A compensation mechanism for flood protection services on farmland

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Aims and structure of the presentation

- Motivation from a case study
- Introduce a payment scheme for flood protection services
- Examine the microeconomic properties
  - efficiency
  - risk sharing
- Determine the key parameters for contract design
- Further research

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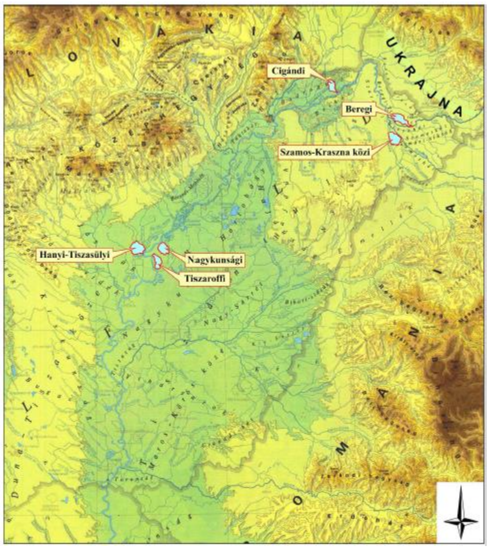
Motivation

River Tisza, Hungary



River regulation from the mid 19th century shortened the river by 400 km

2850 km dikes protect 16000 km^2 (1/3 of the Hungarian part of the catchment)

Motivation

- A series of serious flood events (1998-2001) have triggered new flood protection measures
- Recent flood risk projections
  - More uncertainty
  - Higher peak flows
- Construction of 6 **flood defence reservoirs**
  - 4 completed, 2 still under construction

Key question

How should reservoirs be used and operated?

How should farmers be compensated?

Farmland as a retention area

- The Hungarian case
  - Currently: damage compensation after assessment
    - expensive assessment
    - inefficient crop choice
    - potentially inefficient use of the reservoir
  - We suggest:

  A payment scheme consisting of
  - a fixed annual payment
  - a conditional payment if the retention area is used

The model

A contract design model to compensate for flood protection services

- A simplified hydrological model
- Farmers' crop choice
- River authorities' use of the reservoir

The hydrology (1)

Protection of a downstream city

- River peak flow (given)
- Damage from peak flows
- Reservoir reduces peak flows if flooded

River authorities must balance

- avoided damage downstream

against

- Damage in the reservoir (social welfare perspective)

or

- Compensation claims (public budget perspective)

The hydrology (2)

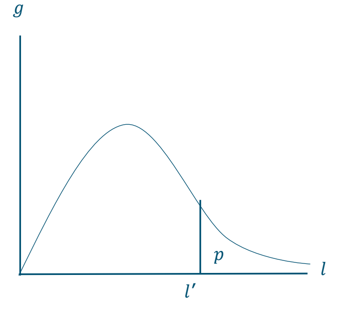
A simple representation of the hydrology

l river peak flow (water level)

$g(l)$ distribution peak flows

l' critical water level

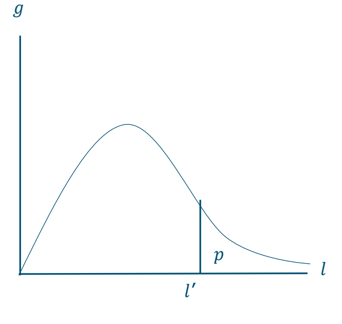
p probability of an event causing damage



The hydrology (3)

If flood gates are opened, the reservoir

- lowers the river peak flow
- decreases the probability of a damaging event



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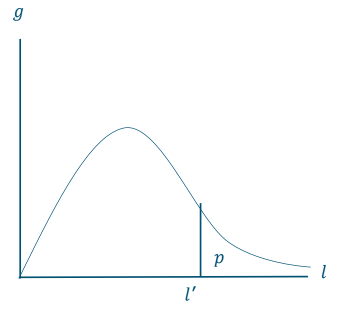
 The tail of the distribution shifts to the left



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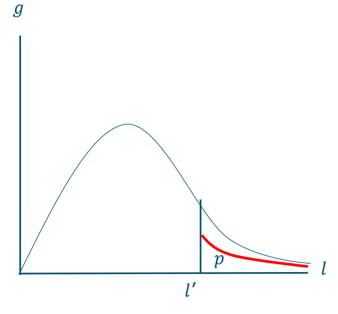

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Farmers’ crop choice: Two benchmarks (1)

x value of harvest
$c(x)$ cost of planting (assuming $\frac{dc}{dx} > 0$ and $\frac{d^2c}{dx^2} > 0$)
M monetary compensation

Would a farmer plant a high value crop?
Maximise

$$(1-p)x + pM(x) - c(x)$$

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Farmers’ crop choice: Two benchmarks (2)

Maximise

$$(1-p)x + pM(x) - c(x)$$

Full compensation $M(x) = x$
Optimality condition: $1 = \frac{dc}{dx}$

 disregards of the risk of flooding

No compensation $M(x) = 0$
Optimality condition: $1 - p = \frac{dc}{dx}$

 flood risk implies less intensive farming
This hold even for risk neutral farmers.

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The compensation scheme

Criteria for a compensation scheme

- Voluntary participation of farmers
- Efficient crop choice
- Efficient risk allocation when farmers are risk averse
- Efficient use of the reservoir when river authorities are concerned with their budget and “responsible” for downstream damage

The compensation scheme

The compensation contains

- an unconditional (fixed) component f and
- a conditional (variable) component v

such that the expected compensation $M = f + pv$

Criteria 1 and 2

Voluntary participation of risk averse farmers

$$u[(1-p)x_L + pv - c(x_L) + f] \geq u[x_H - c(x_H)]$$

- Farmers are happy to have land in the reservoir

Efficient crop choice

$$u[(1-p)x_L + pv - c(x_L) + f] \geq u[(1-p)x_H + pv - c(x_H) + f]$$

- Farmers prefer to plant the low value crop

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Criteria 3 and 4

Efficient risk allocation when farmers are risk averse

- Farmers should be fully insured, i.e. they receive the same income regardless of whether or not a flood occurs.

- Efficient use of the reservoir when river authorities are concerned with their budget
- Floodgates should be opened whenever avoided damage is higher than then variable compensation payment.

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The compensation scheme

The compensation that meets the criteria

- uses $v = x_L$
- and f is set to compensate for the utility difference associated with obtaining x_L instead of x_H

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Properties of the compensation scheme

Participation and **risk allocation**

$$u[(1-p)x_L + pv - c(x_L) + f] \geq u[x_H - c(x_H)]$$

 If $v = x_L$ farmers are fully insured. The fixed part f of the compensation is set to meet the participation constraint.

Efficient crop choice

Maximising $u[(1-p)x + pv - c(x) + f]$

 we obtain x_L as a farmer's optimal crop choice because the compensation is independent of crop choice. At x_L the farmer is fully insured and risk aversion will therefore not impact crop choice.

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Properties of the compensation scheme

Efficient use of the reservoir

When river authorities are concerned with their budget

- Floodgates are opened when avoided damage exceeds the variable compensation payment v. Since v reflects the true damage the reservoir is used efficiently.

Some further properties and conclusions

- Low transaction costs
  - no monitoring, no damage assessments
  - no disputes
- Increasing probabilities of critical peak flows implies lower v and larger f. The river authorities budget requirements are increasing.
- The degree of risk aversion of farmers has no impact on the variable part of the compensation.

We propose a simple and easily implementable scheme.

Our next step is to assess its working in practice.

Thank you!

Tisza at Szeged

Source: Encyclopedia Britannica

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