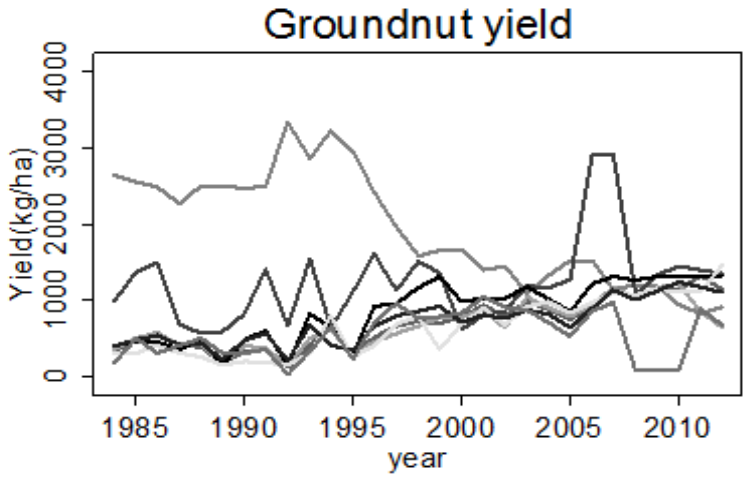


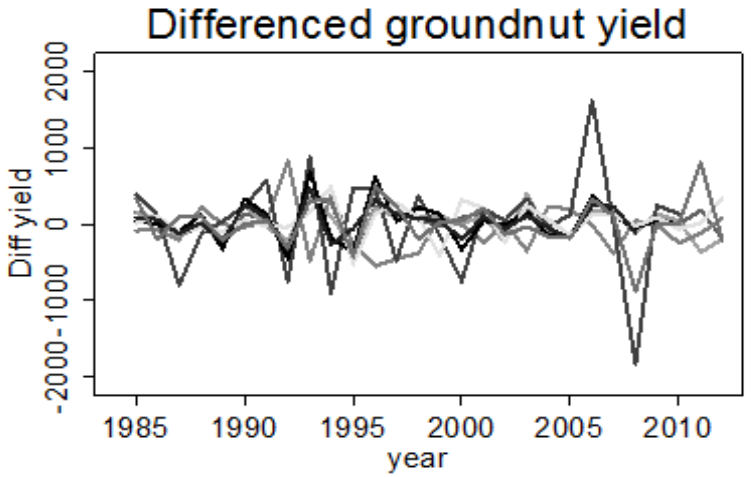


Time series plots: groundnut area and yield their differenced series for major producing districts

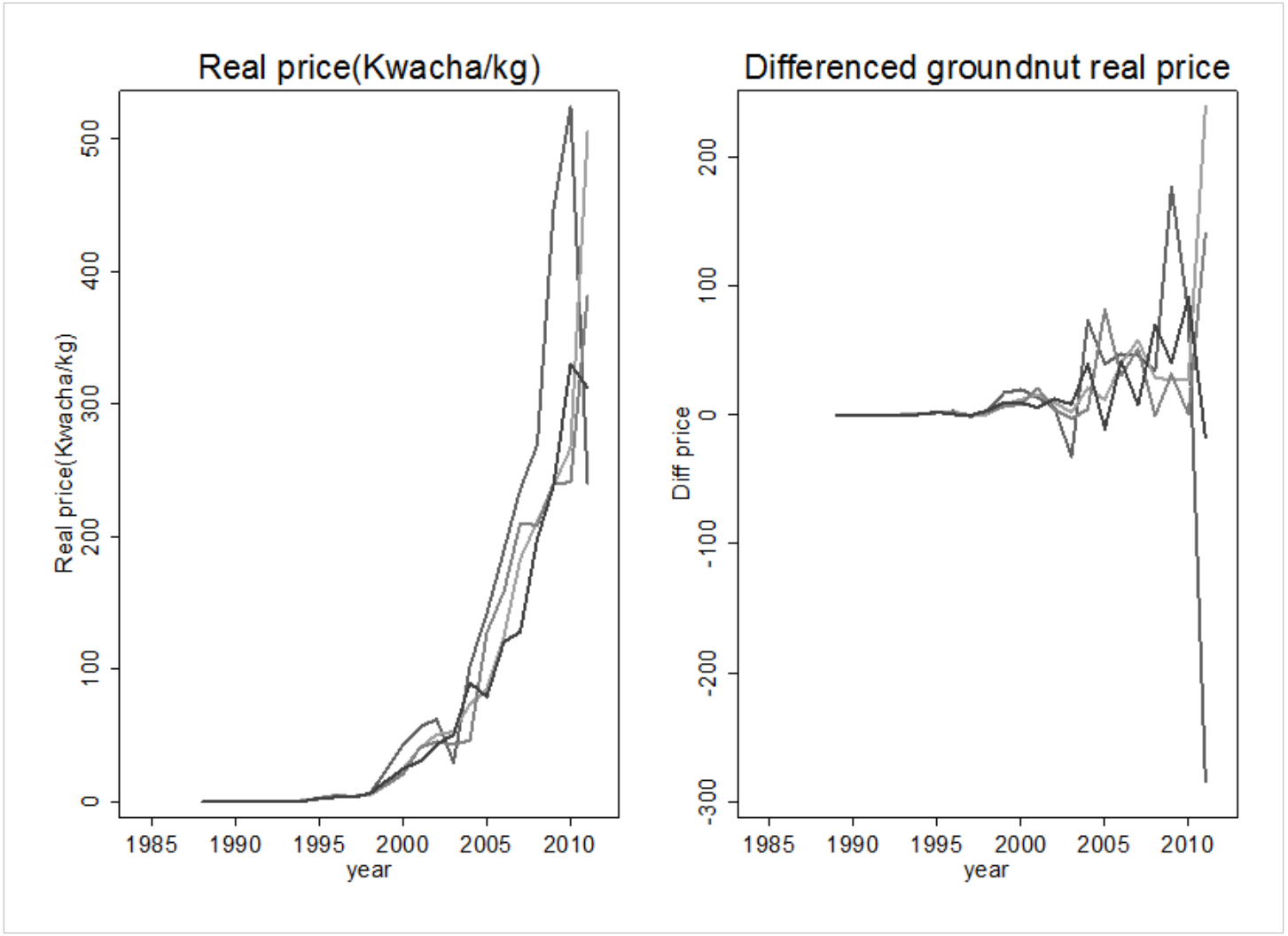








Time series plots: groundnut prices and differenced series for the major producing districts



Intervention analysis

District	Impact effect	Proportion area planted to hybrids	maize area	maize yield	maize price	groundnut area	groundnut yield	groundnut price
Chitipa	Initial	.065 (.0391263)	.009 (.0353642)	.448** (.1673774)	-.244 (.3573749)	.376 (.3217753)	.247 (.1892216)	.081 (.3373906)
	Long-run	0.151	0.042	0.714	18.853	1.785	0.476	1.578
Karonga	Initial	.029 (.0486304)	.151** (.0713138)	.593** (.2153405)	.226 (.3592927)	.117 (.1831765)	.691*** (.1465032)	.084 (.3230828)
	Long-run	0.136	0.376	0.658	4.685	0.526	0.589	1.740
Mzimba	Initial	.085* (.0457244)	-.089 (.0635158)	.351** (.1343896)	-.358 (.3476541)	.455** (.2151328)	-.118 (.1250635)	.394 (.3297975)
	Long-run	0.148	-0.185	0.541	17.032	1.319	-0.717	3.927
Rumphi	Initial	.059 (.0406513)	-.092 (.0850379)	.332** (.1560946)	-.424 (.3757533)	.075 (.1507272)	.414** (.1914261)	.224 (.3342986)
	Long-run	0.162	-0.302	0.546	12.435	0.223	0.958	2.510
Nkhata-bay	Initial	.074 (.0667234)	.309** (.1288698)	.354** (.1515709)	.133 (.3360996)	.694** (.270398)	.213* (.1233645)	
	Long-run	0.301	1.093	0.787	3.733	1.368	0.572	
Kasungu	Initial	-.013 (.0386416)	.223** (.0885573)	.174 (.1281993)	.226 (.4205419)	.145 (.1851825)	.797*** (.2299733)	
	Long-run	-0.093	0.514	0.309	4.051	0.618	0.821	
Mchinji	Initial	.038 (.0336606)	.232** (.0957091)	.313** (.1410398)	-.117 (.5079286)	.228 (.1512651)	.876* ** (.2886524)	.108 (.3510942)
	Long-run	0.071	0.615	0.317	-7.985	0.892	0.869	2.023
Dowa	Initial	.033 (.0408321)	.044 (.0521141)	.143 (.1291086)	.241 (.4228721)	.315 (.1954911)	.160 (.1759376)	
	Long-run	0.066		0.151	4.427	1.675	0.221	
Ntchisi	Initial	.090 (.0574222)	.159 (.106978)	.282* (.1588756)	.270 (.4431222)	-.064 (.235094)	.576** (.2087707)	
	Long-run	0.141	0.214	0.258	4.371	-0.228	0.591	
Lilongwe	Initial	.047 (.0317858)	-.140** (.0667545)	.361** (.1608382)	-.366 (.3845292)	.223 (.167339)	.688*** (.2356528)	

Intervention analysis continued)

District	Impact effect	Proportion area planted to hybrids	maize area	maize yield	maize price	groundnut area	groundnut yield	groundnut price
	Long-run	0.187	-0.294	0.518	15.493	0.572	0.880	
Dedza	Initial	.036 (.0289595)	.215* (.1118655)	.163 (.1069793)	-.415 (.3879287)	.544* (.2924394)	.456* (1.74)	
	Long-run	0.143	0.592	0.454	15.552	1.559	1.029	
Salima	Initial	.078* (.0434703)	-.109 (.0659427)	.597*** (.19002)	-.367 (.4019016)	.808*** (.2833092)	.627** (.2817306)	.367 (.348787)
	Long-run	0.173	-0.437	0.528	21.129	0.805	0.640	3.697
Machinga	Initial	.020 (.0356748)	.179 (.1308778)	.452* (.1821173)	-.515 (.3465648)	1.362 *** (.4619002)	.418** (.1671419)	
	Long-run	0.080	0.521	0.402	13.504	1.324	0.448	
Mangochi	Initial	-.015 (.0225927)	.116* (.061457)	.892** (.366535)	.158 (.353162)	1.627*** (.548738)	.530* (.2814302)	
	Long-run	-0.144	0.225	0.810	4.185	2.408	0.455	
Zomba	Initial	.077 (.0454123)	.028 (.0452814)	.676*** (.1712602)	-.347 (.4961472)	1.516*** (.3703346)	.384* (.2209284)	.342 (.4655896)
	Long-run	0.236	0.038	0.571	28.347	1.310	0.442	3.320
Balaka	Initial	.127*** (.0377922)	.324*** (.1033452)	1.244** (.514249)	-.414 (.3428367)	1.833* ** (.5912859)	1.721** (.7220607)	
	Long-run	0.155	0.284	1.014	13.876	1.710	1.749	
Blantyre	Initial	-.004 (.0381357)	-.455*** (.105583)	.499* (.2215225)	-.465 (.3832036)	.183 (.2173968)	.487** (.1850863)	-.299 (.3050112)
	Long-run	-0.044	-0.851	0.574	14.719	0.509	0.695	-85.294
Phalombe	Initial	.026 (.0371975)	.091** (.043501)	.472** (.1726611)	.277 (.4417205)	.085 (.1957116)	.594*** (.2065565)	
	Long-run	0.123	0.106	0.498	4.721	0.760	0.693	
Mwanza	Initial	.072 (.0468817)	-.129 (.0988887)	.849*** (.2784387)	-.015 (.3715391)			
	Long-run	0.205	-0.270	0.719	-0.978			
Chiradzulu	Initial				.188 (.3873294)	.732** (.2740664)	.436* (.2475685)	
	Long-run				4.009	1.349	0.621	
Chikwawa	Initial	.078* (.0443387)	.146 (.2090967)	.025* (.1780406)	-.606* (.3382914)	.044 (.4014981)	.335 (.2743664)	.356 (.4414125)
	Long-run	0.124	0.379	0.082	11.920	0.273	0.359	3.745
Nsanje	Initial	.115* (.0592424)	.643** (.2858856)	.061*** (.1616084)	-.026 (.3613904)	.173 (.1871245)	-.067 (.1329448)	.158 (.4148875)
	Long-run	0.236	0.861	0.082	-1.846	0.407	-0.079	2.401

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Dynamic panel data model

Dependent variable	log maize area			log maize yield				log groundnut area		log groundnut yield		
Model	Arellano-Bond one step GMM for AR(2) panel model	Arellano-Bond two-step GMM for AR(2) panel model	Arrelano-Bond two step GMM for a dynamic panel model with additional regressors using xtdpdsys	Arellano-Bond one step GMM for AR(2) panel model	Arellano-Bond two-step GMM for AR(2) panel model	Arrelano-Bond two step GMM for a dynamic panel model with additional regressors using xtdpdsys	Arellano-Bond one step GMM for AR(2) panel model	Arellano-Bond two-step GMM for AR(2) panel model	Arrelano-Bond two step GMM for a dynamic panel model with additional regressors using xtdpdsys	Arellano-Bond one step GMM for AR(2) panel model	Arellano-Bond two-step GMM for AR(2) panel model	Arrelano-Bond two step GMM for a dynamic panel model with additional regressors using xtdpdsys
L1.	.5433427 *** (.0613208)	.5457085** (.161856)	.5874047*** (.0452371)	.40818*** (.0305408)	.4054099 (.3975986)	.54015*** (.0641696)	.8926643 *** (.0767311)	.8931901** (.289946)	.7663686** (.246931)	.0965736 (.0753297)	.0970091 (.1429828)	-.0112717 (.0870321)
L2.	.1499074 * (.0712708)	.1529199 (.0906765)	.2913183*** (.023895)	.3466112*** (.02385)	.3411584 * (.1341385)	.2339811*** (.0292092)	-.1444782* (.0649152)	-.1447553 (.1849825)	-.0660796 (.1095803)	.0586836 (.0583706)	.0576774 (.1873363)	-.0492076 (.1026258)
rain L1.			-8.102485** (2.781844)			-.0001284 (.0000982)			-4.088702** (3.322705)			.5603397** (.1769326)
vouchers			.0140798* (.006043)			.00000404* (.00000165)			.0356813* (.0188406)			.0018241 (.0054998)
rain			-1.197601* (2.804479)			.0002305 (.0001787)			1.500496 (1.003463)			.2602061 (.3549678)
constant	18269.97 *** (3426.659)		16879.58 (9982.906	.3636361 *** (.0480415)	.3668034 (.6395444)	-.0156113 (.3707552)	2536.023*** (664.6656)		3906.909 (4835.199)	619.5443*** (103.2488)		-25.41946 (517.423)
Observations	658	632	290	629	629	288	583	583	272	570	570	265
Wald Chi2(2)	153.75	12.98	619.59	359.27	10.14	669.86	903.27	26.43	1519.13	3.85	4.52	40.56
Prob>chi2	0.0000	0.0015	0.0000	0.0000	0.0063	0.0063	0.0000	0.0000	0.0000	0.1459	0.1043	0.0000

Quantile DiD

			Quantile DID without covariates			Quantile DID with covariates		
Baseline-follow up	Outcome	Observations	0.25	0.5	0.75	0.25	0.5	0.75
Baseline 2002/03, follow up 2003/04	maize yield	5676	-13.97 (15.494)	-41.183 (47.828)	-20.591 (64.484)	-5.285 (33.596)	-18.602 (58.175)	104.333 (121.632)
	maize area	5682	0.00 (.)	0.202*** (0.004)	-0.101*** (0.000)	0.000 (0.026)	-0.000 (0.000)	0.021*** (0.000)
	groundnut yield	1332	0.000 (.)	0.000 (.)	53.471 (69.913)	3.784 (9.662)	-10.199 (26.072)	-4.189 (121.577)
	groundnut area	1430	0.002 (0.002)	0.000 (.)	0.000 (.)	-0.006 (0.016)	-0.011 (0.017)	0.036 (0.029)
	weight-for-age	2678	0.014 (0.132)	0.100 (0.120)	0.010 (0.114)	-0.011 (0.143)	0.133 (0.141)	-0.001 (0.118)
Baseline 2003/04, follow up 2009/10	maize yield	5177	261.067*** (1.995)	214.150*** (45.261)	82.366*** (12.329)	178.721*** (49.843)	168.314*** (65.027)	67.411 (101.950)
	maize area	5275	0.101*** (0.003)	-0.202*** (0.004)	0.202*** (0.000)	-0.013 (0.010)	-0.052** (0.022)	-0.019 (0.028)
	groundnut yield	1262	-98.839*** (8.799)	-98.839*** (4.949)	-172.473** (70.268)	-23.431 (29.919)	-26.280 (52.815)	-68.012 (83.581)
	groundnut area	1329	0.000 (0.002)	-0.123 (0.092)	0.000 (.)	-0.009** (0.004)	0.000 (.)	-0.021 (0.041)
	weight-for-age	6490	-0.190** (0.092)	-0.123 (0.092)	-0.107 (0.094)	-0.271** (0.127)	-0.142 (0.160)	-0.119 (0.120)

Conclusion

- Input subsidies popular with African governments but swirling controversy
- Malawi experience with crafting technological, institutional and political foundations for smart input subsidies
- Intervention analysis: subsidies increase % area hybrids, yields
- DPD analysis: path dependent; vouchers significant
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- Quantile DiD: raise distribution of outcomes at lower quantiles
- Policy makers concerned about distributional effects can increase lower tail and help poor through subsidies

THANK YOU FOR LISTENING