Supplementary Materials

Appendix A: Theoretical framework of behaviours in response to income shocks

The theoretical model aims to capture household behaviour when shocks can affect the productivity of land, capital and labour differently. To this end household i at time t has productive assets k_{it} and allocates h_{it}^{agri} labour hours to farm work. In the current period the farms assets are deterministic, but farm profit and labour availability may be subject to shocks. Assets are also subject to shocks at the end of the current production period. The household is faced with a set of shocks that have an idiosyncratic or covariate, income effect: covariate shocks are agricultural income shocks $0 \leq CS_t^{income} \leq 1$ and productive asset shocks $0 \leq CS_t^{asset} \leq 1$. Labour shocks $0 \leq IS_{it}^{labour} \leq 1$ are idiosyncratic. In the empirical model CS_t^{asset} is due to animal disease and floods that damage productive assets, CS_t^{income} is due to crop disease and the labour shock IS_{it}^{labour} is due to a household health shock.

The household also participates in an off-farm labour market and earns $w_{it}(T_{it} - h_{it}^{agri})$ where w_{it} is the wage rate and T_{it} represents total working hours of household i. The household labour time constraint is binding and T_{it} allows for leisure time, although for simplicity the leisure decision is not explicitly represented here.

Agricultural income is given by a restricted farm profit function $\pi(p_{it}, w_{it}, k_{it})$ (Lau, 1976) where productive assets are treated as fixed. Agricultural labour input demand is given by Hotelling's lemma:

$$h_{it}^{agri} = h(p_{it}, w_{it}, k_{it}) = -\partial\pi(p_{it}, w_{it}, k_{it})/\partial w_{it}$$

If the underlying production function is concave, the demand for labour is increasing in the fixed asset. Thus if a shock reduces capital, this also reduces the allocation of labour to agriculture and, due to the fixed time available for work, increases off-farm work.

The household maximises Bellman's equation

$$V(k_{it}) = Maximum[U(c_{it}) + \beta_i V(k_{it+1})]$$

where $U(c_{it})$ is a strictly concave utility of consumption that satisfies the Inada conditions, β_i is a discount factor and the value function $V(k_{it+1})$ gives the future utility starting with a capital asset level k_{it} and is strictly concave in the initial capital. The household is subject to a budget constraint:

$$c_{it} + I_{it} = \pi(k_{it}) + w_{it}(T_{it} - h_{it}^{agri})$$

where the budget is allocated to either consumption c_{it} or investment in productive assets I_{it} and income is generated from agricultural profit and wages for off-farm labour given by the difference between the total time available T_{it} and agricultural labour h_{it}^{agri}. Capital growth follows the equation:

$$k_{it+1} = k_{it}(1 - CS_{\mathrm{t}}^{asset}) + I_{it}$$

We derive comparative static results for the three shocks. For simplicity, we assume the asset shock to have a one-off effect on the capital stock, which affects future incomes, but not the current budget. Thus Bellman's equation becomes:

$$U(c) + \beta V\left[k\left(1 - CS^{asset}\right) + I\right]$$

The household subscript and time subscript are dropped to increase clarity. The comparative statics for the effects of the shock on investment is given by:

$$\frac{\partial I}{\partial CS^{asset}} = \frac{\beta k V''\left[k\left(1 - CS^{asset}\right) + I\right]}{U''(c) + \beta k V''\left[k\left(1 - CS^{asset}\right) + I\right]}$$

Assumptions about the strict concavity of the utility and Bellman's function indicate that investment is increasing with the size of the shock. On the same basis, consumption falls

$$\frac{\partial c}{\partial CS^{asset}} = -\frac{\beta k V''\left[k\left(1 - CS^{asset}\right) + I\right]}{U''(c) + \beta k V''\left[k\left(1 - CS^{asset}\right) + I\right]}$$

In response to the shock, the household increases investment and reduces consumption. A binding budget constraint would ensure that this is by an equal amount.

If an income shock affects agricultural income, the budget constraint becomes:

$$c + I = [\pi(k)(1 - CS^{income}) + w[T - h(p, w, k)\ ]$$

Investment and consumption fall:

$$\frac{\partial I}{\partial CS^{income}} = -\frac{TwU''(c)}{U''(c) + \beta V''(k + I)}$$

$$\frac{\partial c}{\partial CS^{income}} = -\frac{\pi(k)\ U''(c)}{U''(c) + \beta V''(k + I)}$$

If a labour shock occurs that reduces the hours available for work, the budget constraint is:

$$c + I = \pi(k) + w\left[T\left(1 - IS^{labour}\right) - h(p, w, k)\right]$$

Consumption and investment fall:

$$\frac{\partial I}{\partial IS^{labour}} = -\frac{TwU''(c)}{U''(c) + \beta V''(k + I)}$$

$$\frac{\partial c}{\partial IS^{labour}} = -\frac{\beta TwV''(k + I)}{U''(c) + \beta V''(k + I)}$$

If we relax the budget constraint so that household receives support from the community to insure against idiosyncratic shocks, the constraint becomes:

$$\pi(k) + w\left[T\left(1 - IS_t^{labour}\right) - h(k)\right] - c - I + B\left(IS_t^{labour}\right) = 0$$

where $B\left(IS_t^{labour}\right) \geq 0$ represents the transfer function, which could be either public transfers, private transfers, or even credits, triggered when idiosyncratic shocks occur. With a transfer function, the comparative statics of an idiosyncratic shock are as follows. For investment we have:

$$\frac{\partial I}{\partial IS^{labour}} = \frac{[B'\left(IS_t^{labour}\right) - Tw\,]\,U''(c)}{U''(c) + \beta V''(k+I)}$$

and for consumption:

$$\frac{\partial c}{\partial IS^{labour}} = \frac{\beta[B'\left(IS_t^{labour}\right) - Tw\,]\,V''(k+I)}{U''(c) + \beta V''(k+I)}$$

In both cases the sign of the first-order conditions depend upon the sign of the term: $[B'\left(IS_t^{labour}\right) - Tw\,]$. If this term is positive, both investment and consumption increase because the transfer more than compensates the household's loss of income due to the labour shock. If this term is negative both investment and consumption are reduced.

Appendix B. Regression results for the consumption of home production

	Growth of consumption of home production	**Log consumption of home production**
	(1)	**(2)**
Occurrence of:		
Floods	0.13***(0.01)	
Animal diseases	-0.05***(0.00)	
Crop diseases	0.33***(0.00)	
Health shocks	-1.10 (0.21)	
HH characteristics included but not reported		
Constant	-1.53 (0.32)	
Permanent income		0.39***(0.00)
Income effects due to		
Floods		-1.45**(0.03)
Animal diseases		-0.70(0.11)
Crop diseases		-4.88***(0.00)
Health shocks		0.92 (0.11)
Unexplained income		0.16***(0.00)
Constant		-4.28***(0.00)
No. of HH	1,915	1,915
R^2	0.12	0.66

Regressions are pooled OLS with household fixed effect. Two-tailed p-values in (.) are based on robust standard errors. *** p<0.001; **p<0.05; *p<0.1

Appendix C. Response of labour allocation to shocks

	Percent of wage-related activities in total labour days
Floods	-0.03***(0.00)
Lagged floods	0.003 (0.85)
Animal diseases	0.001 (0.46)
Lagged animal diseases	-0.001 (0.44)
Crop diseases	0.01 (0.40)
Lagged crop diseases	-0.01 (0.35)
Health shocks	-0.21 (0.12)
Lagged health shocks	0.23 (0.11)
HH size	0.06***(0.00)
% of labour members	0.17***(0.00)
% of small children	-0.02 (0.79)
Head education	-0.003 (0.48)
Head age	-0.01***(0.01)
Head age^2	0.0001***(0.00)
Head gender	0.06 (0.15)
% of male member	0.22***(0.00)
Agricultural land area log	-0.02*(0.10)
Constant	0.56*(0.07)
No. of HH	1,915
R^2	0.77

Regressions are pooled OLS with household fixed effect. Two-tailed p-values in (.) are based on robust standard errors. *** p<0.001; **p<0.05; *p<0.1

Appendix D

Table D1. Regression results for PIH and AST test for different labour allocations

		Log food consumption-PIH test	**Changes in asset balance - AST test**
		(1)	**(2)**
Permanent income	*Agriculture*	0.81***(0.00)	1.00 (0.81)
	Wage	0.65***(0.00)	9.56 (0.18)
	Business	0.46***(0.00)	760.76 (0.31)
	Mixed	0.79***(0.00)	-14.66*(0.11)
Income effect due to floods	*Agriculture*	1.41***(0.00)	89.01 (0.17)
	Wage	1.57***(0.00)	61.61 (0.35)
	Business	0.92**(0.02)	-201.79 (0.72)
	Mixed	2.24***(0.00)	64.76 (0.11)
Income effect due to animal diseases	*Agriculture*	0.86***(0.00)	-127.20 (0.21)
	Wage	1.20***(0.00)	17.47 (0.35)
	Business	0.86***(0.00)	312.83 (0.75)
	Mixed	0.46 (0.49)	-49.66 (0.16)
Income effect due to crop diseases	*Agriculture*	1.75***(0.00)	-6.17 (0.65)
	Wage	1.88**(0.01)	23.00 (0.60)
	Business	-0.29 (0.76)	-4160.92 (0.24)
	Mixed	0.46 (0.69)	11.75 (0.62)
Income effect due to health shocks	*Agriculture*	-0.10 (0.79)	23.28 (0.25)
	Wage	0.13 (0.73)	-2.61 (0.74)
	Business	-1.04**(0.02)	3,726.81 (0.25)
	Mixed	-0.78 (0.45)	3.512 (0.81)
Unexplained income	*Agriculture*	0.48***(0.00)	7.544 (0.26)
	Wage	0.46***(0.00)	4.461 (0.22)
	Business	0.41***(0.00)	-31.50 (0.46)
	Mixed	0.53***(0.00)	-1.24 (0.60)
Constant		-0.001 (0.10)	-105.16 (0.18)
No of HH		1,915	1,915
R^2		0.64	0.05

Regressions are pooled OLS with household fixed effects. Two-tailed p-values in (.) are based on robust standard errors. *** p<0.001; **p<0.05; *p<0.1

Note: AST test (column 2) using productive asset growth rates shows that only agricultural households significantly increase their investments in productive assets when income is reduced by crop diseases and floods.

Table D2. Regression results for CMH test for different labour allocations

		Food consumption growth-CMH test
		(1)
Floods	*Agriculture*	-0.06**(0.02)
	Wage	-0.05*(0.08)
	Business	-0.08**(0.02)
	Mixed	-0.17***(0.01)
Animal diseases	*Agriculture*	0.01 (0.43)
	Wage	0.01 (0.20)
	Business	0.003 (0.75)
	Mixed	0.004 (0.86)
Crop diseases	*Agriculture*	-0.14***(0.00)
	Wage	-0.16*(0.06)
	Business	0.01 (0.92)
	Mixed	0.03 (0.79)
Health shocks	*Agriculture*	-0.78 (0.12)
	Wage	-0.86 (0.19)
	Business	0.65 (0.30)
	Mixed	0.73 (0.66)
HH characteristics included but not reported		
Constant		-0.90 (0.26)
No. of HH		1,915
R^2		0.14

Regressions are pooled OLS with household fixed effects. Two-tailed p-values in (.) are based on robust standard errors. *** p<0.001; **p<0.05; *p<0.1