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Agricultural productivity and water supply variability in Spain: a model to manage hydrological risks

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Droughts have impacts on farmers

Distribution of types of indemnified hazards (in % number).

Source: Agroseguro (2006)

	2004	2005	2006
Hail	54.47	26.40	46.06
Fire	1.48	0.81	1.63
Frost	19.78	24.04	8.68
Drought	**0.28**	**32.39**	**22.83**
Strong wind	9.70	10.53	4.25
Excessive rain	1.36	0.57	1.01
Flood	3.48	0.26	1.25
Lack of curdled (fruits)	3.71	2.64	6.02
Excessive (persisent) rain	4.45	0.46	4.63
Other	1.40	1.40	3.64
Number of indemnified hazards	82,249	113,006	89,037

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Drought worries farmers

Risk perception rankings among farmers in Spain
(1-5 scale: 1=not important; 5=very important).

Type of production	Hail	Price volati	Frost	Drought	Controllable not	Other risks	Ddieases	Strong winds	Torrental rain	Flloods	Excessive rain	Fire
Fruit crops	4.8	4.2	4.5	3.1		3.2	3.2	2.7	2.9	2.3	2.7	2.0
Vineyard	4.7	4.5	4.8	3.7		3.3	3.8	2.8	2.7	2.5	2.6	1.9
Cereals	4.6	4.5	4	4.4		4.2	3.9	3..3	3.5	3.6	3.4	3.9
Vegetables	4.8	4	3.8	3.5		3.5	3.2	3.2	3.3	3.1	3.1	2.6
Citrus	4.9	4.7	3.8	3		3.4	3	2.6	2.6	2.4	2.7	2.2

Source: ENESA (2007); IKEFEL (2006)

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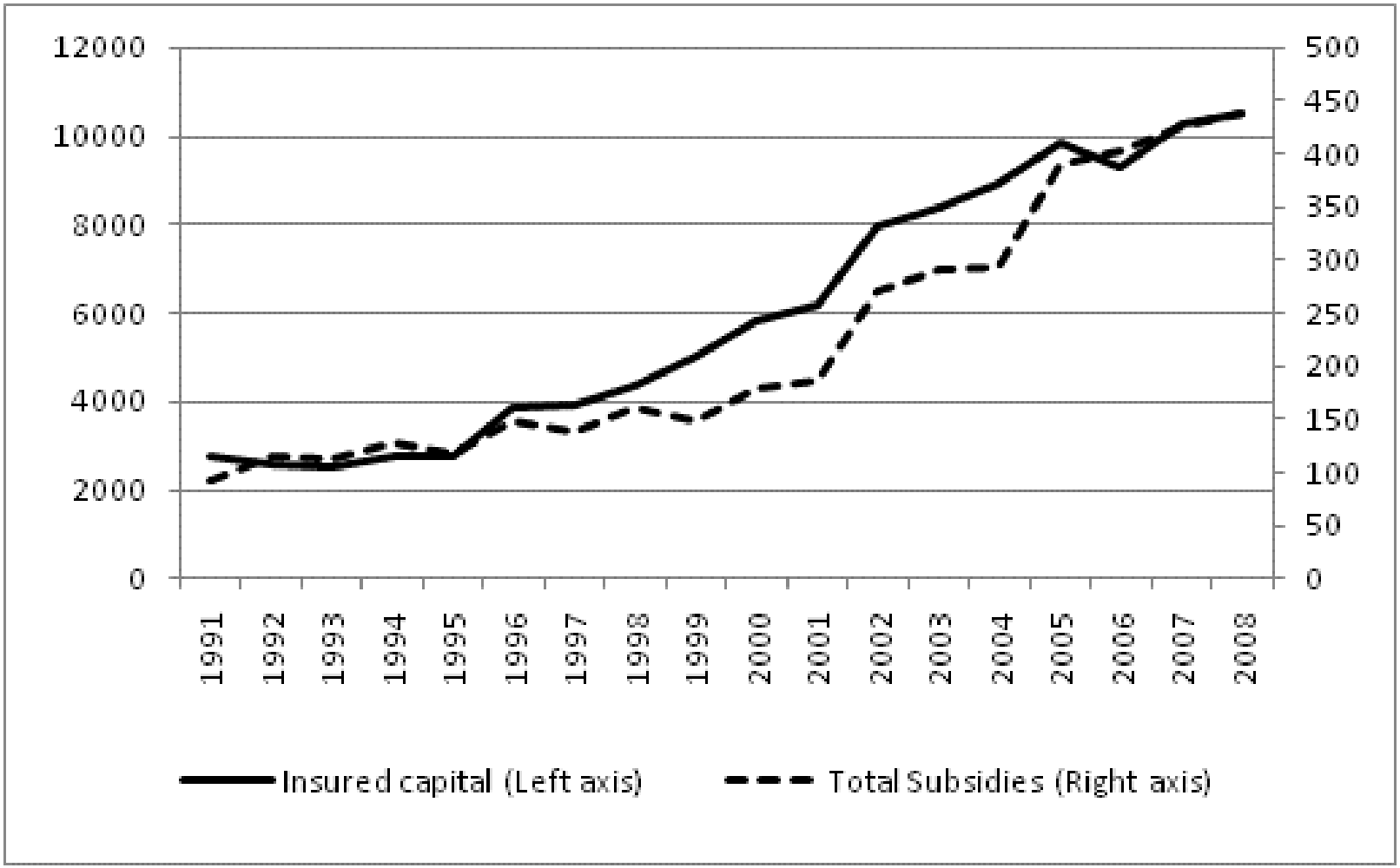
Insurance has become a common practice



Source: ENESA (2009)

Goals

- Model farm sector (only) economics' based on water used for irrigation:
  - Micro-level (Production value of irrigated land)

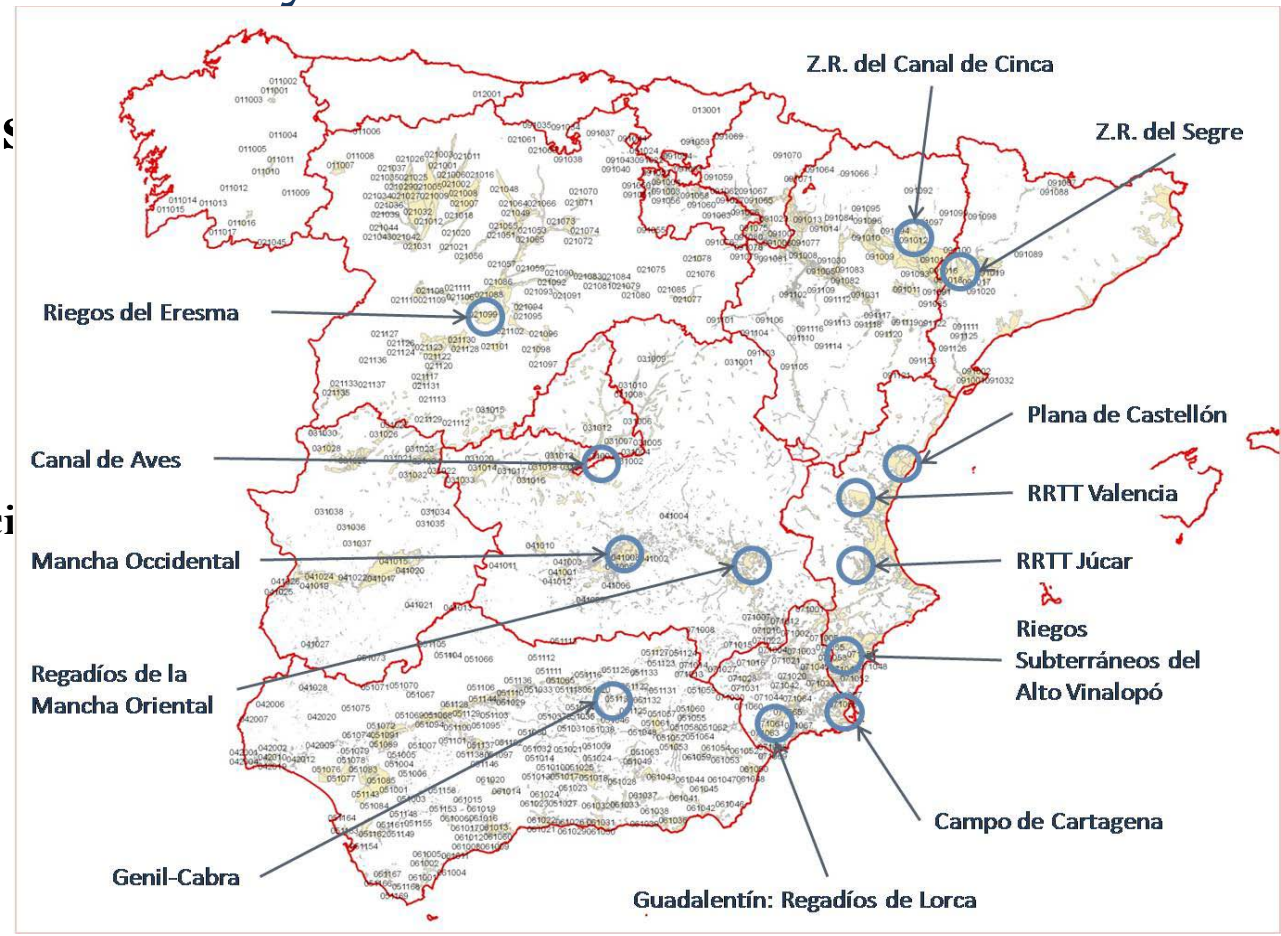
- Develop risk management monitor ex –ante economic drought effects

- Carry-out preliminay analysis for designing'insurance' policy for irrigators

Study areas

13 Irrigated areas

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



Method 1: attribution models

- Variables of interest:

MICRO

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

Easy to evaluate, but not necessarily what farmers focus on (profit)

Data

- Irrigation districts(14 provinces)
- Time data: 1995-2007 (14 years)

- Provincial Agric statistics (94 crops: yield, area and prices)

Results: Micro-economic variable

Irrigation production value

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

IPV: Irrigation producion value (€)

T: Trend (Year)

WA : Water Availability (3 alternative evaluations)

Ip: Price index

Results: Micro-economic variables (Irrig Areas)

Adjusted R2 (three models)

$$IPV_{it} = a_i + b_i T_t + c_i WA_{it} + d_i Ip_{it} + u_{it} \qquad u_{it} = \varepsilon_{it} + \rho\varepsilon_{it-1}$$

	Crop demand (Déficit de agua)[1]			Pennman-Monteih[2]			Extended demand		
Irrig District	**Ad R^2**	**N**	WA (Sign)	**Ad R^2**	**N**	WA (Sign)	**Ad R^2**	**N**	WA (Sign)
Genil-Cabra	0.99	5	**	0,76	10		0,82	10	
Vinalopó	0,50	6		0,34	10		0,36	10	
RRTT Júcar	0,81	6		0,59	10		0,70	10	
RRTT Valencia	0,25	6		0,26	10		0,67	10	
Plana Castellón	0,35	6		0,44	10		0,79	10	
M. Oriental	0,69	6		0,77	10		0,76	10	
Campo Cartagena	0,49	6		0,73	10		0,56	10	
R. de Lorca	0,72	6		0,22	10		0,26	10	
Canal de Cinca		3		0,64	10	*	0,52	10	*
ZR del Segre	0,84	6		0,86	10	*	0,38	10	
M. Occidental	0,75	6		0,86	10		0,83	10	
Eresma	0,24	6		0,68	10		0,45	10	
Canal de Aves	0,88	6		0,77	10	*	0,83	10	**

Results: Micro-economic variables

Adjusted R2 (three models)

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

	COEFICIENT		COEFFICIENTS			COEFFICIENTS			
province	Ad-R²	year	Ad-R²	year	WA	Ad-R²	year	WA	Ip
Albacete	0.58	+ (**)	0.56	+ (**)	+	0.63	+ (**)	-	-
Badajoz	0.67	+ (**)	0.70	+ (**)	+	0.81	+	+	+ (*)
Castellón	0.20	- (*)	0.12	-	-	0.22	-	-	+
Ciudad Real	0.80	+ (**)	0.78	+ (**)	-	0.80	+ (**)	-	-
Córdoba	0.81	+ (**)	0.91	+ (**)	+ (**)	0.92	+ (**)	+ (**)	+
Huesca	0.38	+ (*)	0.59	+ (**)	+ (*)	0.74	+ (**)	+ (**)	- (*)
Jaén	0.55	+ (**)	0.51	+ (**)	-	0.49	+ (**)	+	+
León	0.02	-	0.29	-	+ (*)	0.31	-	+ (*)	+
Lleida	0.19	+	0.30	+ (*)	+	0.53	+	+	+ (*)
Murcia	0.52	+ (**)	0.48	+ (**)	+	0.81	+ (**)	+	+ (**)
Sevilla	0.44	+ (**)	0.59	+ (**)	+ (*)	0.74	+ (**)	+ (**)	+ (*)
Valencia	0.23	- (*)	0.20	- (*)	-	0.15	-	-	+
Valladolid	0.87	+ (**)	0.86	+ (**)	+	0.86	+ (**)	-	+
Zaragoza	0.75	+ (**)	0.78	+ (**)	+	0.82	+ (**)	+	-

Results 2

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

Results: Economic Risk models

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

$$\widetilde{IPV}_{i,1+t}^{h} = \hat{a}_i + \hat{b}_i T_{t+1} + \hat{c}_i B_{i,1+t}^{h} + \hat{d}_i Ip_t + \tilde{u}_i$$

$$\tilde{B}_{i,1+t}^{h} = \tilde{R}_{i,1+t}^{h} - \tilde{D}_{i,t+1} - \bar{S}_i$$

Pdfs of $\tilde{R}_{i,t+1}^{h}$ for storage systems

Pdfs for $\tilde{D}_{i,t+1}$ crops' water demand

$\tilde{B}_{i,1+t}^{h}$ ex – ante water balance, calculated h months before the end of the season

Results: Economic Risk models

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

$$\widetilde{IPV}_{i,1+t}^{h} = \hat{a}_i + \hat{b}_i T_{t+1} + \hat{c}_i B_{i,1+t}^{h} + \hat{d}_i Ip_t + \tilde{u}_i$$

$$\tilde{B}_{i,1+t}^{h} = \tilde{R}_{i,1+t}^{h} - \tilde{D}_{i,t+1} - \bar{S}_i$$

Environmental restriction

Pdfs of $\tilde{R}_{i,t+1}^{h}$ for storage systems

Pdfs for $\tilde{D}_{i,t+1}$ crops' water demand

$\tilde{B}_{i,1+t}^{h}$ ex – ante water balance, calculated h months before the end of the season

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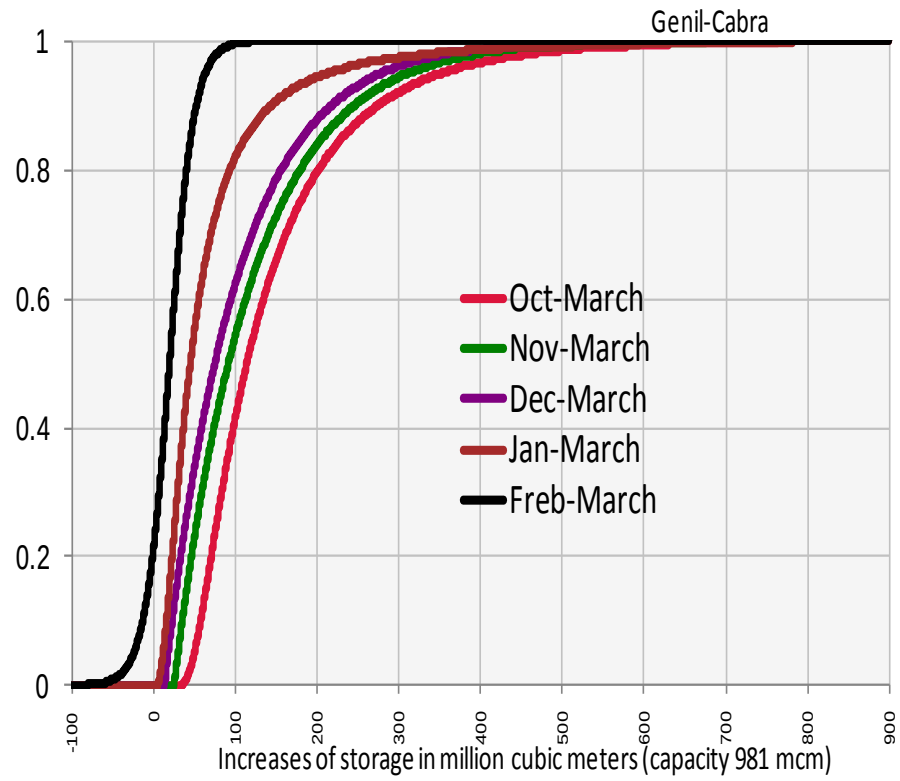
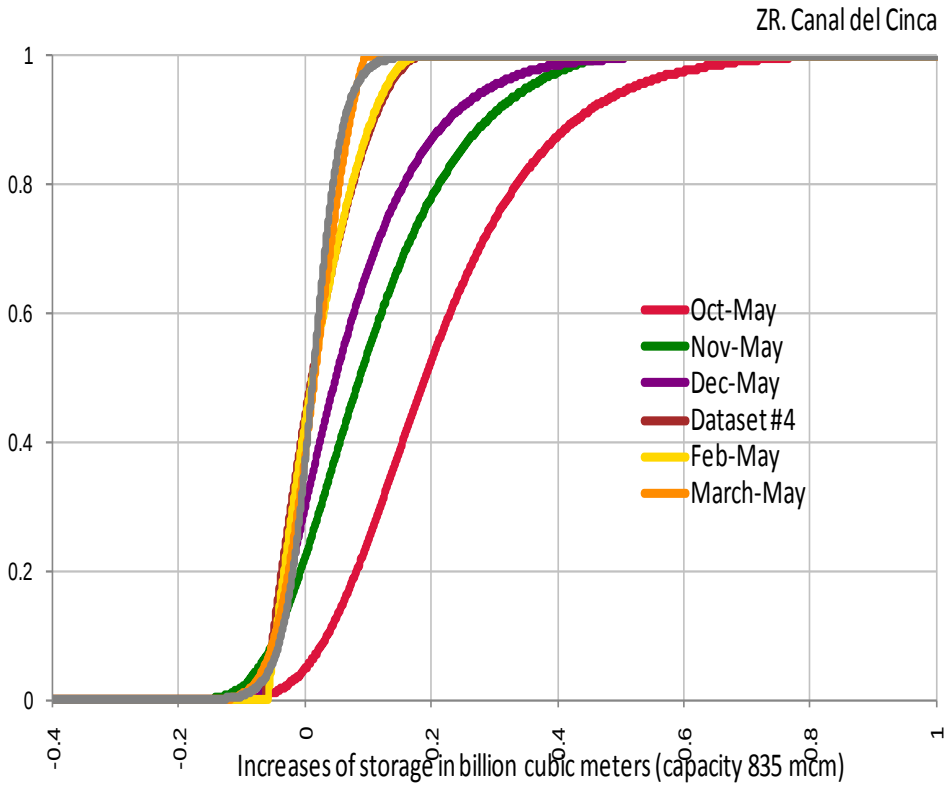
Results: Supply variability Risk models

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

Increases of storage till March



Increases of storage till May



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Results: Supply variability Risk models

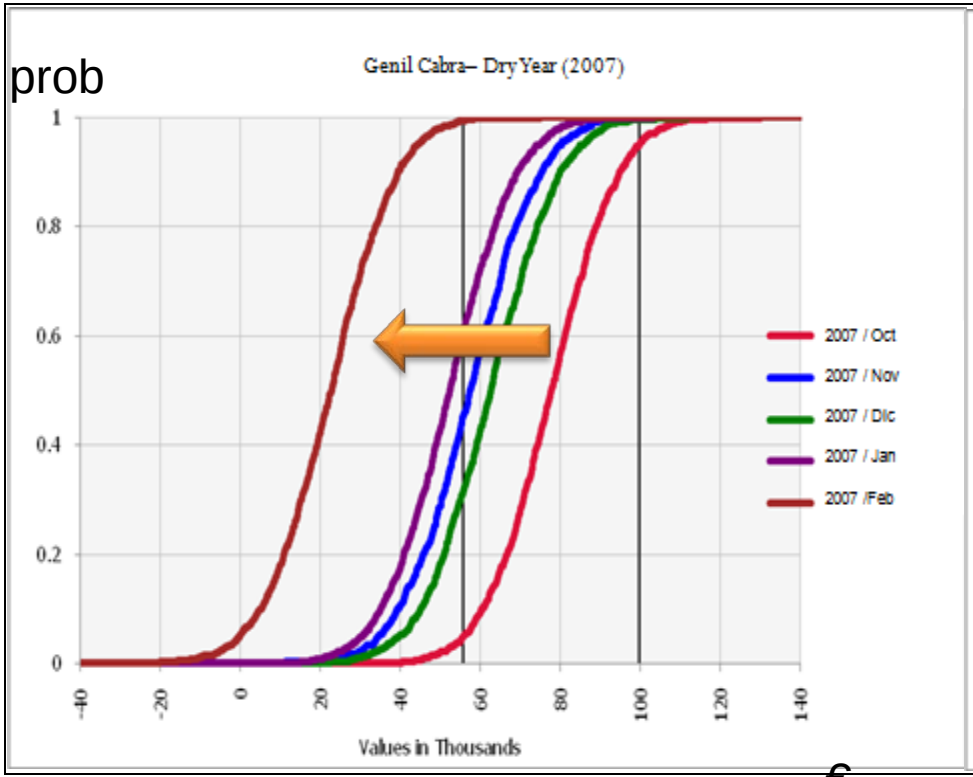
Probability of $\tilde{B}^{h}_{i,1+t} = \tilde{R}^{h}_{i,1+t} - \tilde{D}_{i,t+1} - \bar{S}_i < 0$

Irrig Seas	Genil-Cabra (Guadalquivir, Andalusia)							RR TT Valencia (Jucar, Valencia)						
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	Oct	Nov	Dec	Jan	Feb	Mar	Apr
2001	0.75	0.76	0.76	0.69	0.28	0	0	0.91	0.81	0.59	0.69	0.54	0.15	0
2002	0	0	0	0	0	0	0	0.58	0.55	0.39	0.53	0.54	0.54	0.3
2003	0	0	0	0	0	0	0	0.07	0.06	0.06	0.02	0	0	0
2004	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2005	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2006	0.37	0.42	0.42	0.46	0.58	0.62	0.18	0	0	0	0	0	0	0
2007	0.67	0.73	0.75	0.85	0.98	1	0.98	0.43	0.53	0.34	0.57	0.54	0.54	0.3
	Plana de Castellón (Júcar, Valencia)							Canal del Cinca (Ebro, Aragón						
2001	0.99	0.59	0.5	0.51	0.3	0.3	0.3	0.47	0.59	0.25	0	0	0	0
2002	0.73	0.69	0.65	0.67	0.64	0.64	0.42	0.12	0.11	0.15	0.28	0.29	0.25	0.15
2003	0.24	0.29	0.37	0.39	0.3	0.15	0	0.57	0.54	0.33	0.03	0	0.01	0
2004	0.34	0.34	0.37	0.35	0.3	0.15	0.15	0.15	0.02	0	0	0	0	0
2005	0.36	0.37	0.42	0.38	0.3	0.3	0.3	0.33	0.42	0.5	0.66	0.7	0.77	0.85
2006	0.81	0.84	0.72	0.69	0.64	0.64	0.73	0.8	0.65	0.69	0.8	0.79	0.76	0.42
2007	0.91	0.94	0.93	0.96	0.96	0.92	0.73	0.36	0.14	0	0	0	0	0

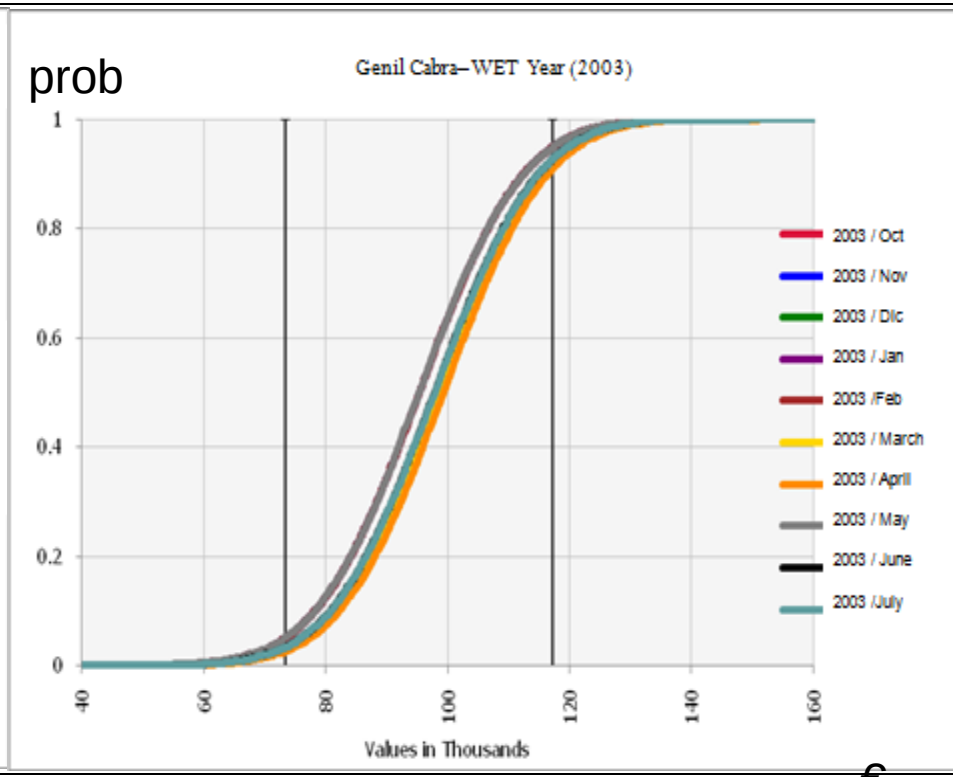
Results: Economic Risk models

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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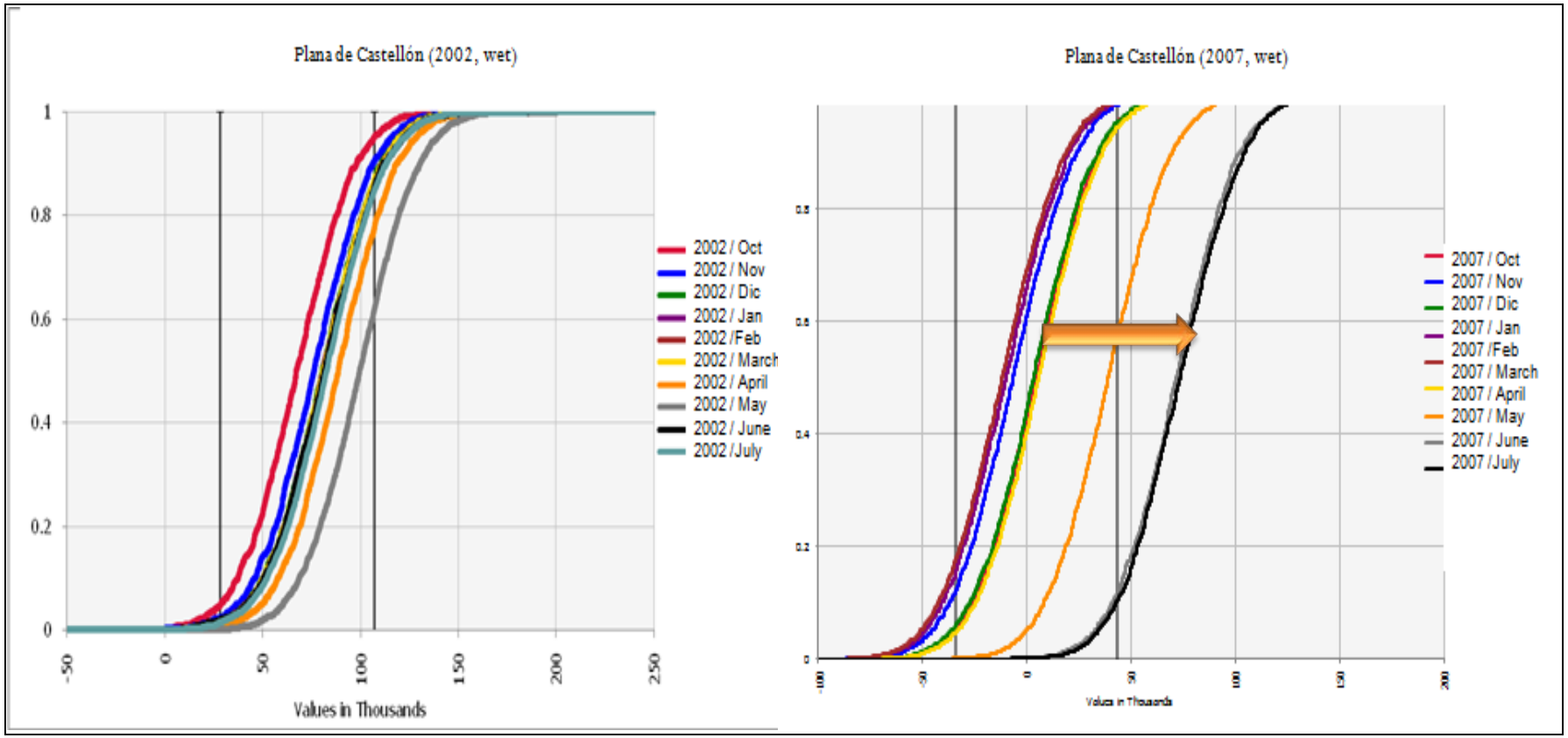
Results: Economic Risk models

Pdfs of $\widetilde{IPV}_{i,1+t}^{h}$ for Plana de Castellón Valencia

Wet year (2007)

Very 2et year (2003)



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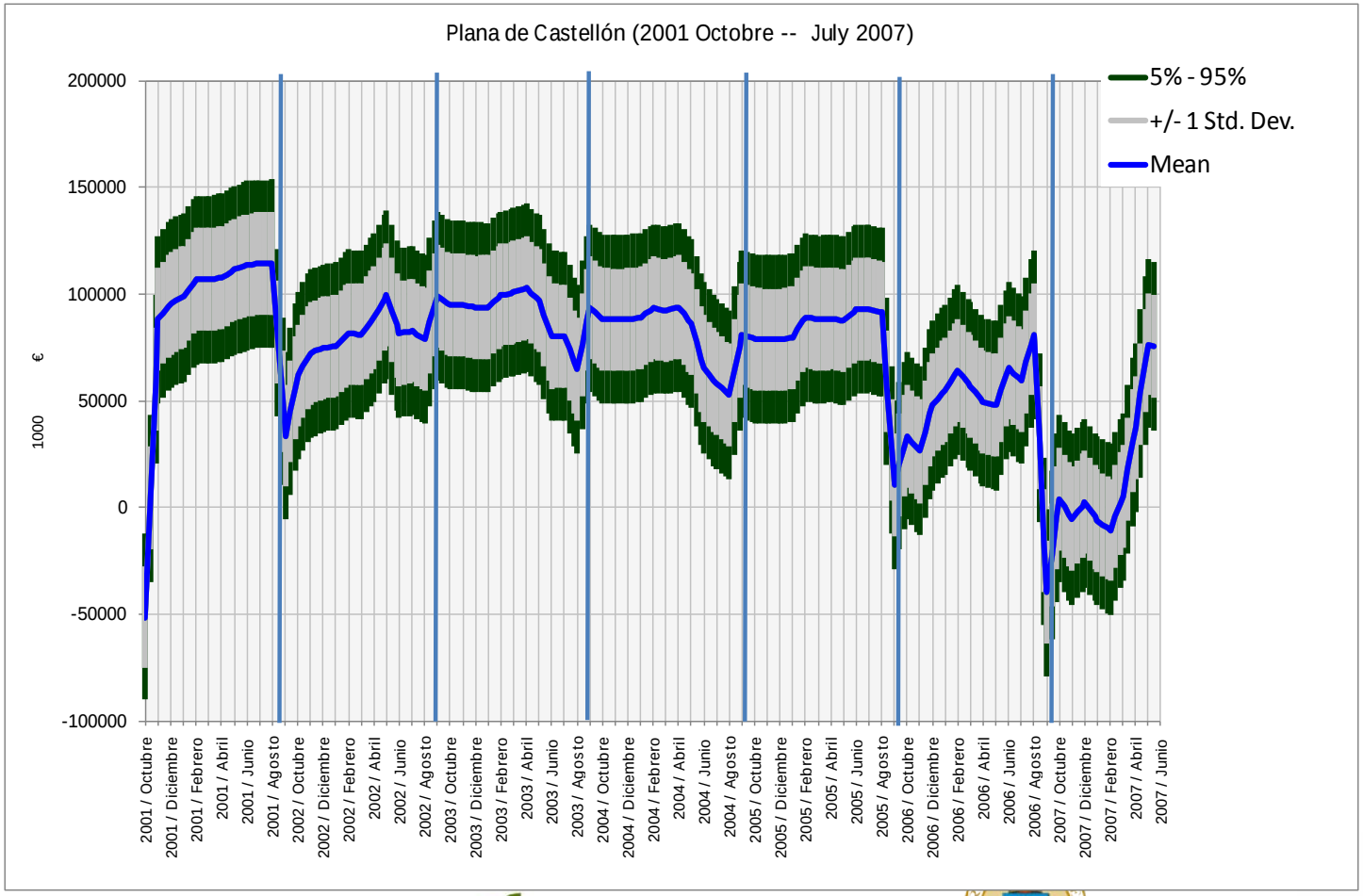
Results: Economic Risk models

Pdfs of $\widetilde{IPV}^{h}_{i,1+t}$ for Plana de Castellón Valencia
Monthly follow-up (2001-2007)



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Conclusions

- Economic impacts of drought can be measured at micro- and macro-levels (including employment or Value Added)

- 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)

Conclusions

- 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.
  - Insurance policies can be designed and offered commercially to water users (under some specific conditions)

Thank you

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