Innovative EPIs for drought and scarcity management: the case of the Tagus and Segura interconnected river basins

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> Second FP7 EPI-Water Conference. Anticipating the Performance of Economic Policy Instruments (EPIs) in Water Management

Alcalá de Henares, February 6th - 7th, 2013

Evaluating Economic Policy Instruments for Sustainable Water Management in Europe

The research leading to these results has received funding from the *European Community's* Seventh Framework Programme (FP7/2007-2013) / *grant agreement* n° 265213 – project EPI-WATER "Evaluating Economic Policy Instrument for Sustainable Water Management in Europe".

Outline of the presentation

1. **The case study area at a glance.**

2. **The problem: structural water scarcity and droughts.**

3. **What are EPIs useful for?**

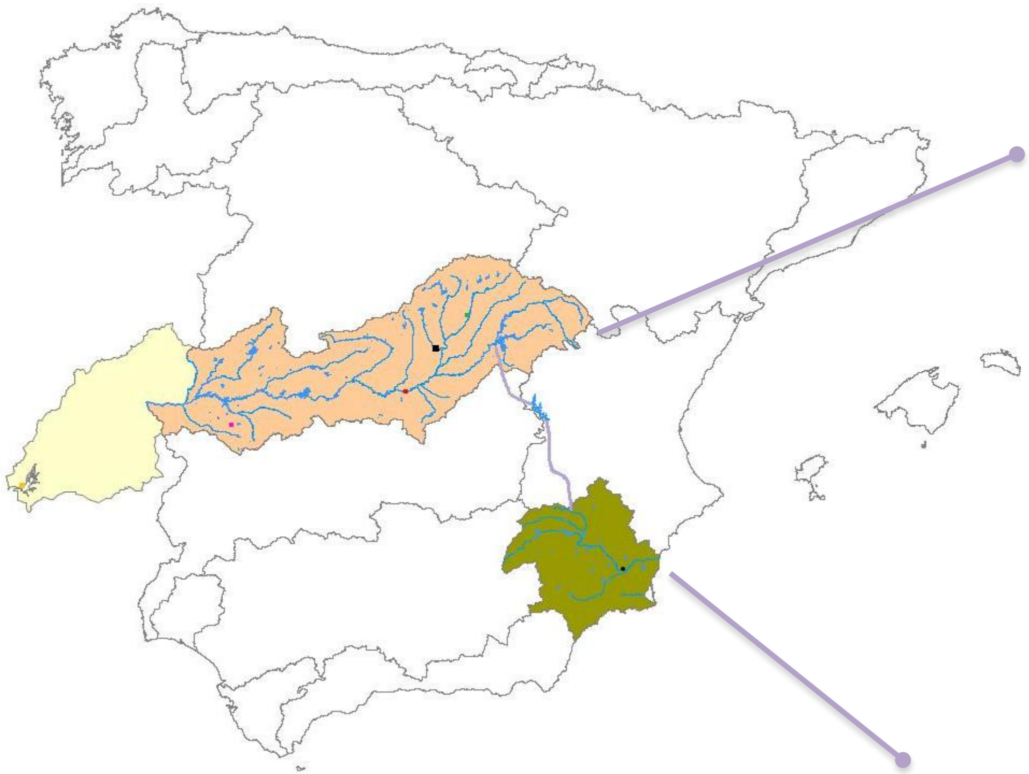
4. **What Innovative EPIs and what for:**
   A. Drought insurance
   B. Water trading
   C. Smart pricing

5. **Methods**

   A. A Risk Assessment Model (RAM) to estimate the Fair Risk Premium
   B. A Revealed Preferences Model (RPM) to assess farmers' productivity and WTP
   C. A prospective model at a municipality level to estimate the urban productivity and WTP
   D. An Agent Based Model (ABM) to assess the potential of agricultural water markets

6. **Conclusions**

I. The study area at a glance: the Tagus and Segura interconnected river basins



Tagus River Basin (TRB) (Tagus RBA, 2011):

> Area: 55 750 km^2 in Spain and 28 033 km^2 in Portugal

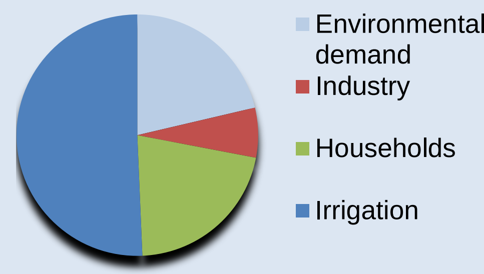
> Population: 7.2 million inhabitants (6 million inhabitants in Greater Madrid)

> Storage capacity: 11 000 trillion m^3

> Average consumptive water use: 2.6 trillion m^3

> Average renewable resources: 12 trillion m^3

> Water Exploitation Index: 0.22



Segura River Basin (SRB) (Segura RBA, 2010):

> Area: 18 870 km^2

> Population: 2 million inhabitants

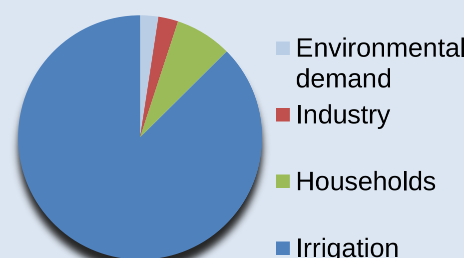
> Storage capacity: 1 141 trillion m^3

> Average consumptive water use: 1.9 trillion m^3 (85% from agriculture)

> Average renewable resources [1940-2005]: 823 hm^3/year

> Average renewable resources [1990-2010]: 650-700 hm^3/year

> Water Exploitation Index: 2.3 – 2.71

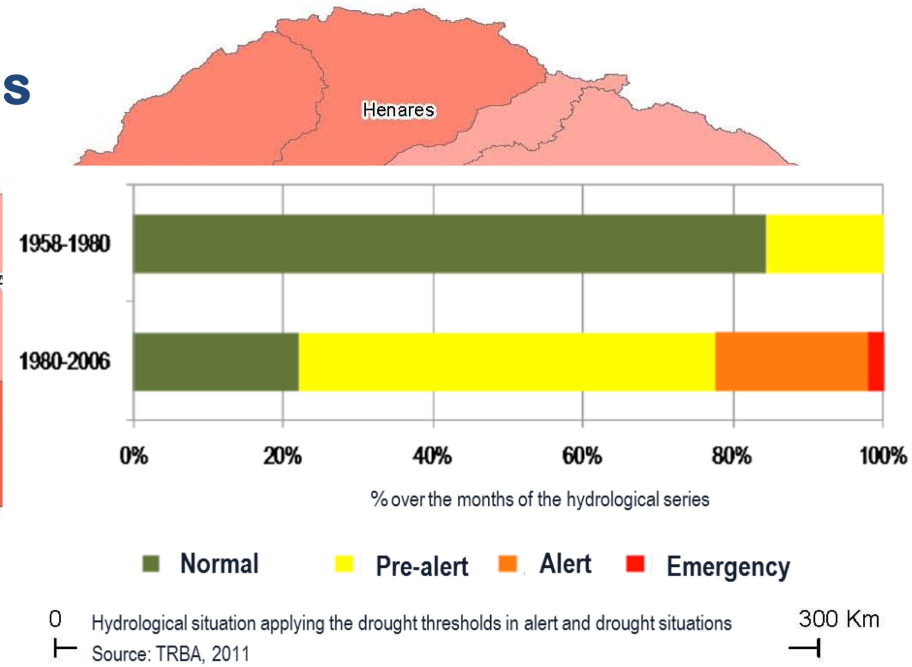


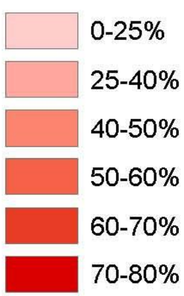
II. The problem (1): Drought - normality is becoming exceptional!!!

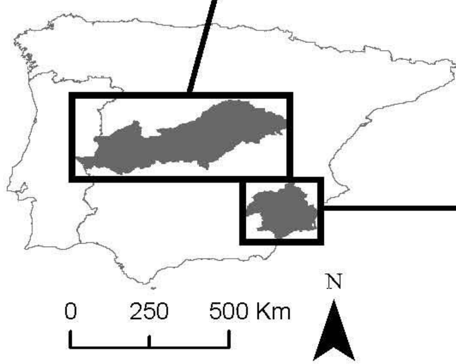
Drought Probability

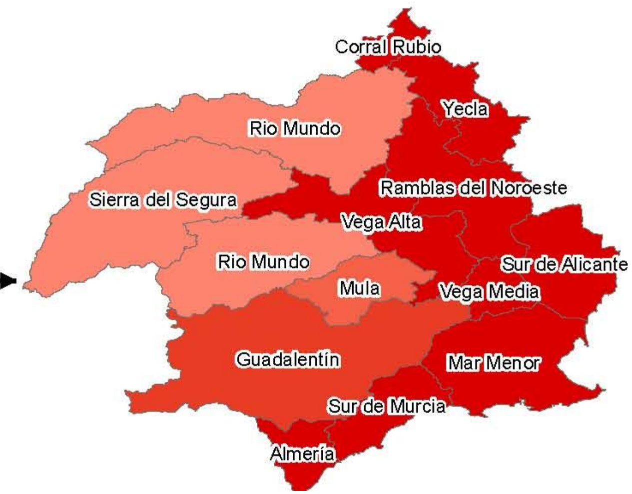
(pre-alert+alert+emergency)

Tagus









Segura

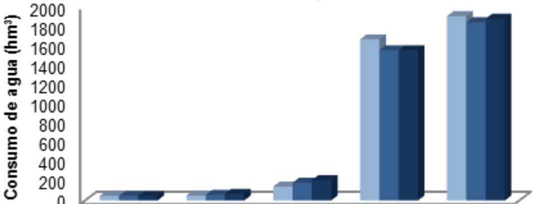
Source: Own ellaboration based on IMDEA Drought Risk Assessment Model

II. The Problem (2): Increasing water scarcity

The SRB is an example of an overexploited river basin

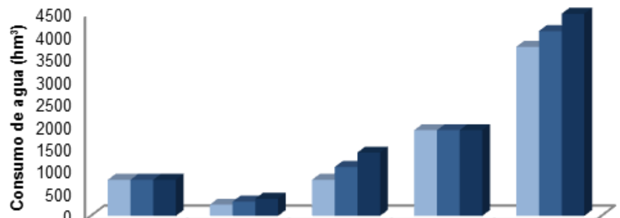
- Overexploitation was already declared in 1995.
  - > WEI (2003) = 1.27 (EEA, 2009)
  - > WEI (2009) = 2.5 (SRBA, 2010)

Forecasted Water Use, Segura 2007-2027 (CHS, 2010)

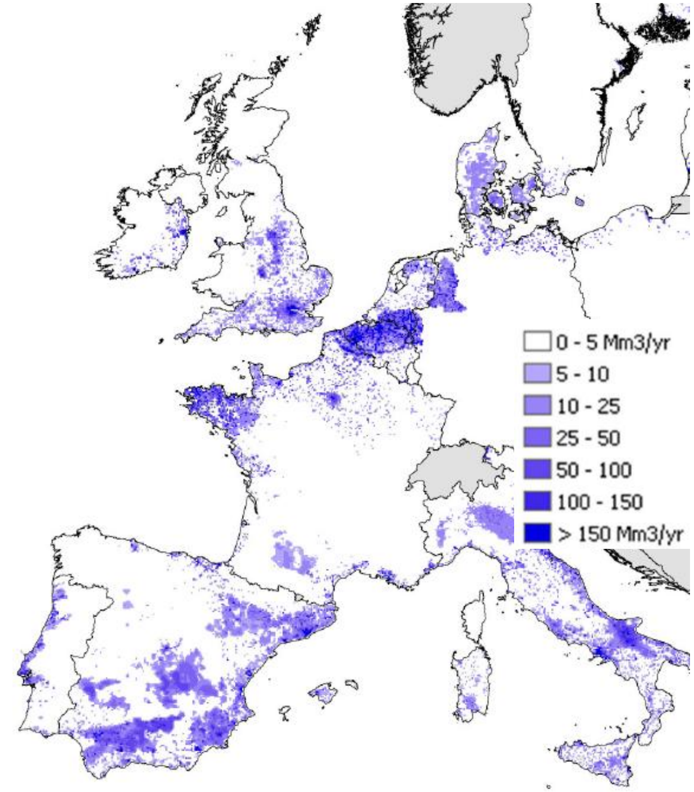


	Environmental demand	Industry	Households	Irrigation	Total
2007	46	50	143	1662	1901
2015	46	58	183	1550	1837,2
2027	46	67	210	1550	1873,5

Forecasted Water Use Tagus, 2007-2027 (CHT, 2010)



	Environmental demand	Industry	Households	Irrigation	Total
2007	800	250	800	1900	3750
2015	800	316	1085	1900	4101
2027	800	381	1404	1900	4485



Estimated water scarcity with respect to the combined water needs from all sectors (average 1990-2010) JRC (2012)

As in many other areas this is the combined outcome of a challenging hydrology pattern, prevailing market incentives and governance failures

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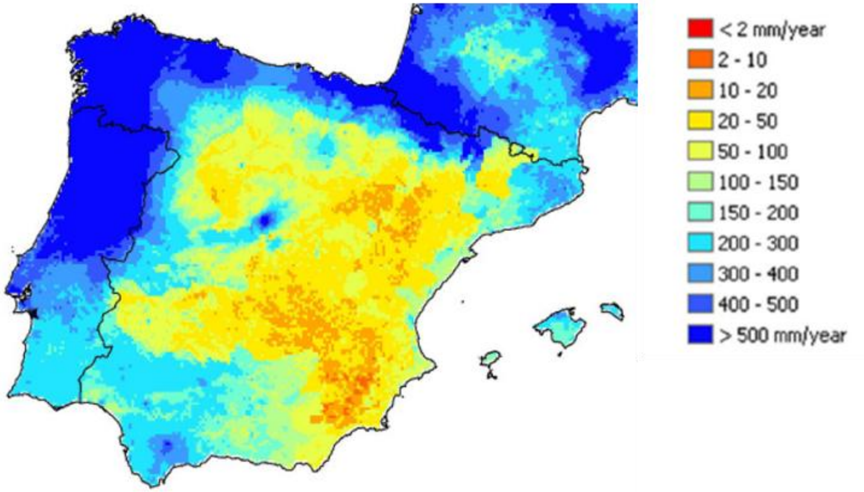
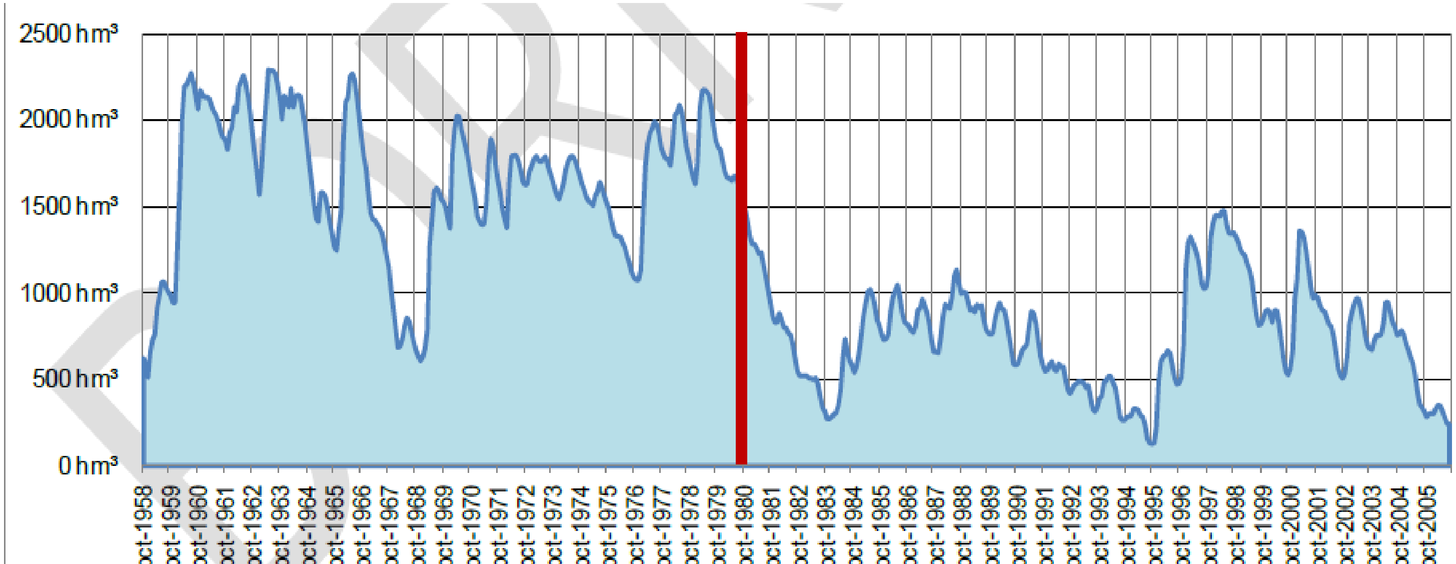
II [a] Challenging hydrology

***Water scarcity*: Long-term average runoff (JRC, 2012)**



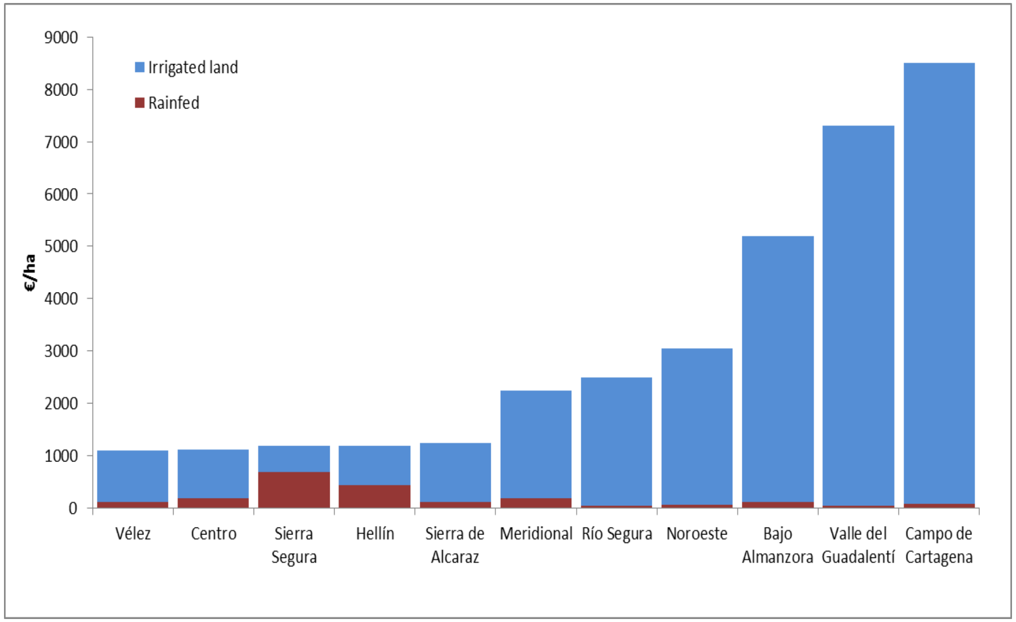
***Water uncertainty*: Climate change and Runoff Variation rates (MARM, 2011)**

***Water variability*: Water stored in the Entrepeñas and Buendía dams in the Tagus' headwaters (starting point of the Tagus-Segura Water Transfer) (TRBA, 2011)**

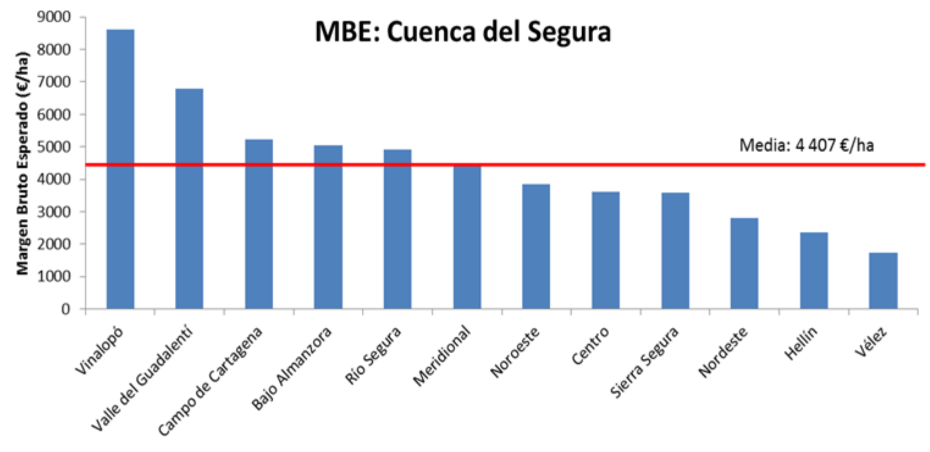


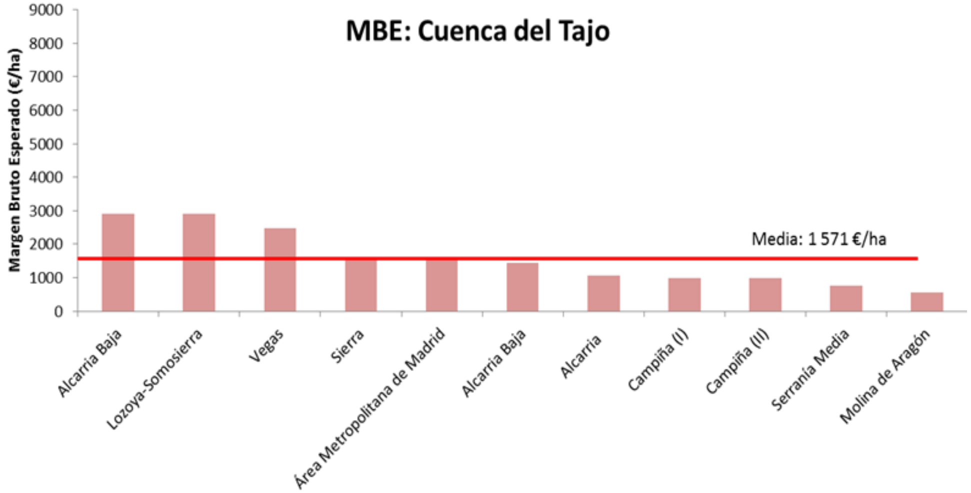
II [b] Strong market incentives

Agricultural productivity (Gross Margin €/ha) in the SRB (MARM, 2007)



- Comparative advantages for a commercial highly profitable agriculture do exist.
- Water is the key input required to take advantage of them.
- Higher benefits in the Segura.





II [c] Water governance failures

Mainly caused by a combination of: poor enforcement of property rights and incentive compatibility problems.

The most important ways to reduce water scarcity and drought risk so far have been:

- **Water transfers** (as the Tagus-Segura water transfer facility)…

… that perform below expectations but increase irrigated areas (Sumpsi, 1995).

- **Water efficient Irrigation Infrastructures:**
  - > Reduce water return flows (hydrological paradox: Ward and Pulido-V. 2005)
  - > Increase water productivity and water demand without reducing water use (Jevons' Paradox) (Gómez, 2011)
  - > Simultaneously increase energy demand (Sustainability paradox, Camacho *et. al.* 2012, Corominas, 2010)

- **Increase in the supply of non-conventional water sources:**
  - > But without a joint supply management strategy (more later)

- **Drought management plans** (contingent constraints on water supply but without provisions to reduce water demand):

  …but increase incentives for illegal abstractions from uncontrolled sources (higher drought risk in the medium term) (Gómez and Pérez, 2012)

III. What are EPIs useful for?

- Align *individual actions* of water users with the *collective goals*.
- Based on incentives, motivation, and voluntary choices.
- Take advantage of the existing opportunities to curb scarcity and improve water security.

In the particular case of the Tagus and Segura interconnected basins, EPIs can:

1. Reap the benefits of water reallocation opportunities to make improvements in market income and employment compatible with the objectives of water policy.
2. Foster efficiency gains and water savings.
3. Increase water supply and water security without additional pressures and degradation.
4. Improve drought response and risk management.
5. Allow for a better enforcement of water use rights.

IV. What innovative EPIs and what for:

A. A structured water trading scheme (to improve allocation of water services)

B. A drought insurance scheme for irrigated agriculture (as both risk and enforcement strategies)

C. A smart pricing system (to build a collective insurance and enhance long-term water security)

A.1. Drought insurance: *A formal response to drought risk*

- *The problem* - uncontrolled groundwater assets play the role of buffer stocks against drought risk. This is supported by (circumstantial evidence):

  - The constantly growing water demand (Martínez and Esteve, 2002; EEA, 2009; SRBA, 2010)
  - The gap between water demand and the availability of renewable water resources (WEI: 2.3-2.71) (SRBA, 2010).
  - The decreasing piezometric level of water tables (MARM, 2013).
  - The relative stability of agricultural incomes in spite of persistent water scarcity (MARM, 2012).

- Informal insurance is neither fair nor sustainable.

A.2. Drought insurance: the instrument

- **Replace the informal insurance in place by a formal scheme provided by the financial sector.**

  > Stabilizing farmers' income is a way to stabilize water use **(MARM, 2007; EC, 2000 and 2012)**

What is the least cost of providing this insurance?

The Fair Risk Premium obtained from a Risk Assessment Model

What is the maximum willingness to pay for water security?

Obtained from a Revealed Preference Model (RPM)

Might implementation problems be solved within this range?

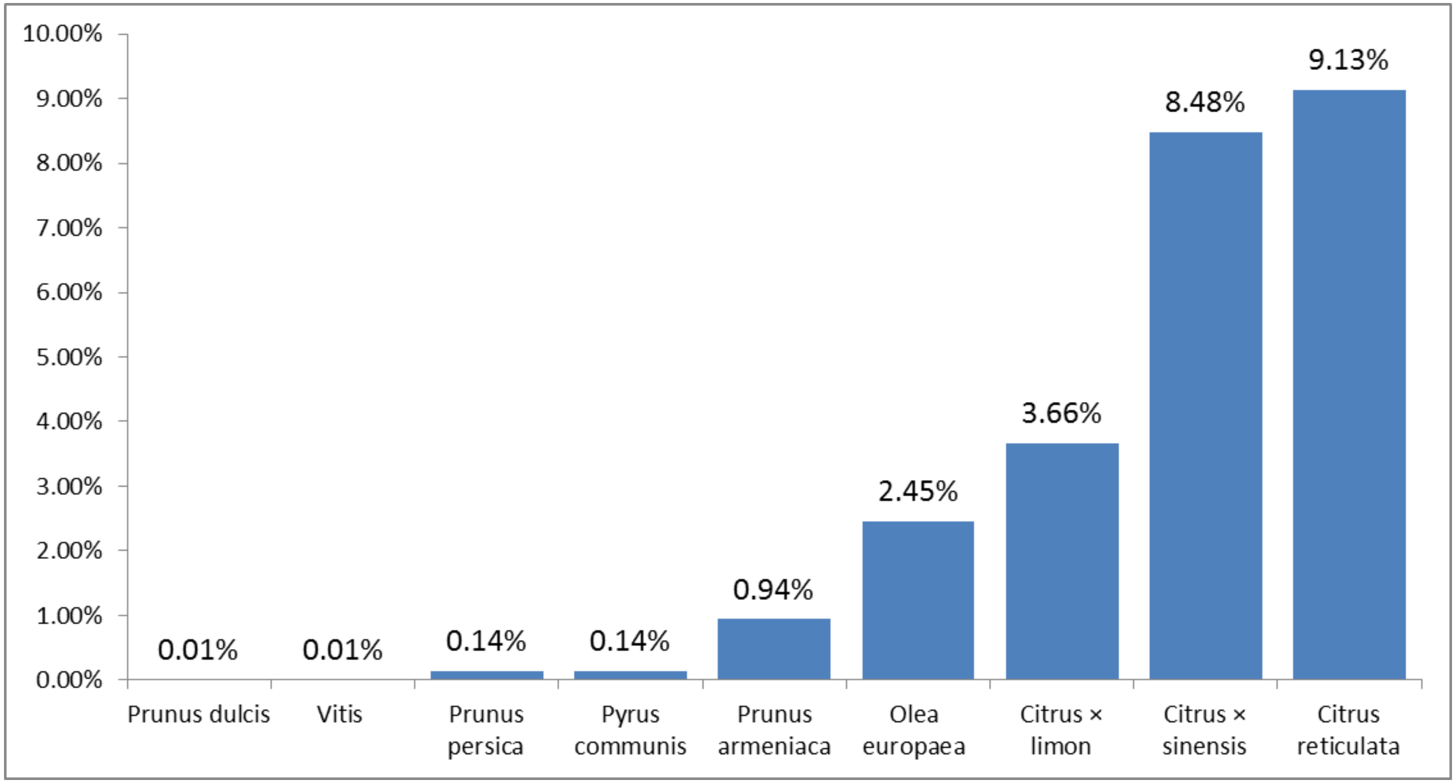
What role for the government and water policy?

A.3. Drought insurance: some results

- Drought insurance may contribute to save up to 22% - 27% of water demand in the case of ligneous crops.

- The fair risk premium (FRP) varies largely among crops:

Fair risk premium for ligneous crops (% over production value). Pilot CS in the SRB



- The WTP is greater in at least one order of magnitude than the FRP

A.4. Design and implementation challenges

- Moral hazard:
  - > Deductibles.
  - > Indemnity linked to an observable variable (yields).
- Adverse selection:
  - > Bundling of risks coverage.
  - > Control of unlawful water abstractions (EC, 2000).
- Systemic risk:
  - > Re-insurance systems and public support.

- Water Governance Issues: An active role for the public sector in order to:
  - > Reduce transaction costs.
  - > Focus support on poor farmers
  - > Co-ordinate and support the reinsurance scheme.
  - > Support insurance monitoring and provide reliable information.

B.1. Water trading

- Water markets (both intra and inter-basin) do exist.
- However, due to legal restrictions, their role is limited to emergency periods (during which significant transactions have been made).

- Water trading can:
    > Promote efficiency gains (the opportunity cost of water in the donor area is converted into a benefit and encourages water saving).
    > Maximize income in the agricultural district or region (and increase the resources that can be used for intersectoral or inter-basin water trading).
    > Increasing financial resources in those areas where water is more productive encourages water saving in other areas.

B.2. Based Upon Incipient and Varied Water Trading Experience

① **Informal trading** (traditional in the SRB mostly for irrigation and household consumption in coastal areas)

- i. With legal sources
- *ii. Water Black Market*

② **Land purchases** (both to control water use and to transfer water –usually from river headwaters to high profit crops downstream-) (Segura and Vinalopó).

③ **Lease contracts:** *Contratos de cesión* (Ley Aguas, 1999).

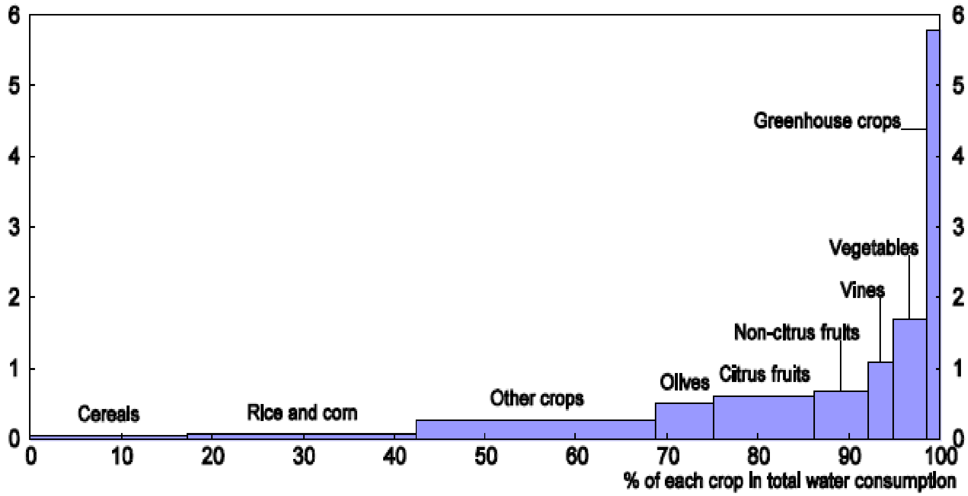
④ **Temporary interbasin exchanges** (RD 15/2005)

⑤ **Takeover of water use rights public offer** (OPAD).

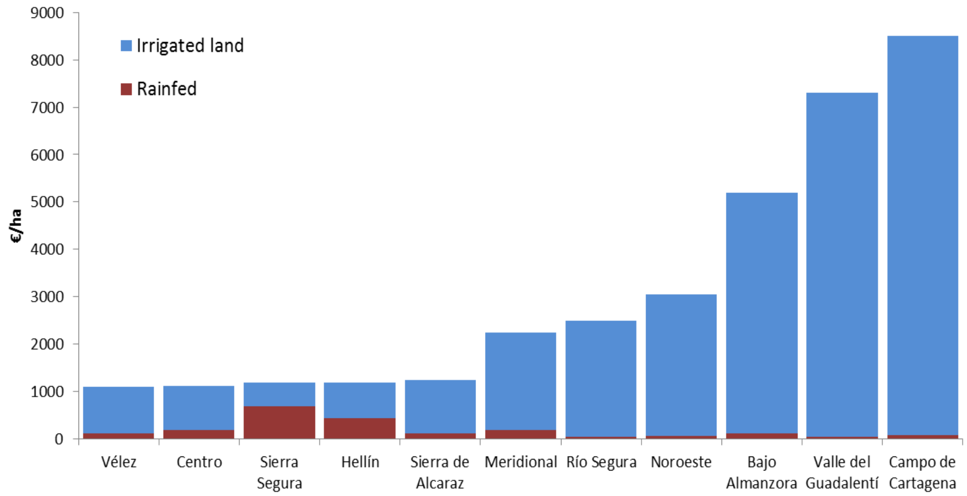
Transfer	Origin	Destiny	Date	Legal Type	Volume (m^3)	Volume (m^3/ha)	Price (€/m^3)
Tagus - Segura	Irrigation (Estremera)	SCRATS	2006	Temporary Inter-basin Exchange	31 500 000	13 500	0.19
			2007		31 500 000	13 500	¿?
			2008		31 500 000	13 500	0.22
		SCRATS	2007-2010		31 000 000		0.19
		SCRATS	2011-2021		10 000 000		0.06
	Irrigation (C. Aves)	Water Utilities (Taiblilla)	2006		35 500 000	12 000	0.288
			2007		36 030 000		0.236
			2008		36 950 000		0.31
	Irrigation		2006		1 200 000		0.3
Tagus	Canal del Henares Irrigation Community	Sorbe Water Community	2002		20 000 000		
Segura	Trades amongst SRB users		2000-2005	Leasing Intrabasin	10 100 000		
			2008-2012		2 374 312		
			2008		1 935 865		
			2009		4 498 563		
			2010		3 528 174		
			2011		27 634 345		
			2012		244 441		
Segura			2007	Public Takeover of water use rights	2 930 000		0.168
			2008				

B.3. Significant opportunities for water reallocation throughout space

Gross value added at market prices (€/m³) (MARM, 2007)

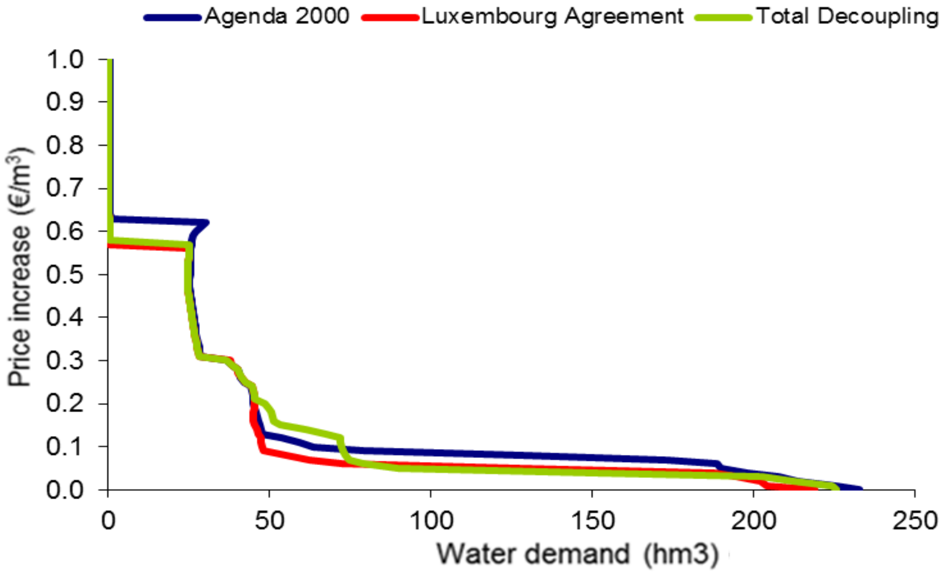


Agricultural productivity (€/ha) in the SRB (MARM, 2007)

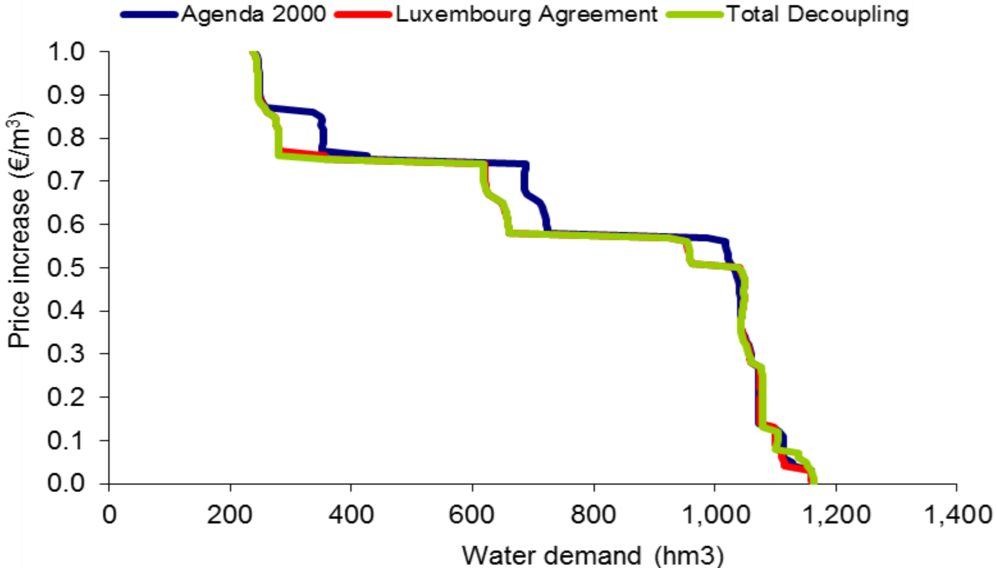


Price elasticity of demand. Pilot CS in the Upper Tagus and SRB

Upper Tagus Sub-Basin



SRB



B.4. The instrument: water trading schemes

- **1st Scheme >** *Inter-basin and intersectoral markets, based on lease contracts (specifically, option contracts will be assessed)*
  > Finding water reallocation alternatives environmentally neutral

  > Creating incentives to enhance water efficiency in low productive areas

  > Reducing water supply cost

- **2nd Scheme >** *Intra-basin markets, working at two levels:*
  > Water use right spot market

  > A right auction system in the receiving basin (to allocate the water obtained in the negotiation among potential users)

What is the potential for water trading?

>A RPM to assess farmers' productivity and WTP

> A prospective model at a municipality level to estimate the urban productivity and WTP

What are the market intrinsic costs (asymmetric information, institutional barriers, distributive effects, etc.)?

> An Agent Based Model (ABM) to assess the potential of agricultural water markets

B.5. Challenges for the implementation of Water Trading

- They must be a mean to reallocate water, not to make more water available for economic uses.

- They must be a means to reduce water scarcity but not to expand water scarcity among users and areas.

- They must be in the interest of the trading parts, but only if they contribute to a common goal (i.e., the water policy objective).

- All conditions are easier to fulfill at local level but all costs and uncertainties increase with distance.

B.6. For further research: a simple scheme with a challenging institutional set-up

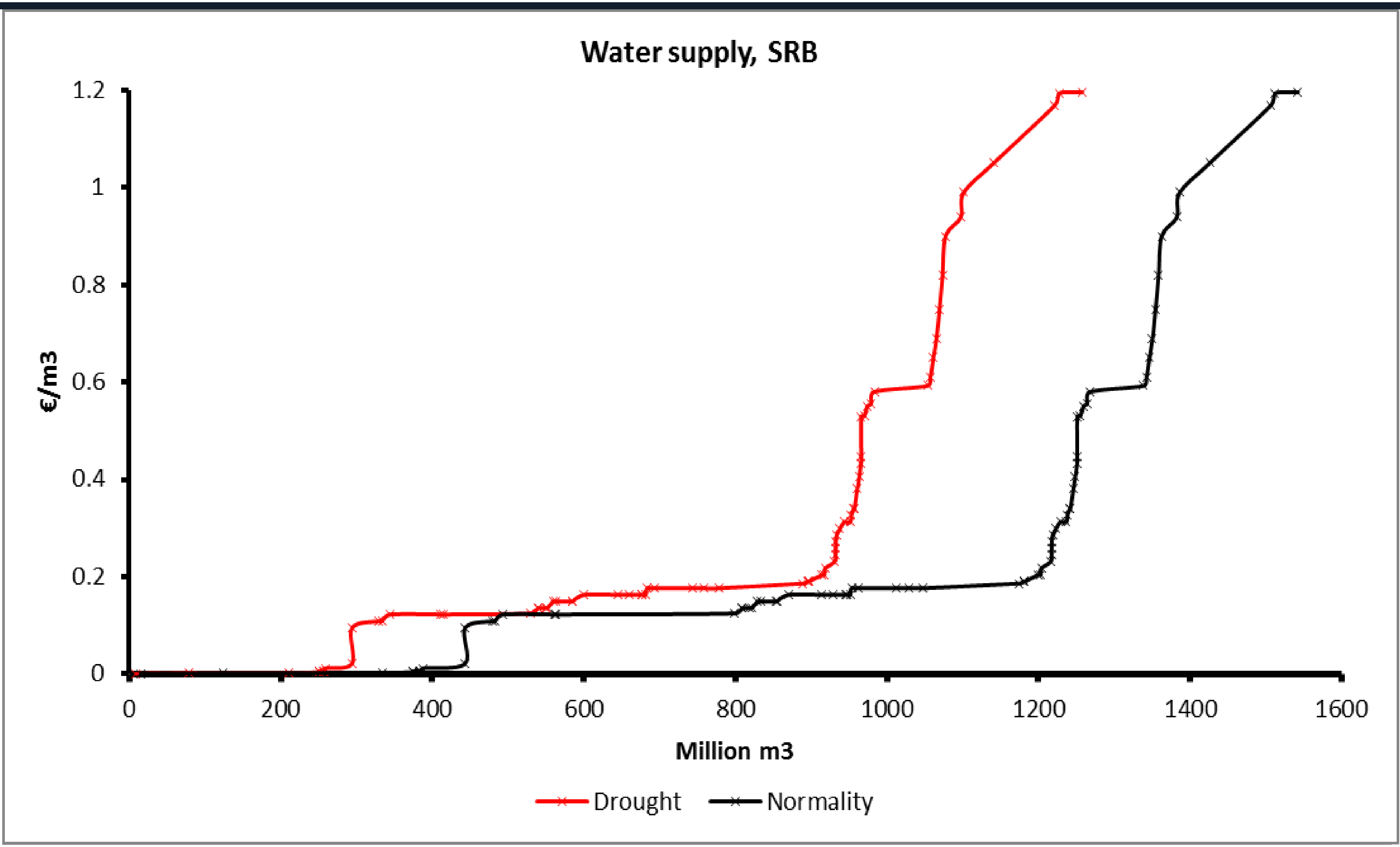
- Markets can work for the interest of those involved in trading, but can they work for the environment and be neutral to third parties?

- Assessing transactions with the perspective of water management increases transaction costs. Is the benefit still within the water trading surplus?

- How can transaction costs be reduced? What role for support measures (information, procedures, banking systems, options, etc.)?

- How to convert water savings into tradable rights? Water use or water depletion?

C.1. Smart water pricing and water security



C.2. The water portfolio

- [Financially] cheap sources are overexploited and unreliable (surface water)
- [Financially] costly sources are reliable but unused (desalinated water)
- In between there are reliable but increasingly overexploited and uncontrolled sources (groundwater) and reliable but limited sources (wastewater).

- This management system has proved wrong because:
  - It compromises the financial viability of the whole supply system.
  - It encourages unsustainable use of freshwater.
  - It increases water insecurity in the long run.

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C.3. How can smart water pricing reduce water scarcity?

- The *instrument* would be made up of three complementary tools:
  - > A price that internalizes the cost of non-conventional resources and distributes this cost among users
  - > A subsidy to encourage the substitution of conventional by non-conventional water sources
  - > A private-public partnership to decide on the use of desalinated water on a normal periods for: replacing groundwater (an allow for aquifers recovery), trading, distribute costs (in exchange of security).

- The cost of non-conventional water sources would increase water price by 0.10-0.15 €/m^3
  - > For some users, this is a prohibitive cost
  - > Thus, the viability of the system depends on the cost allocation among users and on the availability of public support (subsidies)

V. The methods

A. A Risk Assessment Model (RAM) to estimate the Fair Risk Premium

B. A Revealed Preferences Model (RPM) to assess farmers' productivity and WTP

C. A prospective model at a municipality level to estimate the urban productivity and WTP

D. An Agent Based Model (ABM) to assess the potential of agricultural water markets

A. The Risk Assessment Model

What is the Fair Risk Premium for a Drought Insurance in the Segura:

A sketch of the methodology

The Fair Premium: The premium a risk neutral farmer is willing to pay to insure himself against a hydrological drough risk

1 **"Water Demand"**
Crop Evapotranspiration
Type of Variable:
Deterministic

Water Supply

2 ***Environmental Services***
Effective Rainfall
Type of Variable:
Stochastic

5 3 4 ***Administered Water Services***
Water for Irrigation
Type of Variable:
Stochastic Decision Rule Contingent on: Runoff (Stochastic) and the Amount of water stored (Stochastic)

6 Water Deficit (% of Unsatisfied Crop Evapotranspiration)

Production Functions
(Deterministic)

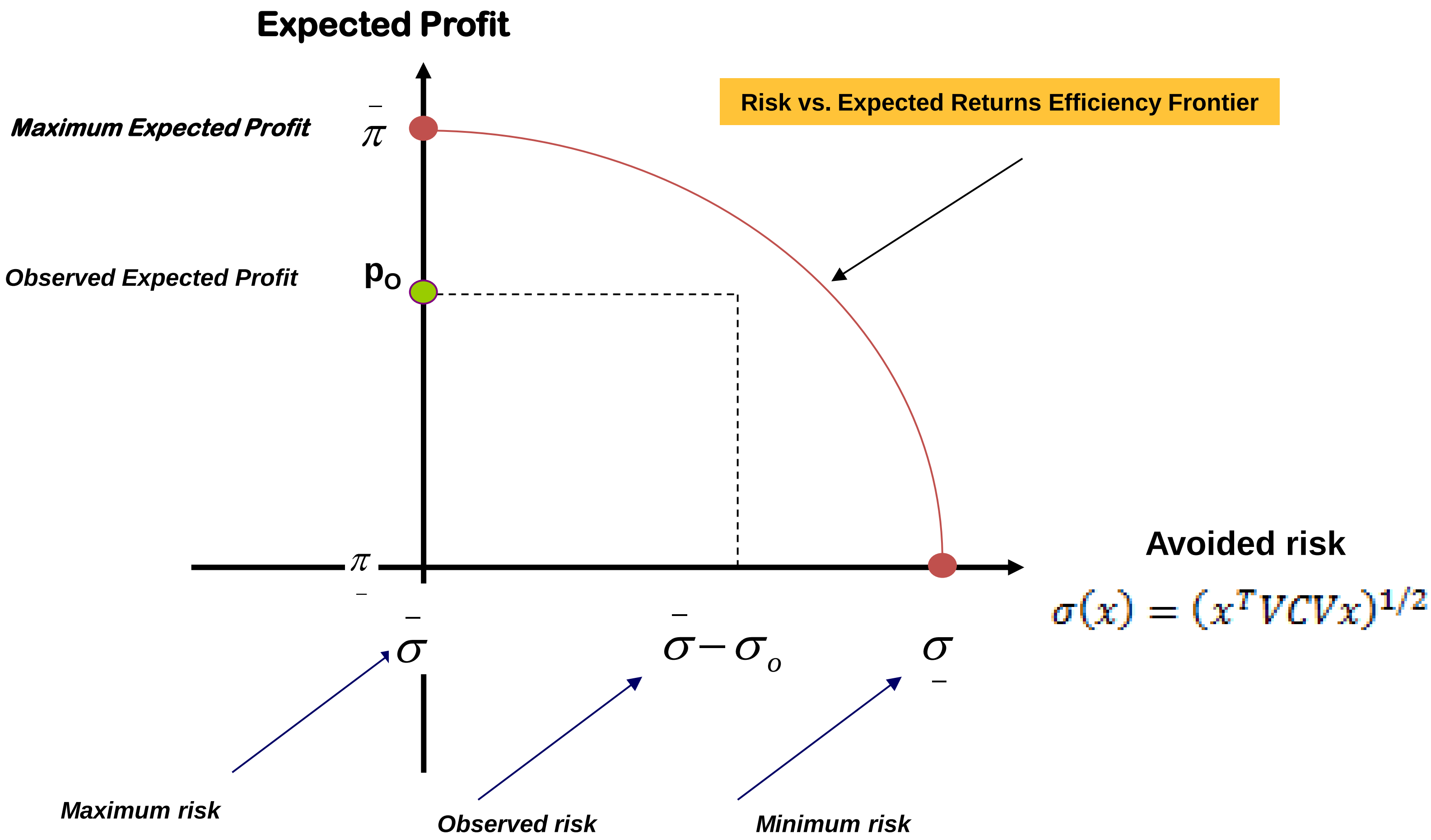
7 Expected Yields

Agrarian Accounts Systems
(Deterministic)

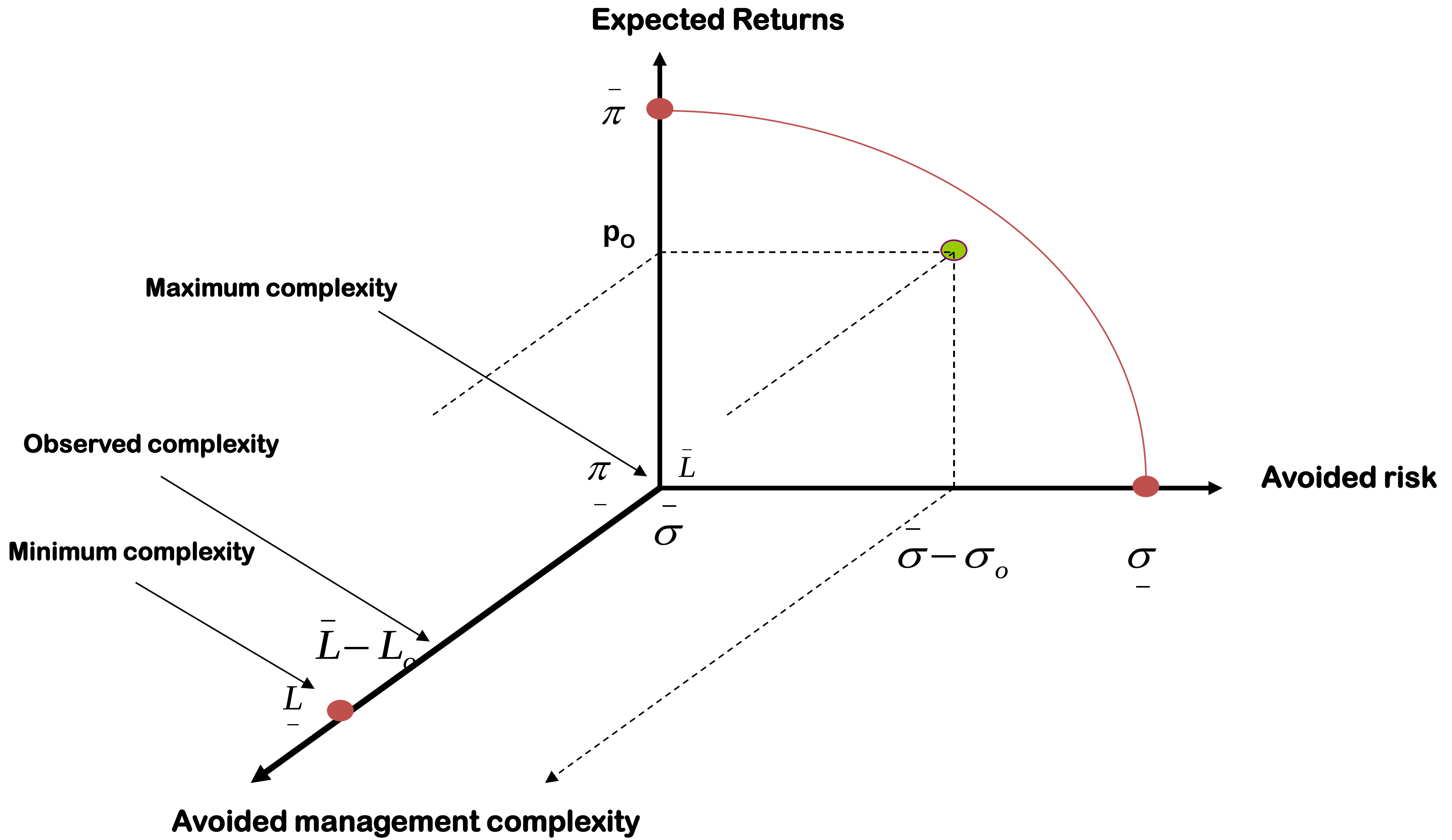
8 **Expected losses from baseline = Hydrological Risk Premium measured in € per hectare per crop**

B. The Revealed Preferences Model (1)

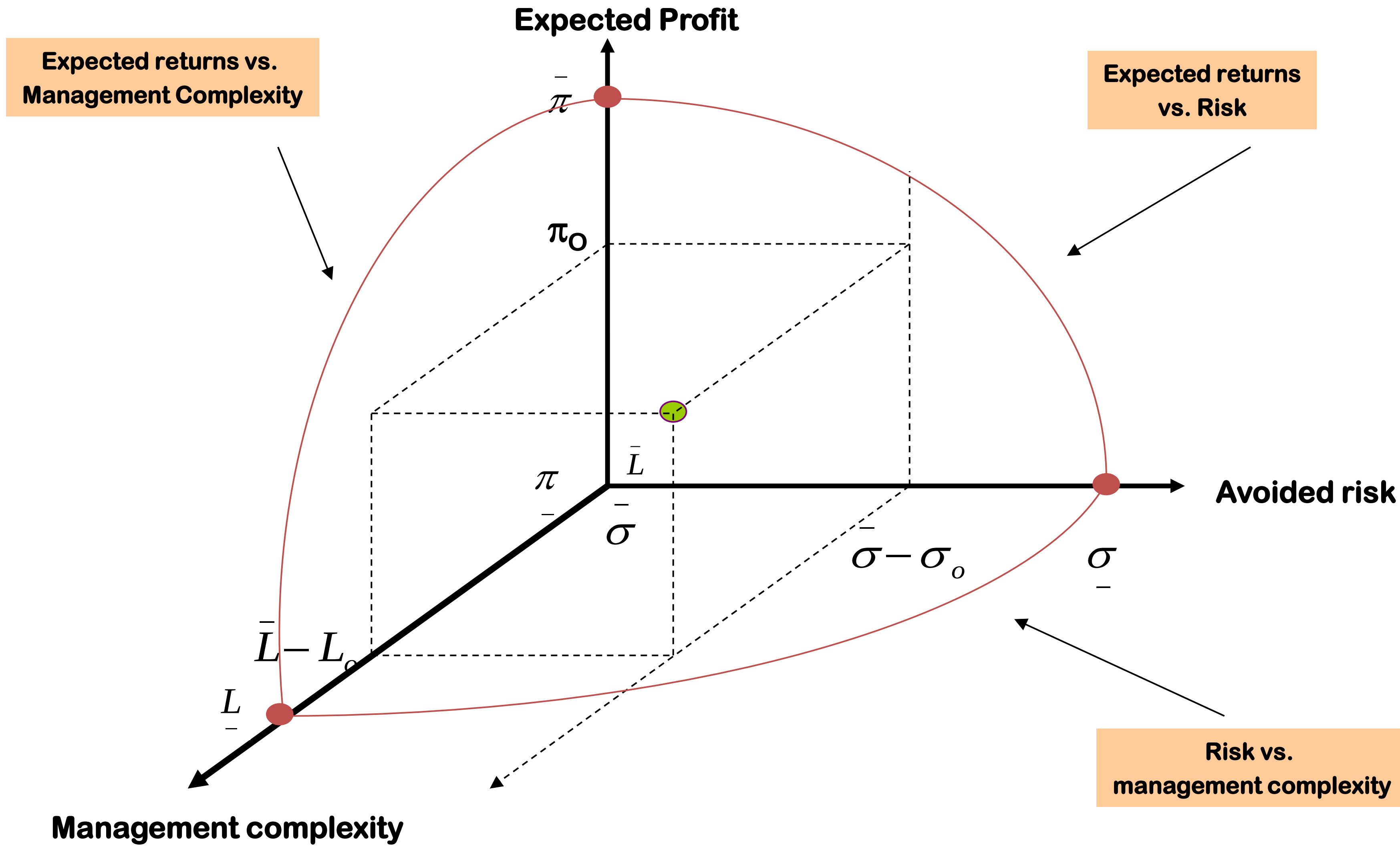
$$\pi(x) = \sum_{k=1}^{n} x_k \pi_k$$



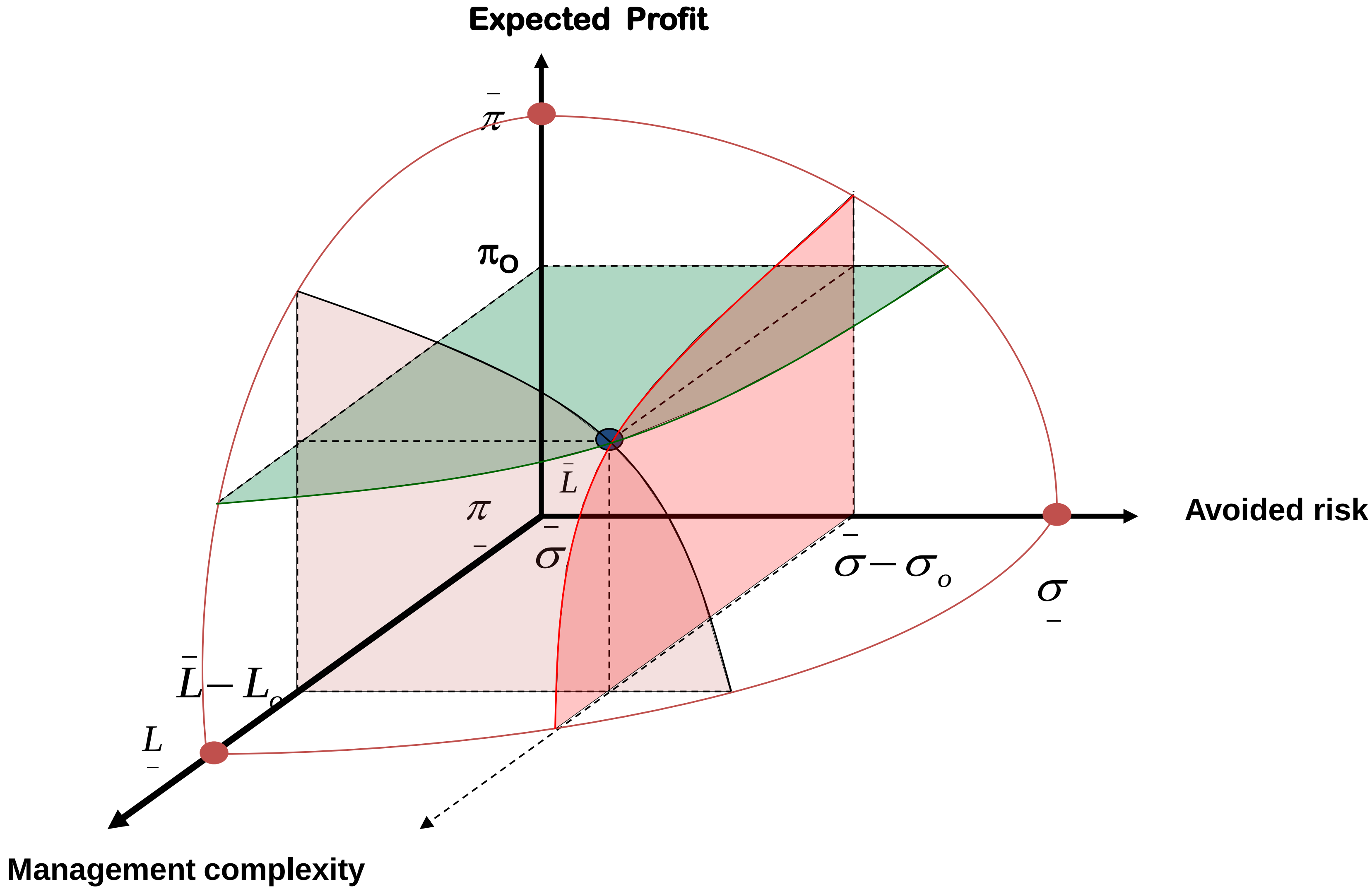
B. The Revealed Preferences Model (2)



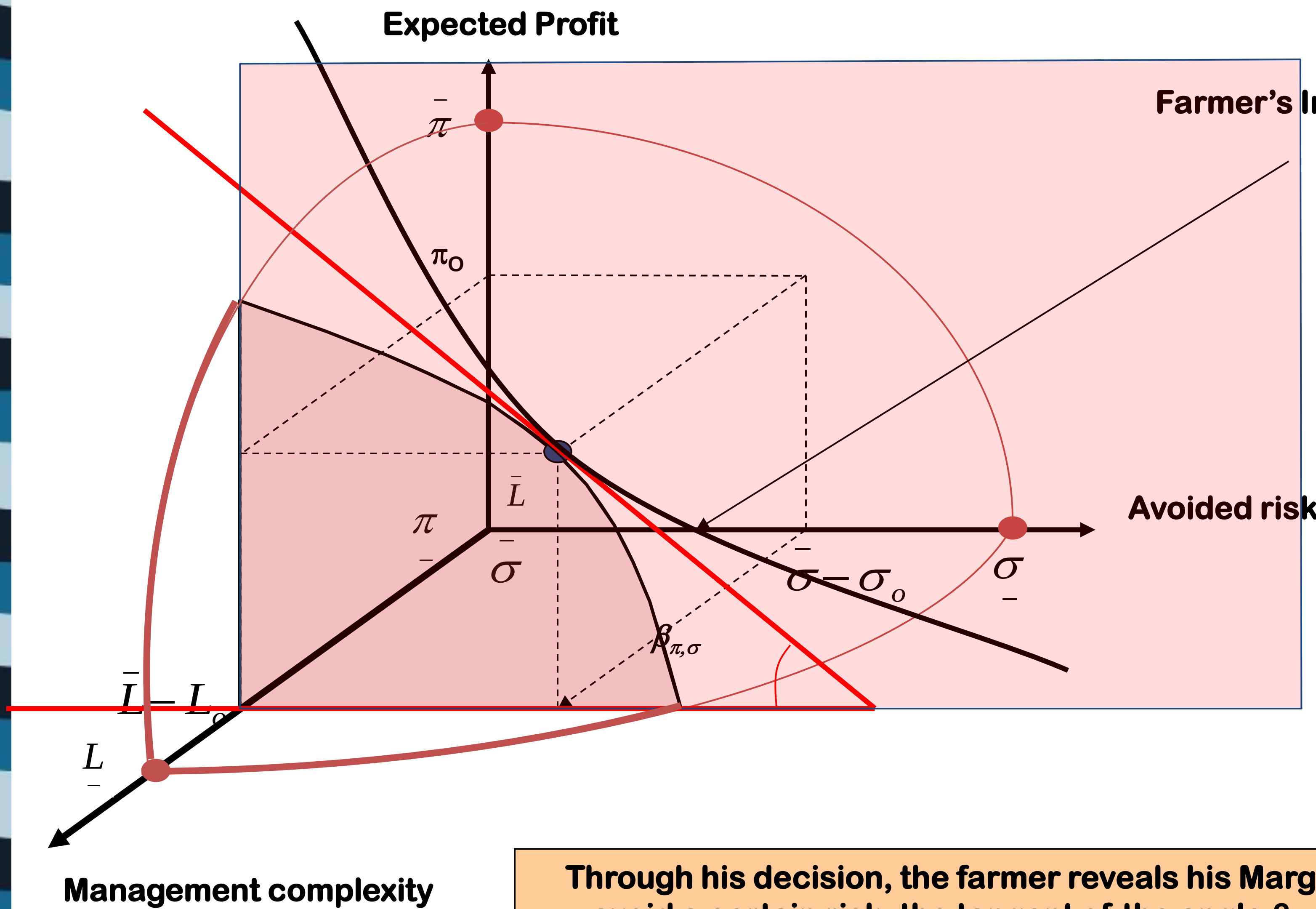
B. The Revealed Preferences Model (3)



B. The Revealed Preferences Model (4)

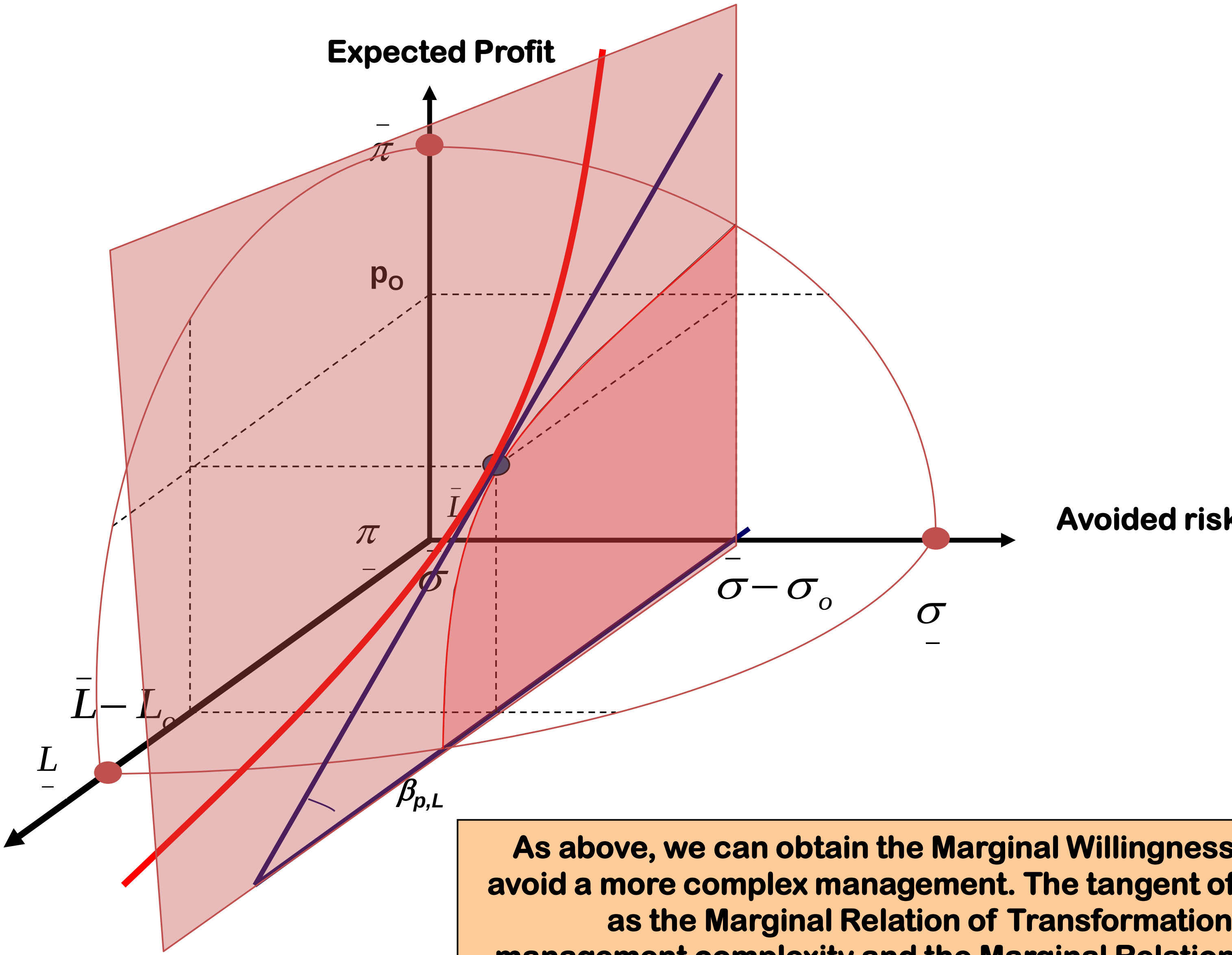


B. The Revealed Preferences Model (5)



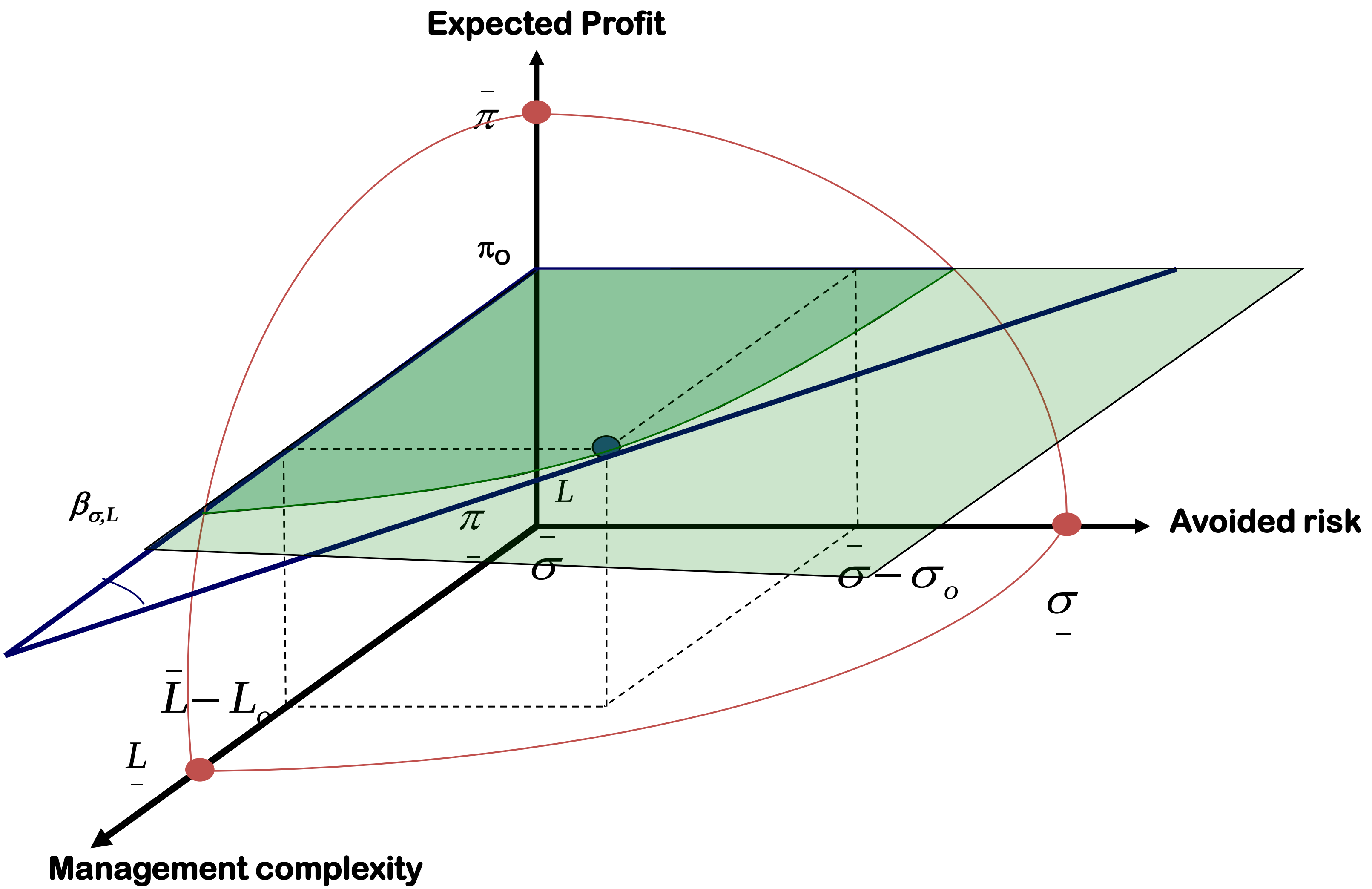
Through his decision, the farmer reveals his Marginal Willingness to Pay to avoid a certain risk, the tangent of the angle β_1, which is the same as the Marginal Relation of Transformation between net margin and risk (according to the choice possibilities frontier) and the Marginal Relation of Substitution between these two attributes (according to farmer's implicit preferences)

B. The Revealed Preferences Model (6)



As above, we can obtain the Marginal Willingness to Pay of each farmer to avoid a more complex management. The tangent of the angle β_2 is the same as the Marginal Relation of Transformation between net margin and management complexity and the Marginal Relation of Substitution between these two attributes.

B. The Revealed Preferences Model (7)



The additional risk that the farmer is ready to assume in order to avoid a more complex management is the tangent of the angle β_3. It is the same as the Marginal Relation of Transformation between risk and management complexity.

C. A prospective model at a municipality level

- The model estimates water demand and WTP
- Both variables are estimated using a comprehensive database at a local (municipal) level
- Relevant attributes include
  - > Income elasticity of water demand
  - > Number of primary/secondary households
  - > Price elasticity of water demand
  - > Income
  - > Prices
  - > Consumption
  - > Cost recovery ratio
  - > …

INDICE RESULTADOS

PARÁMETROS RELATIVOS A LA POBLACIÓN

Tasa de crecimiento de la población (nacional)	2005-2015	0.664%	
	2015-2021	0.664%	Según los valores de cambio de ciclo
	2021-2027	0.664%	

PARÁMETROS RELATIVOS A LA DEMANDA, LOS PRECIOS Y LA RENTA

PARÁMETROS DE DEMANDA

Elasticidad renta 0.04

Elasticidad precio -0.64

PARÁMETROS DE SIMULACIÓN DE PRECIOS

Tasa social 2%

Periodo de recuperación (años) 30

Periodo de incremento de precios (años) 30

Las simulaciones de precios se completan con la incorporación de una serie de programas de inversión o recuperación de coste, cuyo importe (completamente o en parte) se quiere repercutir y que deben añadirse en la hoja COSTES

COSTES CALCULAR PRECIOS

RENTA

Tasa de crecimiento anual de la renta nacional 1.93%

La tasa de crecimiento de la renta se considera para todo el periodo de proyección, es decir hasta 2027 si se dispusiese del dato

CONSUMO (litros/hab/día)

Sin tener en cuenta aumento de precios o de renta per-cápita

		Consumo 2005	% de agua perdida en la dist 2004
	TOTAL NACIONAL	166	18.70%
1	Galicia	152	18.90%
2	Asturias (Principado de)	180	19.40%
3	Cantabria	191	20.60%
4	País Vasco	140	9.10%
5	Navarra (Comunidad Foral de)	134	13.50%
6	Aragón	153	21.90%
7	Cataluña	162	16.60%
8	Castilla y León	160	20.50%
9	La Rioja	145	19.30%
10	Madrid (Comunidad de)	159	13.80%
11	Castilla La Mancha	174	18.40%
12	Comunidad Valenciana	171	24.80%
13	Balears (Illes)	139	23.00%
14	Extremadura	173	21.30%
15	Andalucía	195	20.00%
16	Murcia (Región de)	162	19.50%
17	Canarias	145	19.40%
	Ceuta y Melilla	139	5.40%

Según los datos extraídos de las aplicaciones para la caracterización económica de abastecimiento doméstico del Ministerio de Medio Ambiente, Medio Rural y Marino (MMAMRM), extraídos, a su vez, del Instituto Nacional de Estadística (INE)

PARÁMETROS RELATIVOS A VIVIENDAS

D. An Agent Based Model

- The agents are the *Unidades de Demanda Agraria* (Agricultural Demand Units, *UDAs*)
- UDAs try to maximize their utility, based on the following attributes:

  > Water availability (stochastic shock)

  > Expected production value

  > Costs

  > White noise (capturing any source of revenue variability except water availability)

  > Water market variables:

    - Water availability
    - Transaction costs
    - Water price (water can be sold or purchased)

- The UDAs are subject to physical as well as legal boundaries
- The model runs in Netlogo

VI. Concluding remarks

- **EPIs have the potential to change users' behaviour**
- **EPIs are instruments towards an end and thus they need to specify clearly what they are meant to achieve**
- **In Spain (and the EU), environmental EPIs have been too often *de facto* financial /economic EPIs**
- **This is not to say that EPIs cannot foster tax collection and/or economic growth:**
  - **Environmental EPIs are voluntary and thus if properly designed they will likely lead to a Pareto improvement from a financial/economic perspective**
  - **However, tax collection and/or economic growth should not be their main goal**
- **This concept is particularly important under the current crisis juncture**

Thanks for your attention

The EPI-WATER project - "Evaluating Economic Policy Instruments for Sustainable Water Management in Europe" has received funding from the European Community’s Seventh Framework Programme (FP7/2007-2013) / grant agreement no. 265213