Supporting Drought Policies in Europe
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Economic impacts of drought in Spain

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Goals

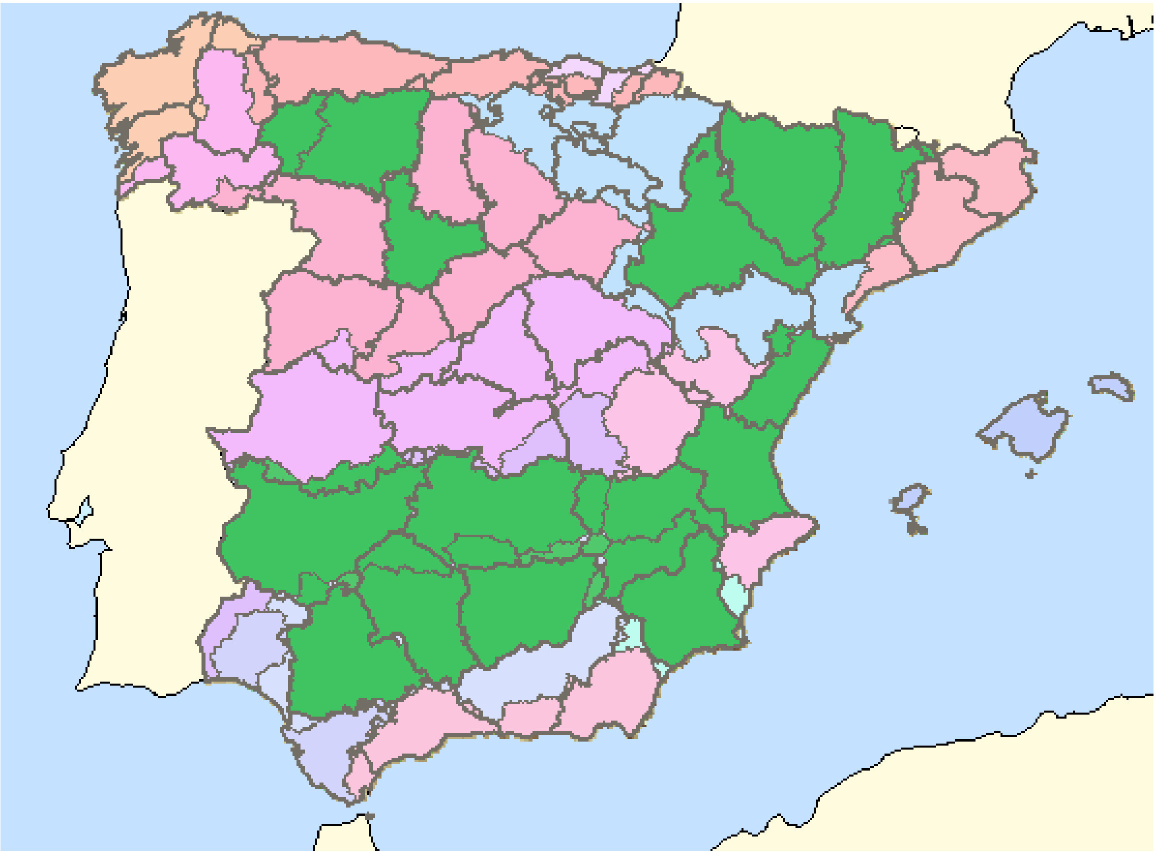
- Develop attribution models of droughts' socio-economic impacts in the farm sector (only):
  - Macro-level (Gross Value Added and employment)
  - Micro-level (Production value of irrigated land)

- Develop risk management methodology to obtain ex –ante economic drought effects

Study areas

14 Provinces

- **Sevilla, Córdoba & Jaén** (**Guadalquivir**),
- **Lleida, Huesca & Zaragoza** (**Ebro)**,
- **Murcia** (**Segura**),
- **Albacete, Castellón & Valencia** (**Júcar**),
- **Badajoz & Ciudad Real** (**Guadiana**),
- **León & Valladolid** (**Duero**).



Representing more than 60% of Spanish irrigated acreage

2 million ha; €10 billion of output

Method 1: attribution models

- Variables of interest:

MACRO

- – Gross-Value Added= Prod-input costs (Labour and Capital imbursements) (All farm sectors) (€)
- – Farm employment = number of employees

MICRO

- – Irrig Prod Value= surface * yield * prices (€)

Method 1: attribution models

- Regression models:

[Eq. 1] $GVA_{it} = a_i + b_i T_t + c_i R_{it} + \varepsilon_{it}$ (Gross-Value Added)

$Empl_{it} = a_i + b_i T_t + c_i R_{it} + \varepsilon_{it}$

[Eq. 2] $IPV_{it} = a_i + b_i T_t + c_i R_{it} + d_i Ip_{it} + u_{it}$ (Farm employment)

[Ed.3] (Irrig Prod Value)

T: Trend (Year)

R : Water Availal filled s age)

Methods 2: Risk models

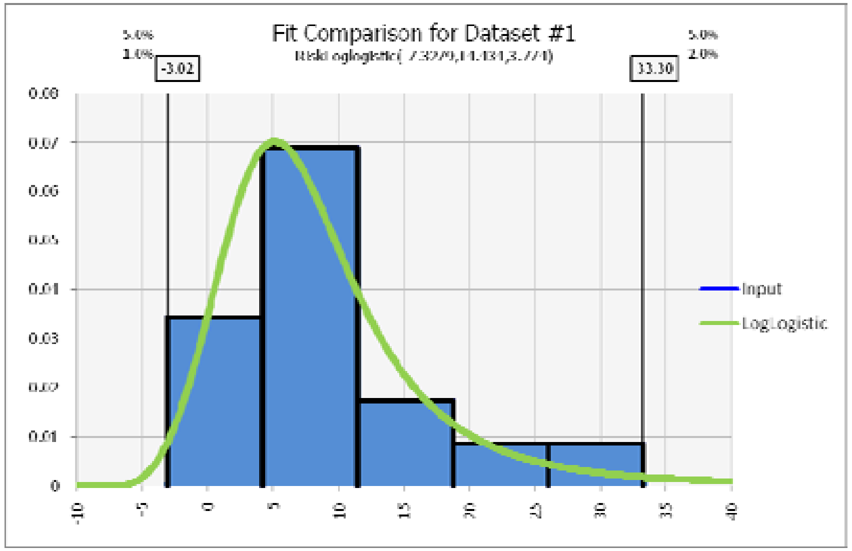
Economic Risk Management Instrument (*1+t* season)

$$I\tilde{P}V^h_{i,1+t} = \hat{a}_i + \hat{b}_i T_{t+1} + \hat{c}_i \tilde{R}^h_{i,1+t} + \hat{d}_i Ip_t + \tilde{u}_i$$

- Attribution model

$$\tilde{R}^h_{i,1+t} = R^h_{i,t} + \Delta\tilde{R}^h_{i,t+1}$$

- $\tilde{R}^h_{i,1+t}$ Available storage
- Stochastic run-off
- Fitted distribution



- Monte-Carlo Simulation
- Monthly revisions

Data

- Geographical Unit: Province (14 provinces)
- Time data: 1995-2007 (14 years)

- Provincial Agric statistics (94 crops: yield, area and prices)
- Gross-Value Added (Macro-economic output of the 'entire' farm sector).
- Employment (Social Security records of farm workers)

Results 1

- Regression models
  - Macro:
    - Gross Value Added (€)
    - Employment (no. Jobs, hired and own-farm)
  - Micro:
    - Production value in irrigated land (€)

Results: Macro-economic variables

Adjusted R2 (two nested models)

$$GVA_{it} = a_i + b_i T_t + \varepsilon_{it}$$

$$Empl_{it} = a_i + b_i T_t + \varepsilon_{it}$$

$$GVA_{it} = a_i + b_i T_t + c_i R_{it} + \varepsilon_{it}$$

$$Empl_{it} = a_i + b_i T_t + c_i R_{it} + \varepsilon_{it}$$

GVA: Gross value added (includes livestock, rainfed, irrig)

Empl; Employment (farm)

T: Trend (Year)

R : Water Availability (% of filled storage)

Results: Macro-economic variables

$$GVA_{it}(Empl) = a_i + b_i T_t + \varepsilon_{it} \quad GVA_{it}(Empl) = a_i + b_i T_t + c_i R_{it} + \varepsilon_{it}$$

Adjusted R2 (two models)

	Gross Value Added	
Province	Trend	Trend+Wat
Albacete	0.50	0.50
Badajoz	0.37	0.54
Castellón	0.36	0.86
C. Real	0.68	0.64
Córdoba	0.70	0.70
Huesca	0.47	0.41
Jaén	0.00	0.28
León	0.21	0.14
Lleida	0.39	0.32
Murcia	0.58	0.54
Sevilla	0.70	0.75
Valencia	0.58	0.52
Valladolid	0.00	-0.07
Zaragoza	0.02	0.01

Results: Macro-economic variables

$$GVA_{it}(Empl) = a_i + b_i T_t + \varepsilon_{it} \quad GVA_{it}(Empl) = a_i + b_i T_t + c_i R_{it} + \varepsilon_{it}$$

Adjusted R2 (two models)

	Hired Labour		Farm (own) labour	
Province	Trend	Trend+Wat	Trend	Trend+Wat
Albacete	0.43	0.34	0.93	0.92
Badajoz	0.70	0.80	0.97	0.97
Castellón	0.92	0.95	0.99	0.99
C. Real	0.86	0.86	0.74	0.73
Córdoba	0.81	0.96	0.80	0.77
Huesca	-0.11	-0.29	0.66	0.66
Jaén	-0.07	0.40	0.94	0.93
León	-0.14	-0.32	0.99	0.99
Lleida	0.48	0.40	0.99	0.99
Murcia	0.33	0.22	0.95	0.95
Sevilla	0.69	0.91	0.97	0.98
Valencia	0.76	0.72	0.51	0.75
Valladolid	-0.09	-0.22	0.98	0.99
Zaragoza	-0.14	0.10	0.99	0.99

Results: Macro-economic variables

$$GVA_{it}(Empl) = a_i + b_i T_t + \varepsilon_{it} \quad GVA_{it}(Empl) = a_i + b_i T_t + c_i R_{it} + \varepsilon_{it}$$

Adjusted R2 (two models)

	Gross Value Added		Hired Labour		Farm (own) labour	
Province	Trend	Trend+Wat	Trend	Trend+Wat	Trend	Trend+Wat
Albacete	0.50	0.50	0.43	0.34	0.93	0.92
Badajoz	0.37	0.54	0.70	0.80	0.97	0.97
Castellón	0.36	0.86	0.92	0.95	0.99	0.99
C. Real	0.68	0.64	0.86	0.86	0.74	0.73
Córdoba	0.70	0.70	0.81	0.96	0.80	0.77
Huesca	0.47	0.41	-0.11	-0.29	0.66	0.66
Jaén	0.00	0.28	-0.07	0.40	0.94	0.93
León	0.21	0.14	-0.14	-0.32	0.99	0.99
Lleida	0.39	0.32	0.48	0.40	0.99	0.99
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Valencia	0.58	0.52	0.76	0.72	0.51	0.75
Valladolid	0.00	-0.07	-0.09	-0.22	0.98	0.99
Zaragoza	0.02	0.01	-0.14	0.10	0.99	0.99

Results: Macro-economic variables

$$GVA_{it}(Empl) = a_i + b_i T_t + \varepsilon_{it} \quad GVA_{it}(Empl) = a_i + b_i T_t + c_i R_{it} + \varepsilon_{it}$$

Adjusted R2 (two models)

	Gross Value Added		Hired Labour		Farm (own) labour	
Province	Trend	Trend+ Wat	Trend	Trend+ Wat	Trend	Trend+ Wat
Albacete	0.50	0.50	0.43	0.34	0.93	0.92
Badajoz	0.37	0.54	0.70	0.80	0.97	0.97
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León	0.21	0.14	-0.14	-0.32	0.99	0.99
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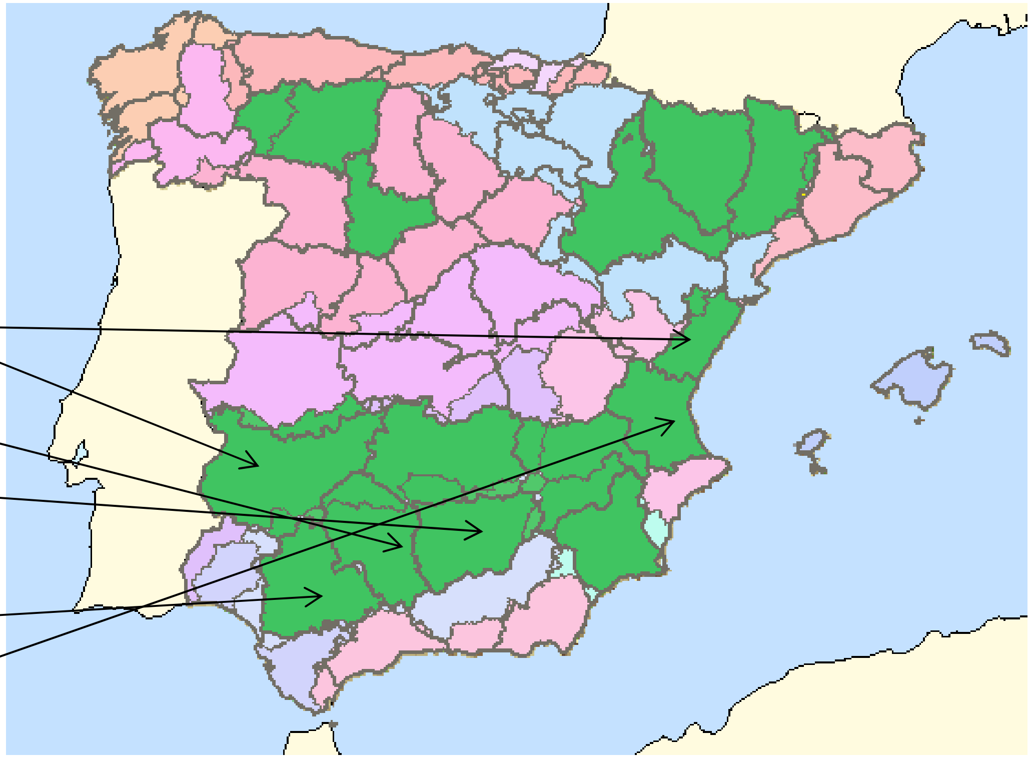
Valladolid	0.00	-0.07	-0.09	-0.22	0.98	0.99
Zaragoza	0.02	0.01	-0.14	0.10	0.99	0.99



Results: Micro-economic variable

Three nested models

$$IPV_{it} = a_i + b_i T_t + u_{it}$$

$$IPV_{it} = a_i + b_i T_t + c_i R_{it} + u_{it}$$

$$IPV_{it} = a_i + b_i T_t + c_i R_{it} + d_i Ip_{it} + u_{it}$$

IPV: Irrigation producion value (€)

T: Trend (Year)

R : Water Availability (% of filled storage over total storage, April st)

Ip: Price index

Results: Micro-economic variables

Adjusted R2 (three models)

$$IPV_{it} = a_i + b_i T_t + u_{it} \qquad IPV_{it} = a_i + b_i T_t + c_i R_{it} + u_{it} \qquad IPV_{it} = a_i + b_i T_t + c_i R_{it} + d_i Ip_{it} + u$$

	Irrig Production Value (IPV)
Province	Trend
Albacete	0.85
Badajoz	0.88
Castellón	0.03
C. Real	0.82
Córdoba	0.69
Huesca	0.28
Jaén	0.21
León	0.01
Lleida	0.34
Murcia	0.77
Sevilla	0.76
Valencia	0.13
Valladolid	0.81
Zaragoza	0.69 (+*)

Results: Micro-economic variables

Adjusted R2 (three models)

$$IPV_{it} = a_i + b_i T_t + u_{it} \qquad IPV_{it} = a_i + b_i T_t + c_i R_{it} + u_{it} \qquad IPV_{it} = a_i + b_i T_t + c_i R_{it} + d_i Ip_{it} + u$$

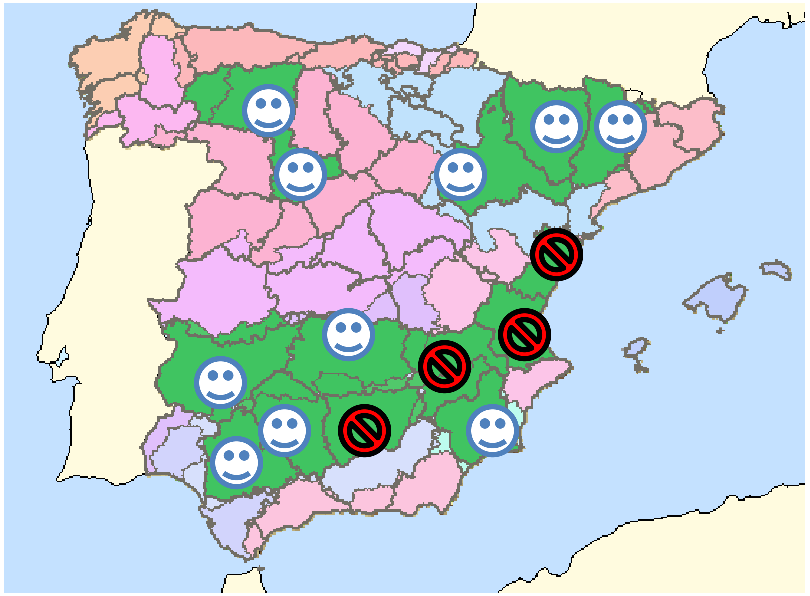
Province	Irrig Production Value (IPV)		
	Trend	Trend+Water	Trend+Water+I Prices
Albacete	0.85	0.85	0.83
Badajoz	0.88	0.87	0.90
Castellón	0.03	-0.08	0.01
C. Real	0.82	0.80	0.80
Córdoba	0.69	0.80	0.78
Huesca	0.28	0.48	0.84
Jaén	0.21	0.19	0.10
León	0.01	0.16	0.38
Lleida	0.34	0.38	0.48
Murcia	0.77	0.75	0.82
Sevilla	0.76	0.75	0.82
Valencia	0.13	0.13	0.02
Valladolid	0.81	0.78	0.79
Zaragoza	0.69 (+*)	0.80	0.88

Results: Micro-economic variables

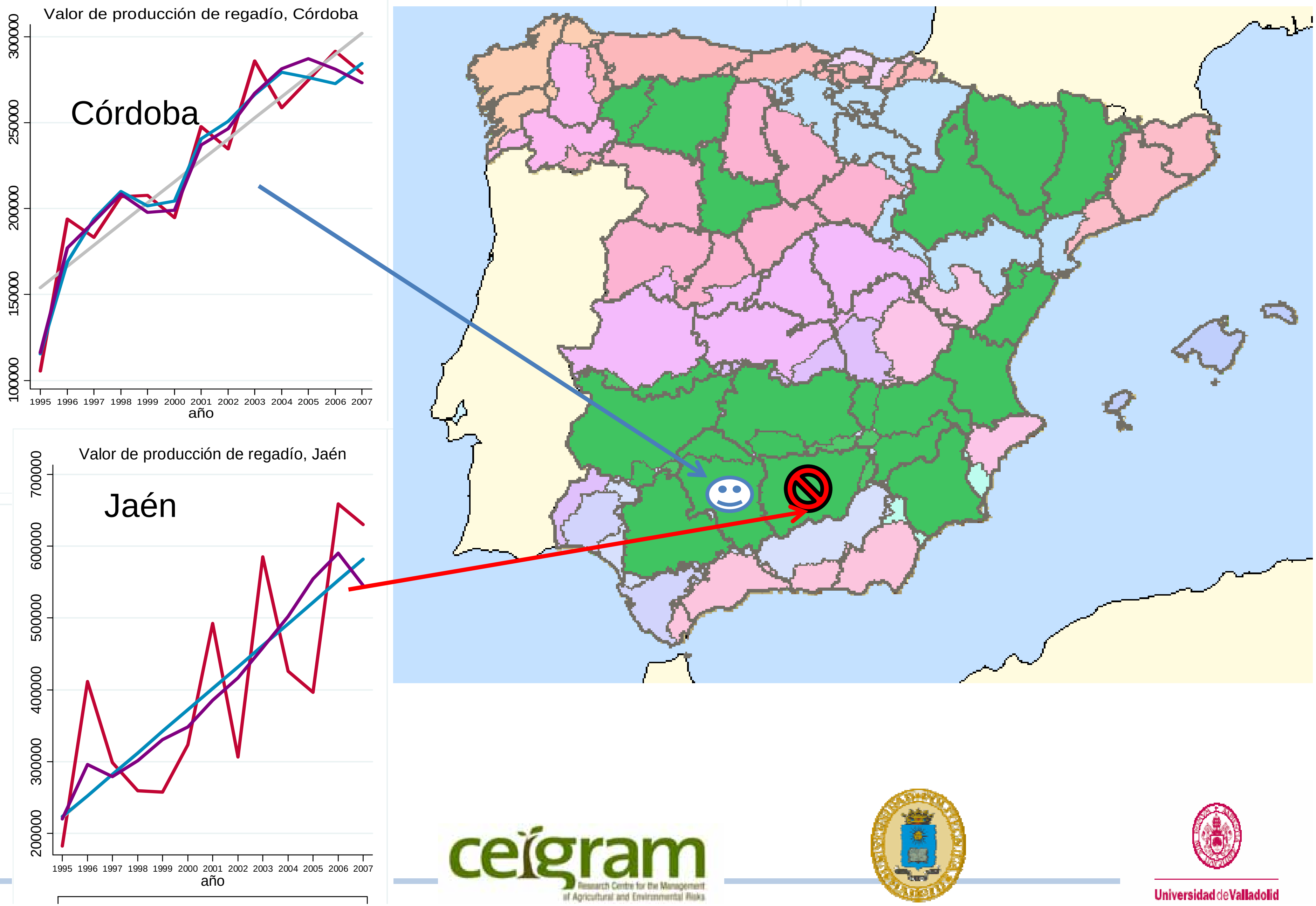
$$IPV_{it} = a_i + b_i T_t + u_{it} \qquad IPV_{it} = a_i + b_i T_t + c_i R_{it} + u_{it} \qquad IPV_{it} = a_i + b_i T_t + c_i R_{it} + d_i Ip_{it} + u_{it}$$

Adjusted R2 (three models)

	Valor de Producción		
Province	Trend	Trend+Water	Trend+Water+I Prices
Albacete	0.85 (+**)	0.85	0.83
Badajoz	0.88 (+**)	0.87	0.90
Castellón	0.03 (-)	-0.08	0.01
C. Real	0.82 (+**)	0.80	0.80
Córdoba	0.69 (+**)	0.80	0.78
Huesca	0.28 (+)	0.48	0.84
Jaén	0.21 (+)	0.19	0.10
León	0.01 (-)	0.16	0.38
Lleida	0.34 (+*)	0.38	0.48
Murcia	0.77 (+**)	0.75	0.82
Sevilla	0.76 (+**)	0.75	0.82
Valencia	0.13 (-)	0.13	0.02
Valladolid	0.81 (+**)	0.78	0.79
Zaragoza	0.69 (+*)	0.80	0.88



Results: Micro-economic variables



Results 2

- Simulation of supply risks obtain ex –ante economic drought effects:
  - –Micro:
    - Production value in irrigated land (€, prob)

Results: Economic Risk models

- Based on the fitted models for Irrig Produc Value (IPV)

$$I\tilde{P}V^h_{i,1+t} = \hat{a}_i + \hat{b}_i T_{t+1} + \hat{c}_i \tilde{R}^h_{i,1+t} + \hat{d}_i Ip_t + \tilde{u}_i$$

$$\tilde{R}^h_{i,1+t} = \bar{R}^h_{i,t} + \Delta\tilde{R}^h_{i,t+1}$$

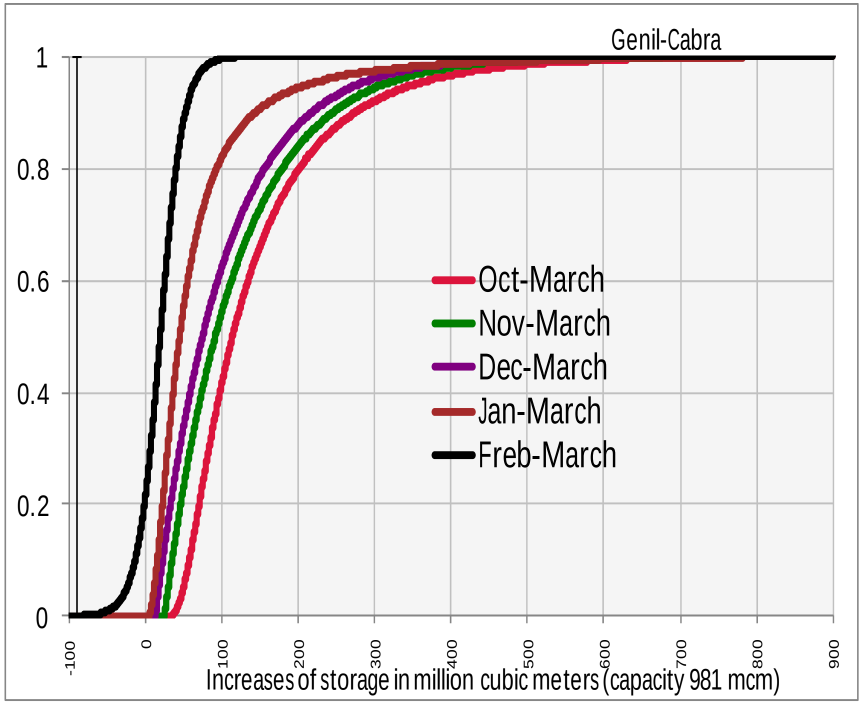
Pdfs of $\Delta\tilde{R}^h_{i,t+1}$ **for storage systems**

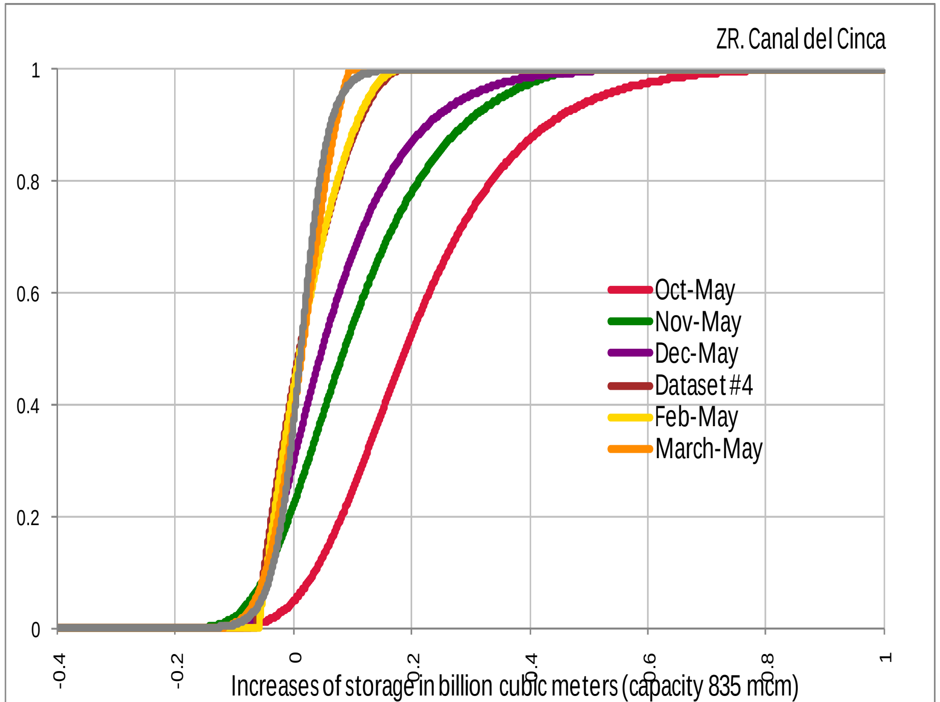
Results: Economic Risk models

- Based on

$$I\widetilde{P}V^{h}_{i,1+t} = \hat{a}_i + \hat{b}_i T_{t+1} + \hat{c}_i \widetilde{R}^{h}_{i,1+t} + \hat{d}_i Ip_t + \tilde{u}_i \longrightarrow \widetilde{R}^{h}_{i,1+t} = \overline{R}^{h}_{i,t} + \Delta\widetilde{R}^{h}_{i,t+1}$$

Pdfs of $\Delta\widetilde{R}^{h}_{i,t+1}$ for two important reservoirs





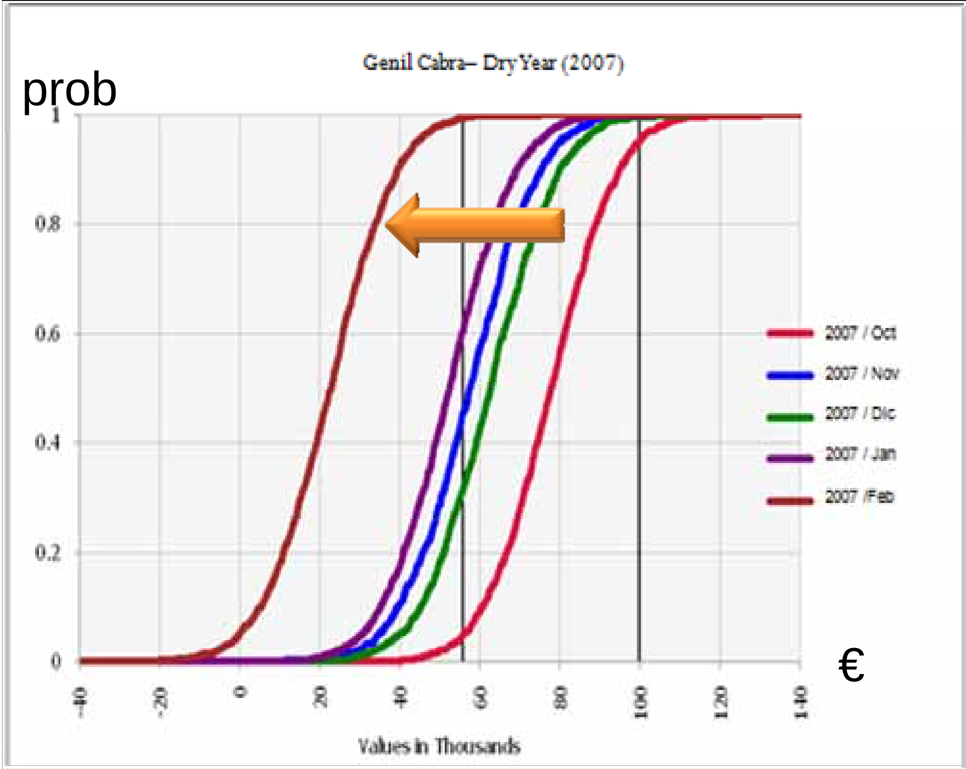
Results: Economic Risk models

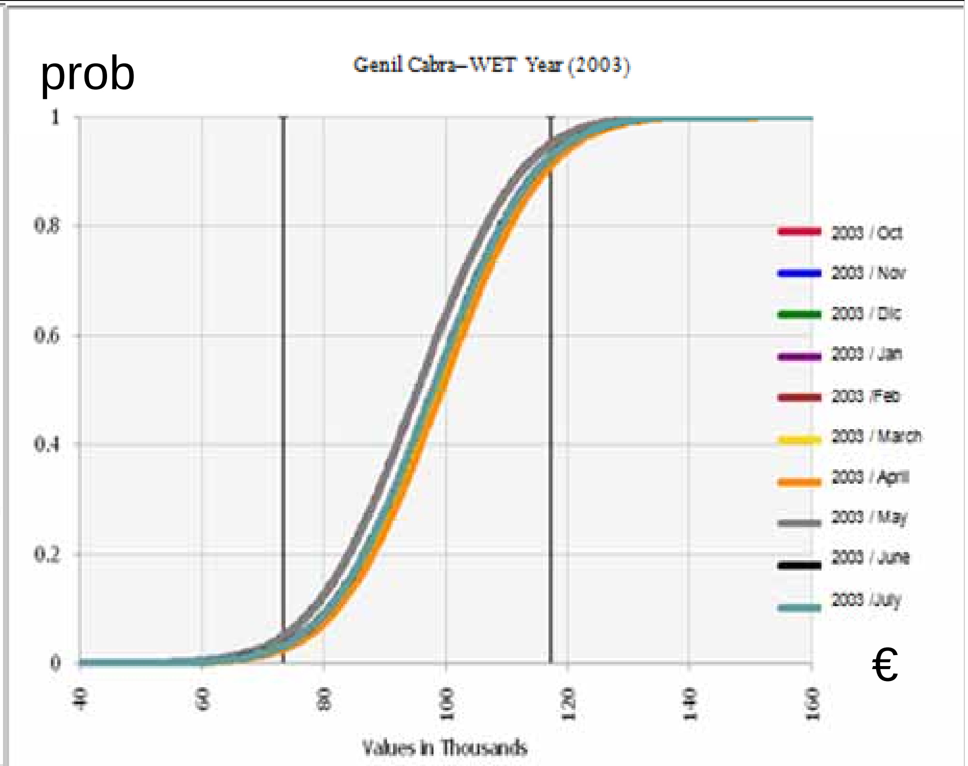
$$I\tilde{P}V^{h}_{i,1+t} = \hat{a}_i + \hat{b}_i T_{t+1} + \hat{c}_i \tilde{R}^{h}_{i,1+t} + \hat{d}_i Ip_t + \tilde{u}_i \longrightarrow \tilde{R}^{h}_{i,1+t} = \overline{R}^{h}_{i,t} + \Delta\tilde{R}^{h}_{i,t+1}$$

Pdfs of $I\tilde{P}V^{h}_{i,1+t}$ for Genil-Cabra (Córdoba, Andalusia)

Drought-evolving year (2007)

Wet year (2003)





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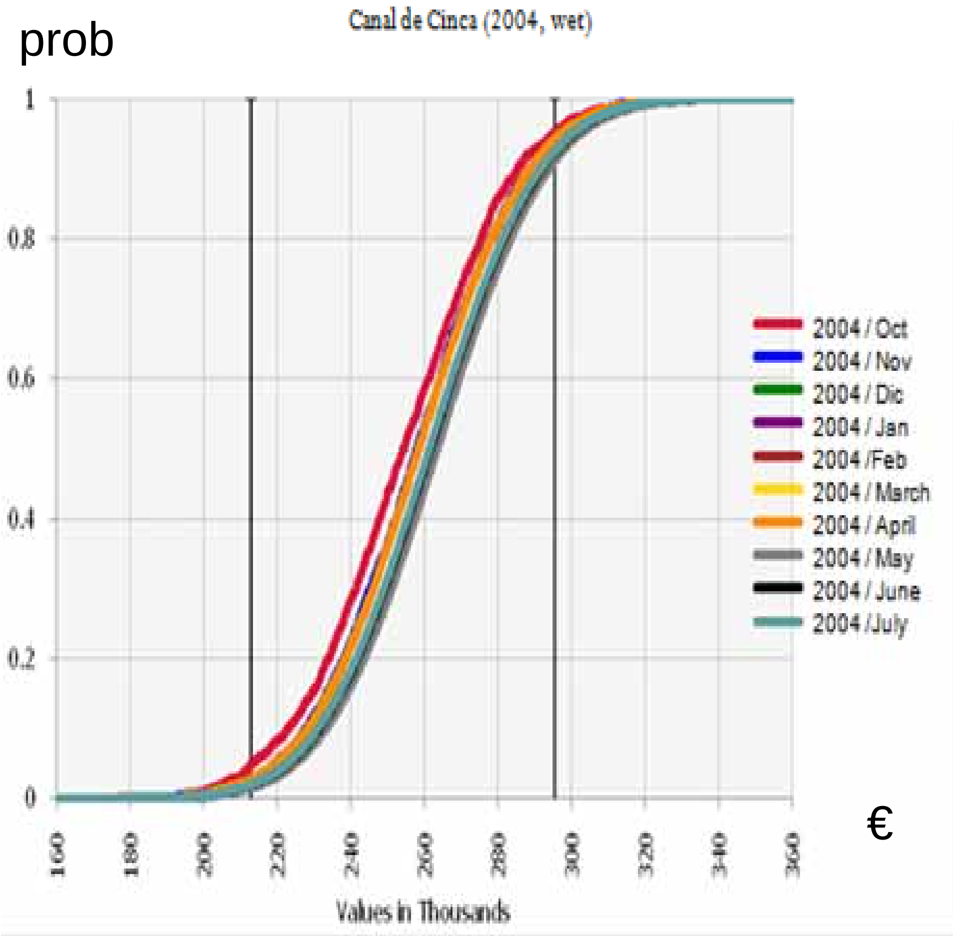
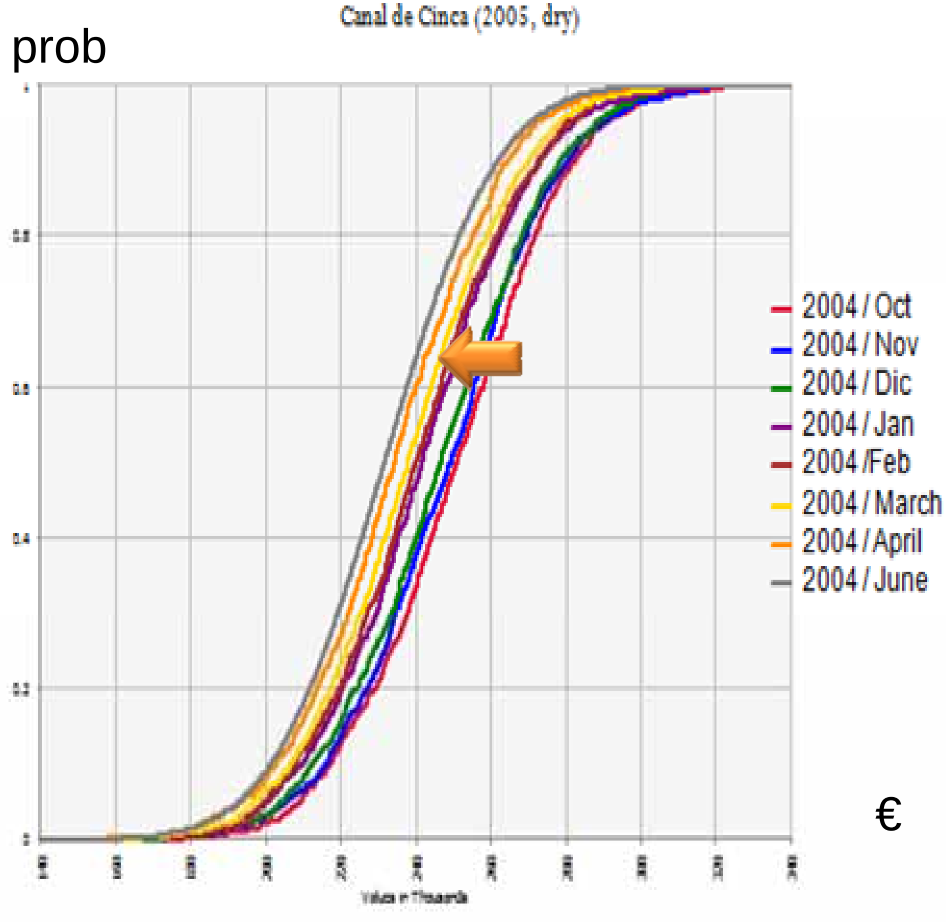
Results: Economic Risk models

$$I\widetilde{P}V^h_{i,1+t} = \hat{a}_i + \hat{b}_i T_{t+1} + \hat{c}_i \widetilde{R}^h_{i,1+t} + \hat{d}_i Ip_t + \widetilde{u}_i \longrightarrow \widetilde{R}^h_{i,1+t} = \overline{R}^h_{i,t} + \Delta\widetilde{R}^h_{i,t+1}$$

Pdfs of $I\widetilde{P}V^h_{i,1+t}$ for Cinca (Huesca, Ebro Basin)





Conclusions

- Economic impacts of drought can be measured at micro- and macro-levels:
  - macro- effects are less important than micro- even within the agric sector

- Economic impacts of drought must be carefully analysed, using robust attribution models:
  - Isolating the effects of water supply variability from other non water-related effects (trends & farm prices)

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Conclusions

- Each geographical unit (province) has idiosincratic components:
  - Use of gwt
  - Type of products and markets
  - Surface storage system
  - Cropping patterns
  - Labour requirements

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Conclusions

- Drought preparedness requires that ECONOMIC models be used in conjunction with HYDROL models.

- If impact attribution models can be fitted and supply systems can be characterised in stochastic terms, then:
  - Economic risks of drought can be evaluted
  - Real-time ex –ante evaluations inform preparatory and anticipatory drought strategies.

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Thank you

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