Catastrophic weather events and (subsidised) crop insurance markets. Evidence from Italy

Supplementary Material

A. Conceptual framework

We outline a simple conceptual framework explaining crop insurance uptake as a function of catastrophic weather events.

Baseline insurance demand. Since, as demonstrated in previous studies (e.g., Deryugina and Kirwan, 2018; Landry et al., 2021; Turner and Tsiboe, 2022), expectations of insurance decisions are formed in part by observing the past insurance functioning, we let $E[Q_{t+1}^{D}|\Omega_t]$ denote the expected insurance demand at time *t+1* given the current information set Ω_t as a function of yield and insurance premium at time *t*:

$$E[Q_{t+1}^{D}|\Omega_t] = f(Yield_t, Premium_t, \Omega_t) \quad \text{(A.1)}$$

The information set includes both private knowledge, such as risk aversion and the familiarity with the insurance schemes, and shared knowledge, such as neighbours' experiences (e.g., Foster and Rosenzweig, 1995; Conley and Udry, 2010; Santeramo, 2019).

Assuming that the information set is proxied by the insurance demand at time *t*, Q_t, the empirical specification of the demand equation in (A.1) is as follows:

$$Q_{t+1}^{D} = \alpha_1 + \beta Y_t + \gamma_1 P_t + \delta Q_t \quad \text{(A.2)}$$

where α_1 is a demand shifter and the parameters β and γ_1 are defined as:

$$\beta \equiv \frac{\partial \ ln\, Q^D}{\partial \ ln\, Y} \ and\ \gamma_1 \equiv \frac{\partial \ ln\, Q^D}{\partial \ ln\, P} \quad \text{(A.3)}$$

The parameter β captures the elasticity of insurance demand with respect to yield and is expected to be negative (i.e., the insurance demand is expected to grow as the yield falls). The parameter γ_1

governs the own-price demand insurance elasticity. A higher (lower) γ_1, which corresponds to less (more) widespread insurance, implies also a more (less) elastic insurance demand.

Baseline insurance supply. The expected insurance supply at time *t+1*, $E[Q^S_{t+1}]$, is a function of insurance premium at time *t*:

$$E[Q^S_{t+1}] = g(Premium_t) \tag{A.4}$$

Empirically, the supply equation (A.4) is defined as follows:

$$Q^S_{t+1} = \alpha_2 + \gamma_2 P_t \tag{A.5}$$

where α_2 is a supply shifter. Based on equation (A.5), one can calculate the own-price supply insurance elasticity which is given by:

$$\gamma_2 \equiv \frac{\partial \ln Q^S}{\partial \ln P} \tag{A.6}$$

where a higher (lower) γ_2 is indicative of a less (more) risky environment and implies a more (less) elastic insurance supply.

Baseline market clearing conditions. The market equilibrium is given by the equality between the baseline insurance demand and supply:

$$Q^D = Q^S$$

$$\alpha_1 + \beta Y_t + \gamma_1 P_t + \delta Q_t = \alpha_2 + \gamma_2 P_t$$

$$Q_t = \underbrace{\frac{1}{\delta}(\alpha_2 - \alpha_1)}_{\alpha'} + \underbrace{\frac{1}{\delta}(-\beta)}_{\beta'} Y_t + \underbrace{\frac{1}{\delta}(\gamma_2 - \gamma_1)}_{\gamma'} P_t$$

$$Q_t = \alpha' + \beta' Y_t + \gamma' P_t \tag{A.7}$$

The equilibrium in the insurance market is a function of equilibrium shifters, α', yield, Y_t, and insurance premium, P_t, such that equations (A.2), (A.5), and (A.7) hold.

We consider an insurance market comprising multiple provinces in a country, indexed by $i \in I \equiv \{1, \dots, I\}$. Each province can produce and insure multiple crops, indexed by $k \in K \equiv \{1, \dots, K\}$. From equation (A.7), we derive the baseline estimating equation:

$$S_{ikt} = \alpha_k + \beta Y_{ikt} + \gamma P_{ikt} + \varepsilon_{ikt} \qquad \text{(A.8)}$$

where S_{ikt} is the share of insured value over the value of production of crop k in province i at time t and ε_{ikt} is the error term. The crop-specific constants, α_k, proxy the level of insured value of the produced value of crop k. The terms Y_{ikt} and P_{ikt} denote respectively the yield and insurance premium of crop k in province i at time t, and β and γ are the related parameters to be estimated.

Insurance demand under catastrophic weather events. As emphasised in previous studies (e.g., Santeramo et al., 2022; Bucheli et al., 2023), the expectations of insurance decisions may be affected by the occurrence of catastrophic weather events. Introducing this determinant in the demand equation in (A.1), we obtain the following:

$$E\left[Q_{t+1}^{D^*} | \Omega_t\right] = f(Yield_t, Premium_t, Catastrophic\ weather\ events_t, \Omega_t) \qquad \text{(A.9)}$$

$$Q_{t+1}^{D^*} = \alpha_1 + \beta Y_t + \gamma_1 P_t + \delta Q_t^* + \psi_1 W \qquad \text{(A.10)}$$

where the terms Ω_t, Y_t, P_t, Q_t^* and the parameters α_1, β, γ_1 are defined as in equations (A.1), (A.2), and (A.3).

In equations (A.9), and (A.10), the insurance demand, $Q_{t+1}^{D^*}$, is also a function of catastrophic weather events, W, and the parameter ψ_1 is the semi-elasticity of insurance demand with respect to catastrophic weather events:

$$\psi_1 \equiv \frac{\partial\ ln\ Q^{D^*}}{\partial W} \qquad \text{(A.11)}$$

The parameter ψ_1 is expected to be positive: the more frequent the occurrence of catastrophic weather events, the higher the insurance demand. When ψ_1 is higher, crops are more homogeneous within a province, which makes the insurance demand more sensitive to the occurrence of catastrophic weather events.

Market clearing conditions under catastrophic weather events. Given the insurance demand and supply as defined in equations (A.9), (A.10), (A.4) and (A.5), the insurance market equilibrium under catastrophic weather events is as follows:

$$Q^{D^*} = Q^{S^*}$$

$$\alpha_1 + \beta Y_t + \gamma_1 P_t + \delta Q_t^* + \psi_1 W = \alpha_2 + \gamma_2 P_t + \psi_2 W$$

$$Q_t^* = \underbrace{\frac{1}{\delta}(\alpha_2 - \alpha_1)}_{\alpha^*} + \underbrace{\frac{1}{\delta}(-\beta)}_{\beta^*} Y_t + \underbrace{\frac{1}{\delta}(\gamma_2 - \gamma_1)}_{\gamma^*} P_t + \underbrace{\frac{1}{\delta}(\psi_2 - \psi_1)}_{\psi^*} \mathrm{W}$$

$$Q_t^* = \alpha^* + \beta^* Y_t + \gamma^* P_t + \psi^* W \tag{A.12}$$

The resulting estimating equation is:

$$S_{ikt}^* = \alpha_k + \beta Y_{ikt} + \gamma P_{ikt} + \psi \boldsymbol{W}_{it} + \upsilon_{ikt} \tag{A.13}$$

where α_k are crop-specific constants, β, γ, ψ are parameters to be estimated, υ_{ikt} is the error term. In equation (A.13), the share of insured value over the value of production of crop k in province i at time t, S_{ikt}^*, is a function of yield and insurance premium of crop k in province i at time t, Y_{ikt} and P_{ikt}, and of catastrophic weather events, $\boldsymbol{W}_{it}$. The matrix $\boldsymbol{W}_{it}$ contains three dummy variables proxying respectively the occurrence of flood, drought, and frost in a province i at time t.

Latent insurance demand. The difference between the baseline insurance demand, defined in equations (A.1) and (A.2), and the insurance demand under catastrophic weather events, defined in equations (A.9) and (A.10), expresses the latent demand in the insurance market due to the occurrence of catastrophic weather events:

$$\overleftrightarrow{Q^D} = Q^D - Q^{D^*} = \psi W \tag{A.14}$$

References

Bucheli, J., Conrad, N., Wimmer, S., Dalhaus, T., & Finger, R. (2023). Weather insurance in European crop and horticulture production. Climate Risk Management, 100525.

Conley, T. G., & Udry, C. R. (2010). Learning about a new technology: Pineapple in Ghana. American economic review, 100(1), 35-69.

Deryugina, T., & Kirwan, B. (2018). Does the Samaritan's dilemma matter? Evidence from US agriculture. Economic Inquiry, 56(2), 983-1006.

Foster, A. D., & Rosenzweig, M. R. (1995). Learning by doing and learning from others: Human capital and technical change in agriculture. Journal of political Economy, 103(6), 1176-1209.

Landry, C. E., Turner, D., & Petrolia, D. (2021). Flood insurance market penetration and expectations of disaster assistance. Environmental and Resource Economics, 79(2), 357-386.

Santeramo, F. G. (2019). I learn, you learn, we gain experience in crop insurance markets. Applied Economic Perspectives and Policy, 41(2), 284-304.

Santeramo, F. G., Russo, I., & Lamonaca, E. (2022). Italian subsidised crop insurance: what the role of policy changes. Q Open, 1-20.

Turner, D., & Tsiboe, F. (2022). The crop insurance demand response to the Wildfire and Hurricane Indemnity Program Plus. Applied Economic Perspectives and Policy, 44(3), 1273-1292.

B. Estimates

Table B.1. Differential relationship between catastrophic weather events and insurance uptake.

	(1)	(2)	(3)
Variables	25th pct.	50th pct.	75th pct.
Premium	0.0851***	0.1258***	0.1974***
	(0.0005)	(0.0003)	(0.0010)
Yield	0.0851***	0.1258***	0.1974***
	(0.0005)	(0.0003)	(0.0010)
Flood	0.0462	0.1229***	0.0331
	(0.0367)	(0.0237)	(0.0959)
Drought	-0.0057***	0.0054***	0.0757***
	(0.0008)	(0.0007)	(0.0047)
Frost	0.0565***	0.0950***	0.1538***
	(0.0014)	(0.0030)	(0.0053)
Constant	0.0660***	0.2818***	1.1796***
	(0.0040)	(0.0078)	(0.0170)
Fixed effects	Crop	Crop	Crop
Observations	283,169	283,169	283,169

Notes: Quantile regression estimates. The dependent variable is the share of insured value of production. All specifications include the natural logarithm of yield and premium, dummy variables proxying the occurrence of flood, drought, and frost events, crop-specific fixed effects, and a constant. Standard errors, clustered at province-crop level, are in parentheses. *** Significant at the 1 percent level. ** Significant at the 5 percent level. * Significant at the 10 percent level.