Adoption of Climate-Resilient Groundnut Varieties Increases Agricultural Production, Consumption, and Smallholder Commercialization in West Africa

Supplementary Data

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1 Robustness checks

1.1 Control function approach

Table S1: Control function estimations of the relationship between adoption and market participation

	Market participation		Quantity sold		Sales value	
variables	FE	CRE	FE	CRE	FE	CRE
Adoption dummy	0.063***	0.050***	0.588***	0.520***	0.565***	0.503***
	(0.020)	(0.018)	(0.133)	(0.119)	(0.122)	(0.109)
	[0.001]	[0.004]	[0.000]	[0.000]	[0.000]	[0.000]
Age of household head (years)	0.002	0.001	-0.010	-0.016	-0.013	-0.018
	(0.003)	(0.003)	(0.024)	(0.024)	(0.022)	(0.022)
	[0.539]	[0.701]	[0.660]	[0.490]	[0.565]	[0.409]
Sex of household head (dummy, male=1)		-0.014		0.071		0.079
		(0.020)		(0.139)		(0.127)
		[0.481]		[0.611]		[0.533]
Education level (Number of years)		0.001		-0.005		-0.005
		(0.001)		(0.009)		(0.008)
		[0.601]		[0.603]		[0.533]
Household size (number of persons)	0.002***	0.002***	0.027***	0.027***	0.026***	0.026***
	(0.001)	(0.001)	(0.005)	(0.005)	(0.004)	(0.004)
	[0.004]	[0.005]	[0.000]	[0.000]	[0.000]	[0.000]
Farmers group membership (dummy)	0.022***	0.023***	0.124***	0.125***	0.111***	0.111***
	(0.005)	(0.005)	(0.035)	(0.035)	(0.032)	(0.032)
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Training on agriculture (dummy)	-0.043***	-0.041***	-0.314***	-0.298***	-0.287***	-0.273***
	(0.011)	(0.011)	(0.078)	(0.078)	(0.071)	(0.072)
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Training on groundnut farming (dummy)	-0.025***	-0.025***	-0.176***	-0.178***	-0.162***	-0.165***
	(0.003)	(0.003)	(0.023)	(0.023)	(0.021)	(0.021)
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Public agricultural extension service (number of visits)	0.002	0.003	-0.024	-0.018	-0.025	-0.020
	(0.002)	(0.002)	(0.016)	(0.016)	(0.015)	(0.015)
	[0.355]	[0.190]	[0.148]	[0.265]	[0.102]	[0.191]
Private agricultural extension service (number of visits)	0.004	0.003	0.045*	0.042*	0.042*	0.040*
	(0.003)	(0.003)	(0.024)	(0.023)	(0.022)	(0.022)
	[0.313]	[0.334]	[0.057]	[0.071]	[0.052]	[0.066]
Cash credit for groundnut farming (dummy)	-0.010	-0.008	-0.188	-0.175	-0.194	-0.182
	(0.023)	(0.023)	(0.156)	(0.156)	(0.143)	(0.143)
	[0.659]	[0.729]	[0.229]	[0.261]	[0.176]	[0.202]
Credit in kind for groundnut farming (dummy)	-0.044***	-0.043***	-0.046	-0.040	-0.022	-0.017
	(0.016)	(0.016)	(0.109)	(0.109)	(0.100)	(0.100)
	[0.007]	[0.008]	[0.675]	[0.712]	[0.829]	[0.867]
Distance to the nearest urban market (km)	-0.000	-0.001***	-0.003*	-0.009***	-0.003*	-0.008***
	(0.000)	(0.000)	(0.002)	(0.002)	(0.002)	(0.002)
	[0.146]	[0.000]	[0.089]	[0.000]	[0.087]	[0.000]
Distance the nearest village market (km)	-0.003***	-0.003***	-0.013**	-0.017***	-0.011*	-0.015***
	(0.001)	(0.001)	(0.006)	(0.005)	(0.006)	(0.005)
	[0.003]	[0.000]	[0.044]	[0.002]	[0.053]	[0.002]
Crop rotation (dummy)	-0.023**	-0.021**	-0.146**	-0.128*	-0.136**	-0.119*
	(0.011)	(0.011)	(0.072)	(0.072)	(0.066)	(0.066)
	[0.029]	[0.043]	[0.044]	[0.076]	[0.041]	[0.072]
Mixed Crops (dummy)	0.004	0.001	-0.062	-0.079	-0.065	-0.080
	(0.009)	(0.009)	(0.061)	(0.061)	(0.056)	(0.056)
	[0.673]	[0.932]	[0.304]	[0.190]	[0.243]	[0.149]
Labor force (man.day)	0.002***	0.002***	0.027***	0.027***	0.026***	0.026***
	(0.001)	(0.001)	(0.005)	(0.005)	(0.004)	(0.004)
	[0.003]	[0.003]	[0.000]	[0.000]	[0.000]	[0.000]
Unit selling price (USDkg)	0.010	0.033	-0.122	-0.001	1.313***	1.426***
	(0.053)	(0.050)	(0.362)	(0.341)	(0.333)	(0.313)
	[0.859]	[0.514]	[0.737]	[0.998]	[0.000]	[0.000]
Seed cost (USDha)	0.002***	0.002***	0.011***	0.010***	0.010***	0.009***
	(0.000)	(0.000)	(0.002)	(0.002)	(0.001)	(0.001)
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Fertilizer cost (USDha)	0.000	0.000	0.001	0.001	0.001	0.001
	(0.000)	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)

Table S1: Control function estimations of the relationship between adoption and market participation *(continued)*

variables	FE	CRE	FE	CRE	FE	CRE
	[0.724]	[0.573]	[0.206]	[0.174]	[0.219]	[0.189]
Pesticide cost (USDha)	-0.001***	-0.001***	-0.005	-0.006*	-0.004	-0.005*
	(0.000)	(0.000)	(0.003)	(0.003)	(0.003)	(0.003)
	[0.004]	[0.002]	[0.108]	[0.054]	[0.138]	[0.071]
Labor cost (USDha)	0.000***	0.000***	0.002***	0.002***	0.002***	0.002***
	(0.000)	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)
	[0.001]	[0.000]	[0.004]	[0.002]	[0.004]	[0.003]
Groundnut area (ha)	0.003	0.004	0.198***	0.204***	0.195***	0.201***
	(0.003)	(0.003)	(0.023)	(0.023)	(0.021)	(0.021)
	[0.410]	[0.282]	[0.000]	[0.000]	[0.000]	[0.000]
Off-farm income (dummy)	-0.020	-0.021	-0.035	-0.044	-0.024	-0.032
	(0.014)	(0.014)	(0.098)	(0.098)	(0.090)	(0.090)
	[0.173]	[0.139]	[0.717]	[0.651]	[0.787]	[0.720]
Dependency ratio	0.002	0.002	0.013	0.016	0.012	0.015
	(0.003)	(0.003)	(0.022)	(0.022)	(0.020)	(0.020)
	[0.609]	[0.529]	[0.557]	[0.462]	[0.551]	[0.456]
Clay soil (dummy)	-0.016	-0.013	-0.160*	-0.129*	-0.154*	-0.125*
	(0.013)	(0.011)	(0.087)	(0.073)	(0.080)	(0.067)
	[0.203]	[0.227]	[0.066]	[0.077]	[0.055]	[0.063]
Sandy-clay soil (dummy)	0.006	0.006	0.052	0.039	0.048	0.036
	(0.010)	(0.009)	(0.068)	(0.059)	(0.063)	(0.054)
	[0.526]	[0.486]	[0.448]	[0.503]	[0.449]	[0.507]
Silty soil (dummy)	-0.004	0.001	-0.032	0.010	-0.032	0.007
	(0.013)	(0.011)	(0.086)	(0.073)	(0.079)	(0.067)
	[0.735]	[0.899]	[0.715]	[0.892]	[0.684]	[0.915]
Constant	0.700***	1.021***	5.500***	7.367***	4.331***	6.012***
	(0.183)	(0.076)	(1.242)	(0.521)	(1.142)	(0.478)
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Observations	8,604	8,604	8,604	8,604	8,604	8,604
R-squared	0.066		0.098		0.126	
Number of id	2,868	2,868	2,868	2,868	2,868	2,868
District FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
Standard errors in brackets						
*** p<0.01, ** p<0.05, * p<0.1						

Note: The table provides the results of ontrol function estimations, which investigates the relationship between adoption and various factors related to Market participation, quantity sold, and Sales value under both Fixed effects (FE) and corrolated randome effect (CRE) specifications. Robust standard errors are reported in brackets to account for potential heteroscedasticity. Two-sided t-tests were used for statistical testing, and the corresponding p-values are presented within square brackets. Coefficients marked with an asterisk (*) indicate statistical significance at predetermined levels of significance (*** p<0.01, ** p<0.05, * p<0.1). To control for potential unobserved heterogeneity, all regressions incorporate a comprehensive set of district fixed effects.

1.2 Hausman Taylor IV

Table S2: HAUSMAN TAYLOR IV estimations

variables	Market participation	Quantity sold	Sales value
Adoption dummy	0.038***	0.279***	0.258***
	(0.012)	(0.081)	(0.074)
	[0.001]	[0.001]	[0.001]
Age of household head (years)	-0.002***	-0.016***	-0.015***
	(0.000)	(0.004)	(0.003)
	[0.001]	[0.000]	[0.000]
Household size (number of persons)	0.000	0.012***	0.012***
	(0.001)	(0.004)	(0.004)
	[0.409]	[0.002]	[0.001]
Farmers group membership (dummy)	0.007	0.019	0.015
	(0.004)	(0.029)	(0.027)
	[0.112]	[0.510]	[0.562]
Training on agriculture (dummy)	-0.049***	-0.311***	-0.281***
	(0.009)	(0.066)	(0.061)
	[0.000]	[0.000]	[0.000]
Training on groundnut farming (dummy)	-0.009***	-0.038*	-0.034*
	(0.003)	(0.020)	(0.018)
	[0.003]	[0.061]	[0.067]
Public agricultural extension service (number of visits)	-0.005**	-0.062***	-0.059***
	(0.002)	(0.014)	(0.013)
	[0.011]	[0.000]	[0.000]
Private agricultural extension service (number of visits)	-0.000	0.004	0.002
	(0.003)	(0.020)	(0.018)
	[0.975]	[0.861]	[0.905]
Cash credit for groundnut farming (dummy)	0.014	-0.027	-0.043
	(0.020)	(0.140)	(0.128)
	[0.492]	[0.848]	[0.737]
Credit in kind for groundnut farming (dummy)	-0.037***	0.003	0.023
	(0.014)	(0.096)	(0.088)
	[0.008]	[0.974]	[0.797]
Distance to the nearest urban market (km)	-0.000	-0.000	-0.000
	(0.000)	(0.002)	(0.002)
	[0.135]	[0.807]	[0.895]
Distance the nearest village market (km)	-0.004***	-0.021***	-0.019***
	(0.001)	(0.005)	(0.005)
	[0.000]	[0.000]	[0.000]
Crop rotation (dummy)	-0.050***	-0.487***	-0.461***
	(0.008)	(0.058)	(0.054)
	[0.000]	[0.000]	[0.000]
Mixed Crops (dummy)	0.018**	0.049	0.039
	(0.007)	(0.051)	(0.047)
	[0.016]	[0.343]	[0.410]
Labor force (man.day)	0.003***	0.035***	0.033***
	(0.001)	(0.004)	(0.004)
	[0.000]	[0.000]	[0.000]
Unit selling price (USDkg)	0.093**	0.867***	2.280***
	(0.041)	(0.277)	(0.255)
	[0.024]	[0.002]	[0.000]
Seed cost (USDha)	0.002***	0.012***	0.011***
	(0.000)	(0.001)	(0.001)
	[0.000]	[0.000]	[0.000]
Fertilizer cost (USDha)	0.000***	0.005***	0.005***
	(0.000)	(0.001)	(0.001)
	[0.000]	[0.000]	[0.000]
Pesticide cost (USDha)	-0.001***	-0.000	0.001
	(0.000)	(0.003)	(0.002)
	[0.010]	[0.997]	[0.787]
Labor cost (USDha)	0.000***	0.001	0.001
	(0.000)	(0.001)	(0.001)
	[0.008]	[0.169]	[0.197]
Groundnut area (ha)	0.019***	0.326***	0.314***
	(0.003)	(0.019)	(0.018)
	[0.000]	[0.000]	[0.000]

Table S2: HAUSMAN TAYLOR IV estimations *(continued)*

variables	Market participation	Quantity sold	Sales value
Off-farm income (dummy)	-0.017	0.021	0.030
	(0.012)	(0.084)	(0.077)
	[0.159]	[0.806]	[0.698]
Dependency ratio	0.006**	0.033*	0.030*
	(0.003)	(0.019)	(0.017)
	[0.038]	[0.080]	[0.084]
Clay soil (dummy)	-0.020*	-0.182**	-0.174**
	(0.011)	(0.077)	(0.071)
	[0.079]	[0.018]	[0.014]
Sandy-clay soil (dummy)	0.004	0.034	0.031
	(0.009)	(0.061)	(0.056)
	[0.675]	[0.579]	[0.576]
Silty soil (dummy)	-0.002	-0.025	-0.026
	(0.011)	(0.077)	(0.071)
	[0.848]	[0.747]	[0.716]
Sex of household head (dummy, male=1)	0.044**	0.745***	0.719***
	(0.022)	(0.167)	(0.154)
	[0.047]	[0.000]	[0.000]
Education level (Number of years)	0.004***	0.026**	0.024**
	(0.001)	(0.011)	(0.010)
	[0.005]	[0.013]	[0.014]
Constant	0.783***	4.838***	3.564***
	(0.041)	(0.294)	(0.271)
	[0.000]	[0.000]	[0.000]
Observations	8,604	8,604	8,604
Number of id	2,868	2,868	2,868
Standard errors in brackets			
*** p<0.01, ** p<0.05, * p<0.1			

Note: The table provides the results of the HAUSMAN TAYLOR IV model, which investigates the relationship between adoption and various factors related to Market participation, quantity sold, and Sales value. Robust standard errors are reported in brackets to account for potential heteroscedasticity. Two-sided t-tests were used for statistical testing, and the corresponding p-values are presented within square brackets. Coefficients marked with an asterisk (*) indicate statistical significance at predetermined levels of significance (*** p<0.01, ** p<0.05, * p<0.1). To control for potential unobserved heterogeneity, all regressions incorporate a comprehensive set of district fixed effects.

1.3 Lewbels Test

Table S3: Lewbel instrumental variable estimations of the relationship between adoption and commercialization

				Acess (IV)		
variables	Market participation	Quantity sold	Sales value	Market participation	Quantity sold	Sales value
Adoption dummy	0.043***	0.315***	0.291***	0.043***	0.315***	0.291***
	(0.013)	(0.087)	(0.080)	(0.013)	(0.087)	(0.080)
	[0.001]	[0.000]	[0.000]	[0.001]	[0.000]	[0.000]
Age of household head	0.001	-0.018	-0.019	0.001	-0.018	-0.019
	(0.003)	(0.024)	(0.022)	(0.003)	(0.024)	(0.022)
	[0.864]	[0.450]	[0.383]	[0.864]	[0.450]	[0.383]
Household size	0.002**	0.027***	0.026***	0.002**	0.027***	0.026***
	(0.001)	(0.007)	(0.006)	(0.001)	(0.007)	(0.006)
	[0.036]	[0.000]	[0.000]	[0.036]	[0.000]	[0.000]
Farmers group membership	0.023***	0.132***	0.118***	0.023***	0.132***	0.118***
	(0.006)	(0.044)	(0.041)	(0.006)	(0.044)	(0.041)
	[0.000]	[0.003]	[0.004]	[0.000]	[0.003]	[0.004]
Training on agriculture	-0.042***	-0.300***	-0.274***	-0.042***	-0.300***	-0.274***
	(0.015)	(0.105)	(0.096)	(0.015)	(0.105)	(0.096)
	[0.006]	[0.004]	[0.004]	[0.006]	[0.004]	[0.004]
Training on groundnut farming	-0.025***	-0.179***	-0.166***	-0.025***	-0.179***	-0.166***
	(0.005)	(0.031)	(0.028)	(0.005)	(0.031)	(0.028)
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Public agricultural extension service	0.003	-0.018	-0.019	0.003	-0.018	-0.019
	(0.003)	(0.019)	(0.018)	(0.003)	(0.019)	(0.018)
	[0.293]	[0.352]	[0.282]	[0.293]	[0.352]	[0.282]
Private agricultural extension service	0.003	0.044	0.042	0.003	0.044	0.042
	(0.004)	(0.029)	(0.027)	(0.004)	(0.029)	(0.027)
	[0.476]	[0.128]	[0.116]	[0.476]	[0.128]	[0.116]
Cash credit for groundnut farming	-0.006	-0.150	-0.158	-0.006	-0.150	-0.158
	(0.027)	(0.189)	(0.174)	(0.027)	(0.189)	(0.174)
	[0.835]	[0.427]	[0.366]	[0.835]	[0.427]	[0.366]
Credit in kind for groundnut farming	-0.043**	-0.036	-0.012	-0.043**	-0.036	-0.012
	(0.019)	(0.133)	(0.124)	(0.019)	(0.133)	(0.124)
	[0.025]	[0.784]	[0.925]	[0.025]	[0.784]	[0.925]
Distance to the nearest urban market	-0.000	-0.003*	-0.003*	-0.000	-0.003*	-0.003*
	(0.000)	(0.002)	(0.002)	(0.000)	(0.002)	(0.002)
	[0.146]	[0.087]	[0.084]	[0.146]	[0.087]	[0.084]
Distance the nearest village market	-0.002	-0.009	-0.008	-0.002	-0.009	-0.008
	(0.002)	(0.011)	(0.010)	(0.002)	(0.011)	(0.010)
	[0.131]	[0.393]	[0.421]	[0.131]	[0.393]	[0.421]
Crop rotation	-0.022	-0.136	-0.128	-0.022	-0.136	-0.128
	(0.014)	(0.088)	(0.081)	(0.014)	(0.088)	(0.081)
	[0.112]	[0.122]	[0.111]	[0.112]	[0.122]	[0.111]
Mixed Crops	0.001	-0.081	-0.082	0.001	-0.081	-0.082
	(0.011)	(0.078)	(0.072)	(0.011)	(0.078)	(0.072)
	[0.949]	[0.297]	[0.250]	[0.949]	[0.297]	[0.250]
Labor force	0.002***	0.026***	0.025***	0.002***	0.026***	0.025***
	(0.001)	(0.005)	(0.005)	(0.001)	(0.005)	(0.005)
	[0.004]	[0.000]	[0.000]	[0.004]	[0.000]	[0.000]
Unit selling price	0.050	0.452	1.890***	0.050	0.452	1.890***
	(0.043)	(0.291)	(0.268)	(0.043)	(0.291)	(0.268)
	[0.249]	[0.120]	[0.000]	[0.249]	[0.120]	[0.000]
Seed cost	0.002***	0.011***	0.010***	0.002***	0.011***	0.010***
	(0.000)	(0.002)	(0.002)	(0.000)	(0.002)	(0.002)
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Fertilizer cost	0.000	0.002	0.001	0.000	0.002	0.001
	(0.000)	(0.001)	(0.001)	(0.000)	(0.001)	(0.001)
	[0.505]	[0.106]	[0.117]	[0.505]	[0.106]	[0.117]
Pesticide cost	-0.001***	-0.004	-0.003	-0.001***	-0.004	-0.003
	(0.000)	(0.003)	(0.003)	(0.000)	(0.003)	(0.003)
	[0.007]	[0.218]	[0.280]	[0.007]	[0.218]	[0.280]
Labor cost	0.000***	0.002**	0.002**	0.000***	0.002**	0.002**
	(0.000)	(0.001)	(0.001)	(0.000)	(0.001)	(0.001)
	[0.004]	[0.011]	[0.011]	[0.004]	[0.011]	[0.011]
Groundnut area	0.004	0.208***	0.204***	0.004	0.208***	0.204***

Table S3: Lewbel instrumental variable estimations of the relationship between adoption and commercialization *(continued)*

variables	Market participation	Quantity sold	Sales value	Market participation	Quantity sold	Sales value
	(0.004)	(0.031)	(0.029)	(0.004)	(0.031)	(0.029)
	[0.298]	[0.000]	[0.000]	[0.298]	[0.000]	[0.000]
Off-farm income	-0.020	-0.036	-0.024	-0.020	-0.036	-0.024
	(0.014)	(0.106)	(0.099)	(0.014)	(0.106)	(0.099)
	[0.168]	[0.737]	[0.809]	[0.168]	[0.737]	[0.809]
Dependency ratio	0.001	0.011	0.010	0.001	0.011	0.010
	(0.004)	(0.025)	(0.023)	(0.004)	(0.025)	(0.023)
	[0.693]	[0.663]	[0.657]	[0.693]	[0.663]	[0.657]
Clay soil	-0.019	-0.173	-0.165*	-0.019	-0.173	-0.165*
	(0.016)	(0.109)	(0.100)	(0.016)	(0.109)	(0.100)
	[0.237]	[0.111]	[0.098]	[0.237]	[0.111]	[0.098]
Sandy-clay soil	0.004	0.037	0.034	0.004	0.037	0.034
	(0.012)	(0.082)	(0.075)	(0.012)	(0.082)	(0.075)
	[0.768]	[0.654]	[0.651]	[0.768]	[0.654]	[0.651]
Silty soil	-0.008	-0.047	-0.045	-0.008	-0.047	-0.045
	(0.015)	(0.104)	(0.096)	(0.015)	(0.104)	(0.096)
	[0.608]	[0.656]	[0.641]	[0.608]	[0.656]	[0.641]
Observations	8,604	8,604	8,604	8,604	8,604	8,604
R-squared	0.051	0.085	0.114	0.051	0.085	0.114
Robust standard errors in brackets						
*** p<0.01, ** p<0.05, * p<0.1						

Note: The table provides the results of Lewbel instrumental variable (IV) estimations, which investigate the relationship between adoption and several factors associated with market participation, quantity sold, and sales value. The Lewbel IV approach extends the standard instrumental variable technique by addressing the endogeneity issue that arises when the adoption decision and commercialization are jointly determined. Robust standard errors are reported in brackets to account for potential heteroscedasticity and model misspecification. Statistical tests were conducted using two-sided t-tests, and p-values are presented within square brackets. Coefficients marked with an asterisk (*) indicate statistical significance at predetermined levels of significance (*** p<0.01, ** p<0.05, * p<0.1). Additionally, to control for potential unobserved heterogeneity, all regressions incorporate a comprehensive set of district fixed effects, capturing the district-specific characteristics that may affect the adoption and market outcomes.