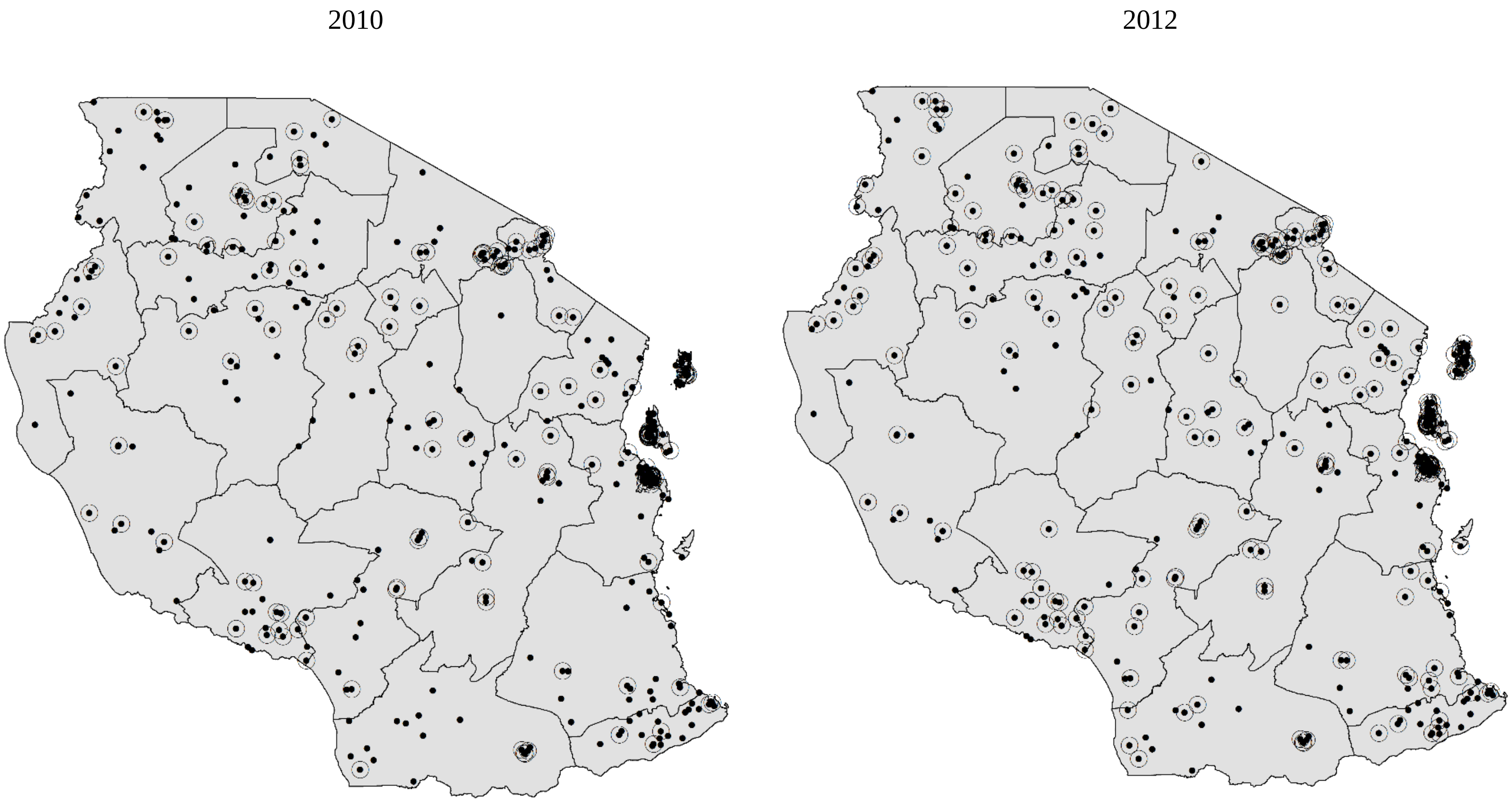
Annex for Online Publication - Financial Inclusion, Shocks, and Poverty: Evidence from the Expansion of Mobile Money in Tanzania

Figure A1: Rollout of mobile money agents across LSMS-ISA enumeration areas (agents operating in 10km radius)



Notes: The maps depict the 26 regions of Tanzania with points representing the enumeration areas from the LSMS-ISA survey. Circles represent enumeration areas with a mobile money agent in operation within a 10km radius around the village. The left panel is for the 2010 survey year, the right panel for the 2012 survey year.

Figure A2: The Relationship between Mobile Money and Distance to Agent

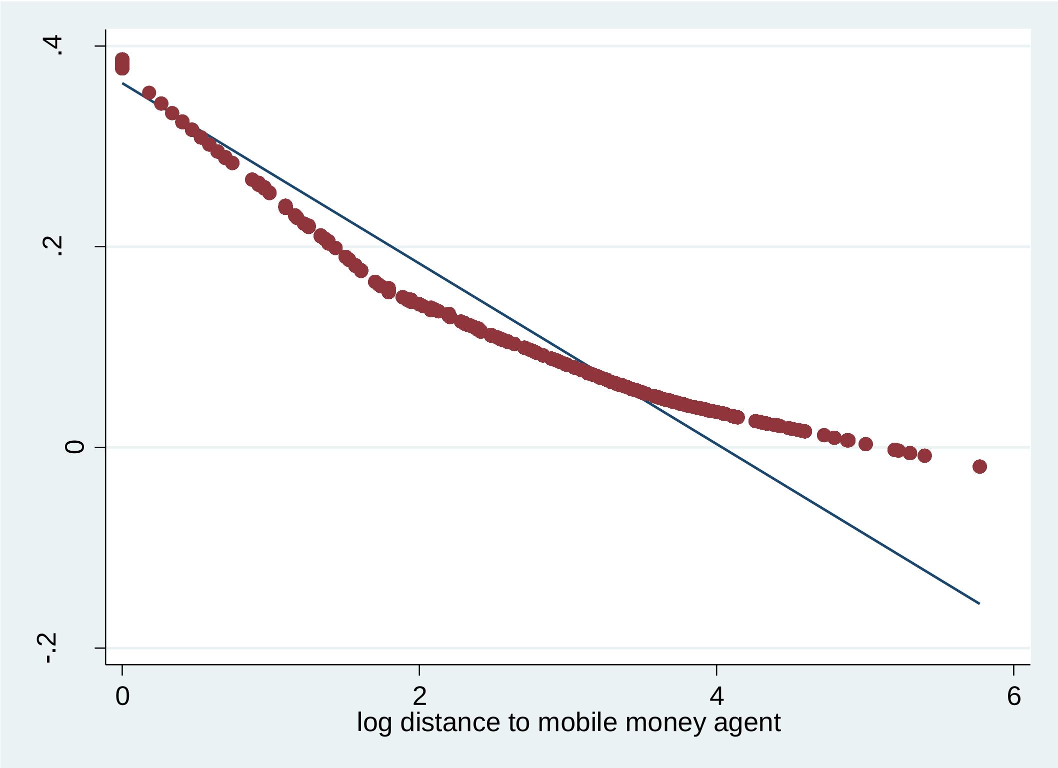
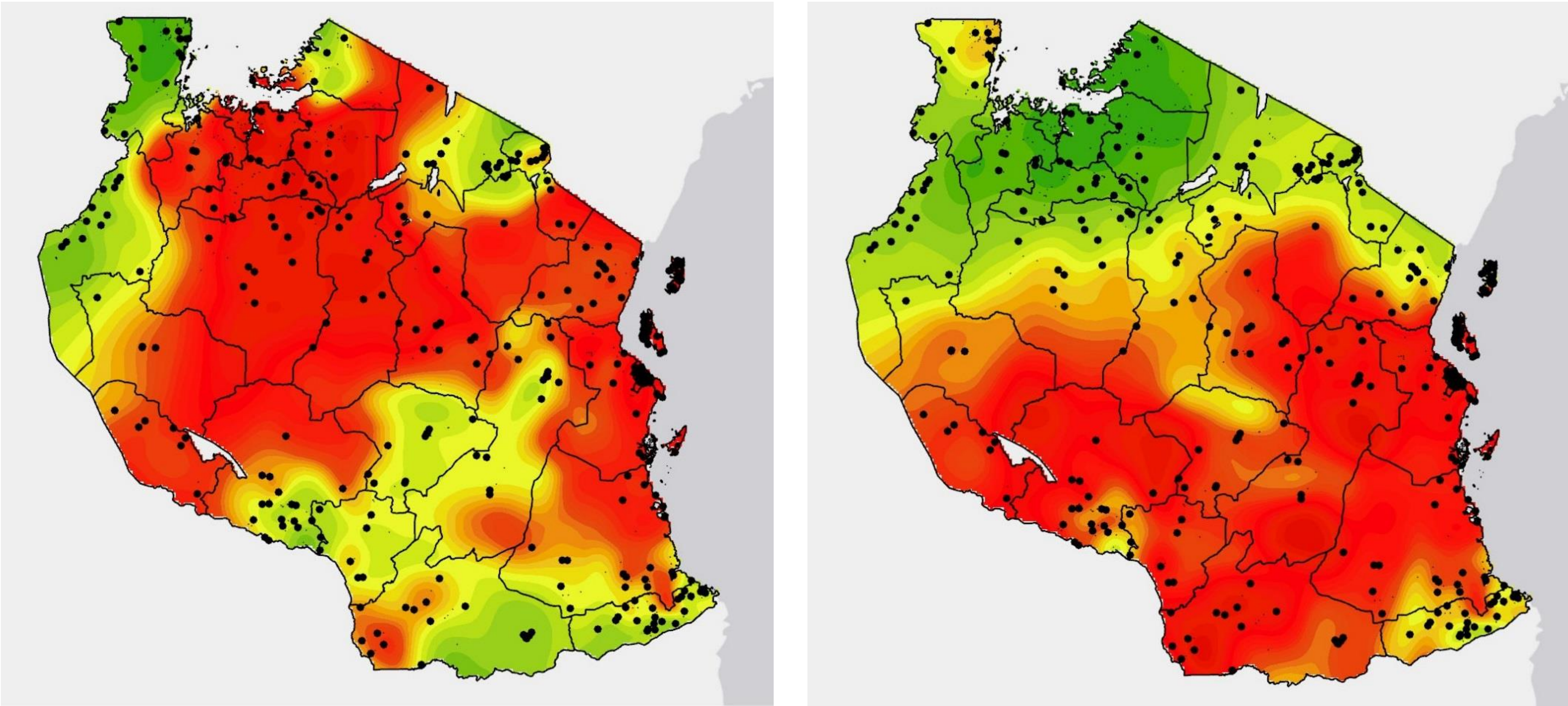


Figure A3: Deviation from Long-term Average Rainfall in the 2010 and 2012 survey years

2010 2012



Notes: The maps report the rainfall for the 2010 and 2012 main growing seasons as deviation from long-term average rainfall. Darker red shades represent less than average rainfall; green shades represent more than average rainfall. The 26 regions of Tanzania and Enumeration Areas in the LSMS-ISA used in this paper (black points) superimposed. The left panel is for the 2010 survey year, the right panel for the 2012 survey years

Table A1: Balancing tests for HH characteristics by treatment status

Variable	Control Households		Treatment Households		
	Mean	SD	Mean	SD	Normalized Difference
Household Size	5.3180	2.7300	5.0479	2.6840	0.0705
No. of Children	2.8256	2.1571	2.6426	2.1006	0.0608
Mean HH age	26.1030	13.8643	27.5776	14.7667	-0.0728
Wealth Measure	73.3078	58.6164	73.5380	49.6918	-0.0030
Female HH Head	0.2625	0.4401	0.2470	0.4314	0.0252
Rural	0.7214	0.4484	0.7084	0.4547	0.0205
Mobile Phone Ownership	0.6389	0.4804	0.6433	0.4792	-0.0065
No. of Phones	1.1414	1.1949	1.1755	1.2743	-0.0195
Voucher Use	0.6384	0.4806	0.6401	0.4801	-0.0024
Voucher Value	5.8317	4.4688	5.8525	4.4723	-0.0033
SACCO Membership	0.2252	0.4178	0.2017	0.4014	0.0407
Bank Account Access	0.1448	0.3520	0.1966	0.3975	-0.0975
Membership in Loan Group	0.0749	0.2633	0.0842	0.2778	-0.0243
Positive Balance in Loan Group	0.0567	0.2314	0.0587	0.2352	-0.0060
Married	0.8294	0.3763	0.8137	0.3895	0.0290
Formal School	0.7341	0.4419	0.7798	0.4145	-0.0754
Occupational Categories					
Agriculture	0.6545	0.4756	0.5801	0.4937	0.1084
Unemployed	0.0574	0.2327	0.0795	0.2706	-0.0618
Self employed	0.1600	0.3667	0.1737	0.3790	-0.0260
Private	0.0813	0.2733	0.0885	0.2841	-0.0182
Public	0.0468	0.2113	0.0782	0.2686	-0.0919
Rainfall Shocks					
Normalized rainfall-deviation (HH)	-0.0632	0.9343	-0.1105	0.9624	0.0353
Drought indicator (below 1SD of mean)	0.3645	0.4814	0.3459	0.4758	0.0275

Notes: Number of observations: treatment households: 719, control households: 1,084. Treatment households refers to households that see a change in access to MM agents from 2010 to 2012, while control households refer to households without change in access to mobile money agents. The normalized difference is calculated as $norm-diff=\frac{\overline{X_0}-\overline{X_1}}{\sqrt{s_{x,0}^2+s_{x,1}^2}}$, where s^2denotes the sample variance of $x_{i.}$

Table A2: Contemporaneous rainfall and household characteristics

Variables	Dependent variable: Rainfall shock
Mean household age	-0.004
	(0.006)
HH head formal schooling	-0.035
	(0.112)
Employment of HH head:	
Agriculture	0.327
	(0.379)
Public servant	-0.264
	(0.480)
Private sector	0.283
	(0.413)
Self-employed	0.352
	(0.398)
Unemployed	0.171
	(0.399)
Married	-0.031
	(0.134)
Female head	-0.117
	(0.217)
Number of children in household	-0.016
	(0.059)
Household size	-0.004
	(0.047)
Household fixed-effects	Yes
Year fixed-effects	Yes
Observations	3,448
R-squared	0.034

Notes: The entries of Table A2 report the coefficients from an OLS regression of the rainfall deviation measure used in the main estimates on the predetermined household characteristics. The regression includes household and year fixed effects. Robust standard errors, clustered at the enumeration area are reported in parentheses.

Table A3: Effect of Agricultural Output and Agricultural Income on Rainfall Deviation

	Dependent variable: Farm output	
	Natural log of Normalized kilogram	Natural log of shillings
Variables	(1)	(2)
ln rainfall	0.302***	0.185*
	(0.105)	(0.097)
Observations	2,374	2,374
R-squared	0.223	0.226

Notes: The entries of column (1) report the results from a regression of the agricultural yield measured in log kilogram of normalized agricultural output on log of rainfall. In column (2), we provide the coefficient from the monetary equivalent using contemporaneous market prices for each cash crop using prices provided by LSMS-ISA. All regressions include the full set of household controls and year fixed effects. Robust standard errors, clustered at the enumeration area are reported in parentheses. ***, ** and * represent significance at 1, 5 and 10 percent, respectively.

Table A4: Contemporaneous rainfall shocks and mobile money agent distribution for the 2010 and 2012 survey years

Panel A	Dependent variable: Rainfall shock in year 2010				
2010 agent distribution	(1)	(2)	(3)	(4)	(5)
MM agent (2km Radius)	-0.081				
	(0.152)				
MM agent (5km Radius)		-0.106			
		(0.140)			
MM agent (10km Radius)			-0.006		
			(0.130)		
MM agent (15km Radius)				-0.061	
				(0.127)	
MM agent (20km Radius)					-0.074
					(0.128)
R-squared	0.176	0.177	0.175	0.176	0.176

Panel B	Dependent variable: Rainfall shock in year 2012				
2012 agent distribution	(1)	(2)	(3)	(4)	(5)
MM agent (2km Radius)	0.031				
	(0.103)				
MM agent (5km Radius)		0.091			
		(0.107)			
MM agent (10km Radius)			-0.018		
			(0.120)		
MM agent (15km Radius)				-0.074	
				(0.130)	
MM agent (20km Radius)					-0.089
					(0.144)
R-squared	0.256	0.257	0.256	0.256	0.256

Notes: Each column reports the coefficients from separate regressions of rainfall variations in the 2010 (Panel A) and 2012 (Panel B) periods on the distribution of mobile money agents. All regressions include community level controls. Robust standard errors clustered at the enumeration area are reported in parentheses. ***, ** and * represent significance at 1, 5 and 10 percent, respectively.

Table A5: Long-term rainfall variability and mobile money agent distribution for the 2010 and 2012 survey years

Panel A	Dependent variable: long-term variability in community rainfall				
2010 agent distribution	(1)	(2)	(3)	(4)	(5)
MM agent (2km Radius)	0.004				
	(0.037)				
MM agent (5km Radius)		-0.004			
		(0.033)			
MM agent (10km Radius)			-0.038		
			(0.031)		
MM agent (15km Radius)				-0.046	
				(0.030)	
MM agent (20km Radius)					-0.019
					(0.031)
R-squared	0.289	0.289	0.293	0.295	0.290

Panel B	Dependent variable: long-term variability in community rainfall				
2012 agent distribution	(1)	(2)	(3)	(4)	(5)
MM agent (2km Radius)	0.001				
	(0.032)				
MM agent (5km Radius)		0.001			
		(0.032)			
MM agent (10km Radius)			-0.014		
			(0.039)		
MM agent (15km Radius)				-0.007	
				(0.045)	
MM agent (20km Radius)					0.020
					(0.050)
R-squared	0.272	0.272	0.272	0.272	0.273

Notes: Each column presents the coefficients from separate regressions of the long-run variability in rainfall on the distribution of mobile money agents in 2010 (Panel A) and 2012 (Panel B). The long-run variability of rainfall is given by the standard deviation of rainfall over the 30 year period prior to the first survey. We compute the long-run rainfall variability by merging precipitation data from the four closest weather stations to the enumeration area GPS covariates from the University of Delaware weather data repository. All regressions include community level controls. Robust standard errors clustered at the enumeration area are reported in parentheses. ***, ** and * represent significance at 1, 5 and 10 percent, respectively.

Table A6: First Stage Instrumental Variable Results and Diagnostic Tests.

Panel A: Estimates Panel A: Mobile Money	(1)	(2)
Agent availability	0.083***	0.083***
	(0.004)	(0.004)
Agent distance	-0.069***	-0.069***
	(0.002)	(0.001)
R-squared	0.985	0.986
F-stat (4, 777)	5109	5209
Diagnostic Panel		
Under Identification Test – Chi-Sq. (3, 777)	18786(0.000)	19452(0.000)
Weak Identification Test - F (3, 777)	6243	6419
Panel B: Mobile Money x Rainfall Shock		
Agent availability x rainfall shock	0.076***	0.076***
	(0.004)	(0.004)
Agent distance x rainfall shock	-0.073***	-0.073***
	(0.001)	(0.001)
R-squared	0.875	0.877
F-stat (4, 777)	12118	12334
Diagnostics Panel		
Under Identification Test – Chi-Sq. (3, 777)	51876(0.000)	53173(0.000)
Weak Identification Test - F (3, 777)	17240	17547
Joint significance		
Kleibergen-Paap rk LM statistic (under identification) Chi-Sq. (3)	240(0.000)	241(0.000)
Kleibergen-Paap Wald rk F statistic (weak identification) F	4649	4809
Household fixed-effects	Yes	Yes
Year fixed-effects	Yes	Yes
Controls	No	Yes
Observations	3,448	3,448

Notes: The entries present the first stage estimates obtained from the main results presented in Table 3 Column 3. Total number of observations for the regression is 3,448 (1,724) households. Panel A reports the first stage estimates for agent availability in the village and its distance to the village while Panel B reports results with both interacted with rainfall shocks. Diagnostics Panel reports the diagnostic tests for the first stage estimates where maximum test statistic from Stock-Yogo weak ID F test critical at 10% maximal IV size is 16.87. R-squared values are obtained from the OLS regression of mobile money on agent availability and proximity and their interactions with rainfall shock respectively. The variable mobile money is instrumented by the smoothened distance to the nearest mobile money agent. Rainfall shock denotes the idiosyncratic shock as deviation from the long-term average rainfall, so that a negative value denotes a less than average rainfall. See notes in Table 3 for the precise specification and set of controls used in the estimation. Robust standard errors clustered at the enumeration area are reported in parentheses. ***, ** and * represent significance at 1, 5 and 10 percent, respectively.

Table A7: DiD Estimates for the Effect of Mobile Money on Per-capita Expenditure and Relative Poverty

	Dependent Variable:	
	Per-capita Expenditure (ln)	Relative poverty
Variables	(1)	(2)
Mobile money	-0.076	-0.033
	(0.109)	(0.062)
Rainfall shock	0.013	0.008
	(0.017)	(0.011)
Interaction (MM x RS)	-0.027	0.040
	(0.064)	(0.046)
Overall effect	-0.013	0.048
	(0.050)	(0.037)
Mean outcome	13.102	0.123
Household fixed-effects	Yes	Yes
Year fixed-effects	Yes	Yes
Controls	Yes	Yes
Observations	3,448	3,448
R-squared	0.098	0.121

Notes: The entries present the coefficients from a linear regression model of mobile money, rainfall shock and their interaction term on the log amount per capita expenditure (Column 1) and relative poverty (Column 2). See notes in Table 3 (column 2) for details on the specifications and the set of controls used in the estimation. Robust standard errors, clustered at enumeration area are reported in parentheses.

Table A8: DiD Estimates for the Effect of Mobile Money on Poverty Classification, by Time from Harvest

	Within six months of harvest	After six months of harvest
	(1)	(2)
Mobile money	-0.164	0.008
	(0.118)	(0.131)
Rainfall shock	0.021	0.062**
	(0.020)	(0.030)
Interaction (MM x RS)	-0.032	-0.184*
	(0.075)	(0.100)
Overall effect	-0.012	-0.121*
	(0.059)	(0.074)
Mean outcome	0.277	0.279
Household fixed-effects	Yes	Yes
Year fixed-effects	Yes	Yes
Controls	Yes	Yes
Observations	1,444	1,664
R-squared	0.173	0.226
Number of observations	722	832

Notes: Table above entries present the coefficients from a linear probability model of mobile money, rainfall shock and their interaction term on a poverty indicator (absolute poverty) by time from the main harvest. Entries in column (1) present coefficients for households surveyed in the first six months of harvest while column (2) presents the estimates for households surveyed after six months from the main harvest. See notes in Table 3 (column 2) for the precise specification and set of controls used in the estimation. Robust standard errors, clustered at the enumeration area are reported in parentheses. ***, ** and * represent significance at 1, 5 and 10 percent, respectively.

Table A9: DiD Estimates for the Effect of Mobile Money on Poverty Classification, Including Enumeration Area Trends

	Dependent Variable: Absolute Poverty			
Variables	(1)	(2)	(3)	(4)
Mobile money	-0.056	-0.050	-0.053	-0.055
	(0.081)	(0.081)	(0.081)	(0.081)
Rainfall shock	0.046***	0.045***	0.046***	0.046***
	(0.016)	(0.016)	(0.016)	(0.016)
Interaction (MM x RS)	-0.125**	-0.127**	-0.127**	-0.126**
	(0.057)	(0.057)	(0.057)	(0.057)
Overall effect	-0.079*	-0.082*	-0.081*	-0.080*
	(0.044)	(0.044)	(0.044)	(0.044)
Mean outcome	0.283	0.283	0.283	0.283
Community varying linear trend	No	Yes	No	No
Community varying quadric trend	No	No	Yes	No
Community varying cubic trend	No	No	No	Yes
Household fixed-effects	Yes	Yes	Yes	Yes
Year fixed-effects	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes
Observations	3,448	3,448	3,448	3,448
R-squared	0.189	0.189	0.189	0.189

Notes: The above entries are the coefficients from a linear probability model of mobile money, rainfall shock and their interaction term on a poverty index, where we add sequentially additional enumeration area specific time varying trends. See Table 3 for the specification and for the controls used in each regression. Each regression is clustered at the enumeration area. Robust standard errors, clustered at the enumeration area are reported in parentheses. ***, ** and * represent significance at 1, 5 and 10 percent, respectively.

Table A10: OLS Estimates of the Effect of Mobile Money on Remittances, by Access to Bank Accounts

	Dependent Variable: Remittances			
	Panel A: No bank account		Panel B: Bank account available	
Variables	Indicator	ln Remittance Amount	Indicator	ln Remittance Amount
	(1)	(2)	(3)	(4)
Mobile money	0.325***	3.235***	0.154	2.307
	(0.082)	(0.921)	(0.300)	(3.499)
Mean outcome	0.217	2.210	0.254	2.822
R-squared	0.144	0.132	0.134	0.124
Observations	1,504	1,504	315	315

Notes: This table reports estimates of mobile money adoption in the households on remittances received by households using data from the 2012 LSMS wave. Columns (1) and (2) present estimates for outcomes and specifications for households without bank account, and columns (3) and (4) for households with access to a bank account. See notes in Table 3 for additional details. Robust standard errors clustered at the enumeration area are reported in parentheses. ***, ** and * represent significance at 1, 5 and 10 percent, respectively.

Table A11: DiD Estimates for the Effect of Mobile Money on Educational Inputs by Gender

	Dependent Variables:				
	School Expenditure (ln)	School Enrolment (indicator)	School Absenteeism (indicator)	Homework (Hours/Day)	Household Chores (indicator)
Variables	(1)	(2)	(3)	(4)	(5)
Panel A : Boys					
Mobile money	-0.128	0.066	-0.440*	-0.699**	0.023
	(0.351)	(0.116)	(0.262)	(0.318)	(0.149)
Rainfall shock	0.003	0.000	-0.080*	0.019	0.001
	(0.055)	(0.018)	(0.049)	(0.036)	(0.023)
Interaction (MM x RS)	0.064	0.021	0.225	-0.192	0.004
	(0.223)	(0.068)	(0.166)	(0.188)	(0.096)
Overall effect	0.067	0.021	0.145	-0.173	0.005
	(0.183)	(0.053)	(0.124)	(0.161)	(0.077)
Mean outcome	2.628	0.867	0.270	0.302	0.256
R-squared	0.033	0.101	0.024	0.089	0.015
Observations	1,926	1,926	1,520	1,520	2,438
Panel B : Girls					
Mobile money	0.078	0.040	-0.642***	-0.612**	0.330**
	(0.388)	(0.098)	(0.243)	(0.271)	(0.150)
Rainfall shock	-0.032	0.012	-0.076*	0.099***	-0.059**
	(0.062)	(0.016)	(0.045)	(0.038)	(0.028)
Interaction (MM x RS)	0.030	-0.002	0.413***	-0.418**	0.325***
	(0.275)	(0.060)	(0.152)	(0.163)	(0.109)
Overall effect	-0.002	0.010	0.337***	-0.319**	0.265***
	(0.226)	(0.048)	(0.114)	(0.133)	(0.086)
Mean outcome	2.727	0.893	0.285	0.300	0.383
Observations	1,996	1,996	1,654	1,652	2,360
R-squared	0.042	0.092	0.044	0.122	0.027
Individual fixed-effects	Yes	Yes	Yes	Yes	Yes
Year fixed-effects	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes

Notes: The entries present the coefficients from a linear regression and linear probability model (for indicator outcomes) of mobile money, rainfall shock and their interaction term on a number of educational inputs by gender. See notes of Table 7 and 8 for additional details. Robust standard errors, clustered at the enumeration area are reported in parentheses. ***, ** and * represent significance at 1, 5 and 10 percent, respectively.

Appendix A1: Rainfall data from the LSMS-ISA

The main rainfall data used in this paper are obtained from the National Oceanic and Atmospheric Administration Climate Prediction Center (NOAA CPC), the African Rainfall Estimation Algorithm Version 2.0. The rainfall data from Rainfall Estimate (RFE) v2.0 provides a standardized time-series for all of the LSMS-ISA countries. Toté *et al.* (2015) provide a validation of the RFE rainfall measure relative to other measurement methods. The RFE outperforms Climate Hazards Group InfraRed Precipitation with Stations (CHIRPS) and TAMSAT African Rainfall Climatology and Time-series (TARCAT) v2.0 products, especially in drought detection for Mozambique.

The RFE is a merged product using data from multiple meteorological satellites and rainfall stations. The remote sensing data provide a continuous surface, at a specific resolution, measuring rainfall estimates. According to technical information received directly from the World Bank's LSMS-ISA team, station data are used to calibrate the merged satellite surfaces. The granularity of the plot-level measure comes from the RFE modelling, as well as the method used to extract the data linking the extrapolated rainfall data at the agricultural plot level. Rainfall values are extracted at household locations using a bilinear interpolation or distance-weighted average of four nearest grid cell values.

Seasonal precipitation data gathered from the Tanzanian meteorological weather stations are used in the interpolation of the global positioning system (GPS) of surveyed Tanzanian households.[1] These data include annual and wet season precipitation measures, respectively. While the household level GPS are withheld for confidentiality reasons, these are used to link rainfall estimates to the individual LSMS-ISA households. The spatial distribution of households within enumeration areas in the LSMS-ISA survey for Tanzania adds to the rainfall variation across enumeration area, adding sources of variation not normally

[1] Due to the spatial distribution of household observations in the survey data, enumerators were provided with a technological device that helps to capture exact GPS location of the respondent household and its immediate environs. Households close to each other have exactly the same GPS, while households farther away may have different GPS measurements.

available in similar household survey data. The intra enumeration variation of rainfall helps to address potential spatial correlation of rainfall data across broader geographical precipitation variation, such as at the district level or other geographic units of much larger size, which is commonly used in the literature.

Appendix A2. Construction of rainfall shock measure

To construct our measure of rainfall shocks, we use precipitation data provided by the World Bank (along with the LSMS-ISA data), which is available at the plot level. We use annual rainfall because households can choose to cultivate either in the short or long rainy seasons. However, data from the agricultural questionnaire of LSMS-ISA show that households in Tanzania predominantly engage in the long rainy seasons' agricultural activities, perhaps possibly due to higher certainty of agricultural yields from the long rainy seasons between December and February as against short rainy seasons in June and July cultivation. We follow the literature in constructing rainfall shocks and create measures of the deviation in rainfall from the long-run mean for a household by constructing shocks in the following way:

$$\text{Rainshock}_{\text{ht}-1} = ln\, R_{ht-1} - ln\, \overline{R_h} \qquad (2)$$

where $\text{R}_{\text{ht}-1}$ indicates the yearly rainfall in household h for the preceding year's planting season, and $\overline{R_h}$ represents the average historical yearly rainfall in household h. Thus, the $\text{Rainshock}_{\text{ht}-1}$ above is equivalent to the shock measure used for the deviation of the natural logarithm of the total rainfall in the 12 months prior to the 2010 and 2012 periods and the natural logarithm of the average yearly historical rainfall in the household h prior to the corresponding years.[2] The rainfall deviation denotes a percentage deviation from mean rainfall (Maccini and Yang 2009). We follow the recent literature when using lagged values of rainfall in equation (4) (see Appendix A3) to ensure the rainfall shock realization is a measure of the current economic resources of the households.[3]

[2] We normalize the rainfall shock variables constructed from equation (4) for each of the two years. This approach aids the comparison of deviation from historical average over the two panel waves and helps with the interpretation of the results.
[3] A substantial number of papers in the economics literature has adopted this procedure. Recent examples include Maccini and Yang (2009), Björkman-Nyqvist (2013), and Rocha and Soares (2015).

Appendix A3. Details on IV-DiD estimation strategy

Because equation (1) includes an interaction term ($\mathrm{MM}_{\mathrm{ht}} * \mathrm{Rainshock}_{\mathrm{ht-1}}$), we interact the two instruments for mobile money adoption with rainfall.

The first stage of the estimation is specified as follows.

$$\mathrm{MM}_{\mathrm{ht}} = \boldsymbol{\varphi_1}(\mathrm{Agent}_c) + \boldsymbol{\varphi_2}(\mathrm{Agent\_dist}_c) + \xi_{ht} \quad (3)$$

$$\mathrm{MM}_{\mathrm{ht}} * \mathrm{Rainshock}_{\mathrm{ht-1}} = \boldsymbol{\varphi_1}(\mathrm{Agent}_c * \mathrm{Rainshock}_{\mathrm{ht-1}}) + \boldsymbol{\varphi_2}(\mathrm{Agent\_dist}_c * \mathrm{Rainshock}_{\mathrm{ht-1}}) + \varsigma_{ht} \quad (4)$$

where $\mathbf{Agent_c}$ represents an indicator variable for mobile money agent availability, and $\mathbf{Agent\_dist_c}$ represents the distance (in kilometres) to the nearest agent. Identification for the instrumented DiD strategy relies on the exclusion restriction to hold, namely that agent availability and proximity over time affect poverty (and other outcomes) only through the use of mobile money.

We estimate equation (1) using two-stage least squares (2SLS). In equations (3) and (4), we use one continuous instrument (distance to agent) and one binary instrument (availability of agent). While the use of a continuous instrument for a binary endogenous variable may yield consistent estimates in our 2SLS estimates, there is some ambiguity about consistency in the context of binary endogenous variables and outcomes (Wooldridge 2010). To avoid any ambiguity, we use a transformation employed in Björkman-Nyqvist (2013) and Blumenstock *et al.* (2016), and we use the smoothed values of the mobile money indicator variable for mobile money access propensity over the distance to the nearest agent in our specifications to address this concern. For consistency, we use the same approach for the interaction term between mobile money and rainfall shocks.