IVM Institute for Environmental Studies

Kennis voor Klimaat

VU UNIVERSITY AMSTERDAM

Economic modelling and assessment of the impacts of climate change on freshwater resources

Jason Levin-Koopman, Onno Kuik, Roy Brouwer, Richard Tol

Contents

- Recap of the goal and aims of the project
- Recap of the Methodological approach
- Highlights of the first paper
- Goals and aims of the second paper
- Methodological approach
  - Shipping
  - Industry

Goals of the project

- Examine the economic consequences of water scarcity in connection with climate change scenarios.

- Particular focus is on establishing the extent and influence of the economic feedbacks to water scarcity and integrating the results with previous studies and methodological approaches that do not include these feedbacks. (Deltares)

Goals of the project

The goal of this project is an increased understanding of the importance of economic feedbacks in projections of the impacts of climate change and how including economic feedbacks might alter the results of current approaches for assessing the economic impact that do no currently include them.

Methodological approach

- Use a computable general equilibrium model which is purely focused on economic feedbacks.

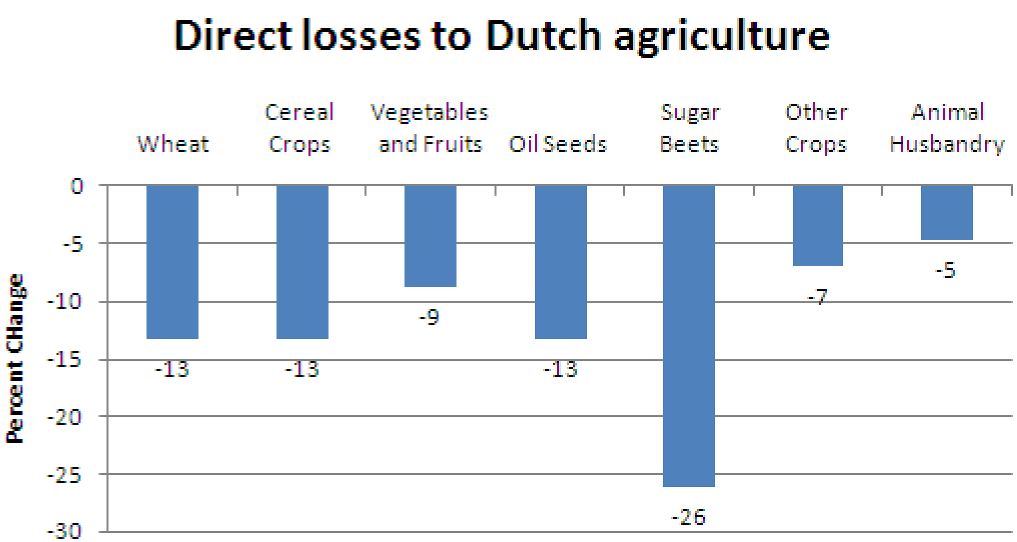
- Climate change scenarios and Dutch water resources are international in nature. Therefore we choose a CGE that includes multiple regions.

- Being fully aware of the lack of detail inherent in CGE modelling we attempt to both add in further detail in water resources and interpret the CGE results so they can be used to refine or illuminate methods that focus on hydrological detail but lack economic complexity.

First paper: The importance of economic feedbacks in assessing the economic impact of water scarcity in agriculture.

Modeling approach

In this paper we used a data from the Delta Program Phase Three results on crop losses to rainfed and irrigated agriculture that would occur to the current Dutch economy from the extremely dry climate of 1976 and used that data to calibrate the shocks to the CGE model to explore that scenario in a general equilibrium setting.

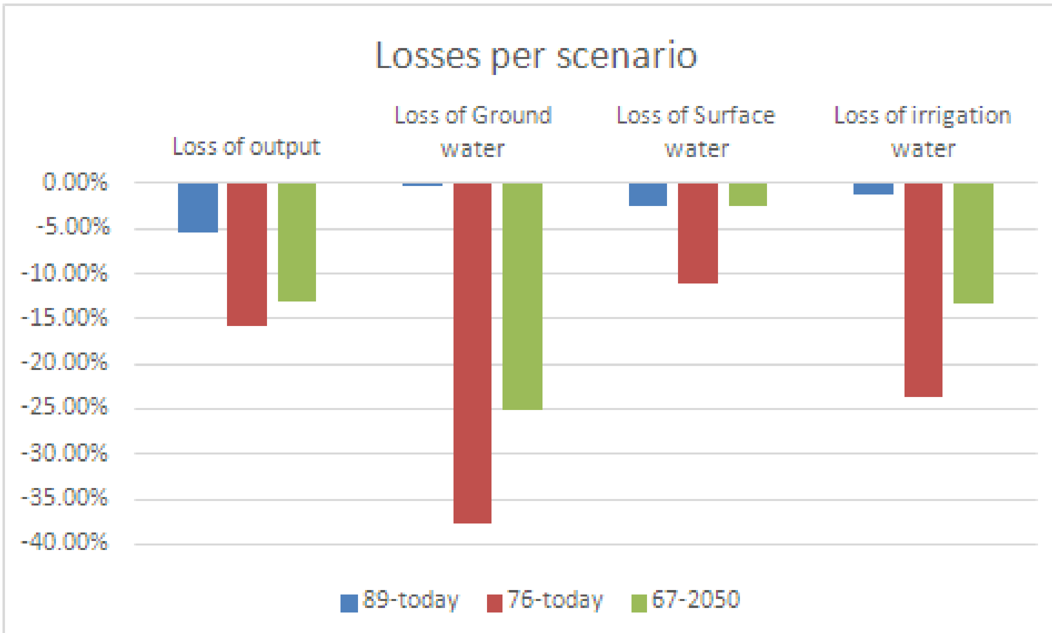


CGE Model

Loss of irrigation water

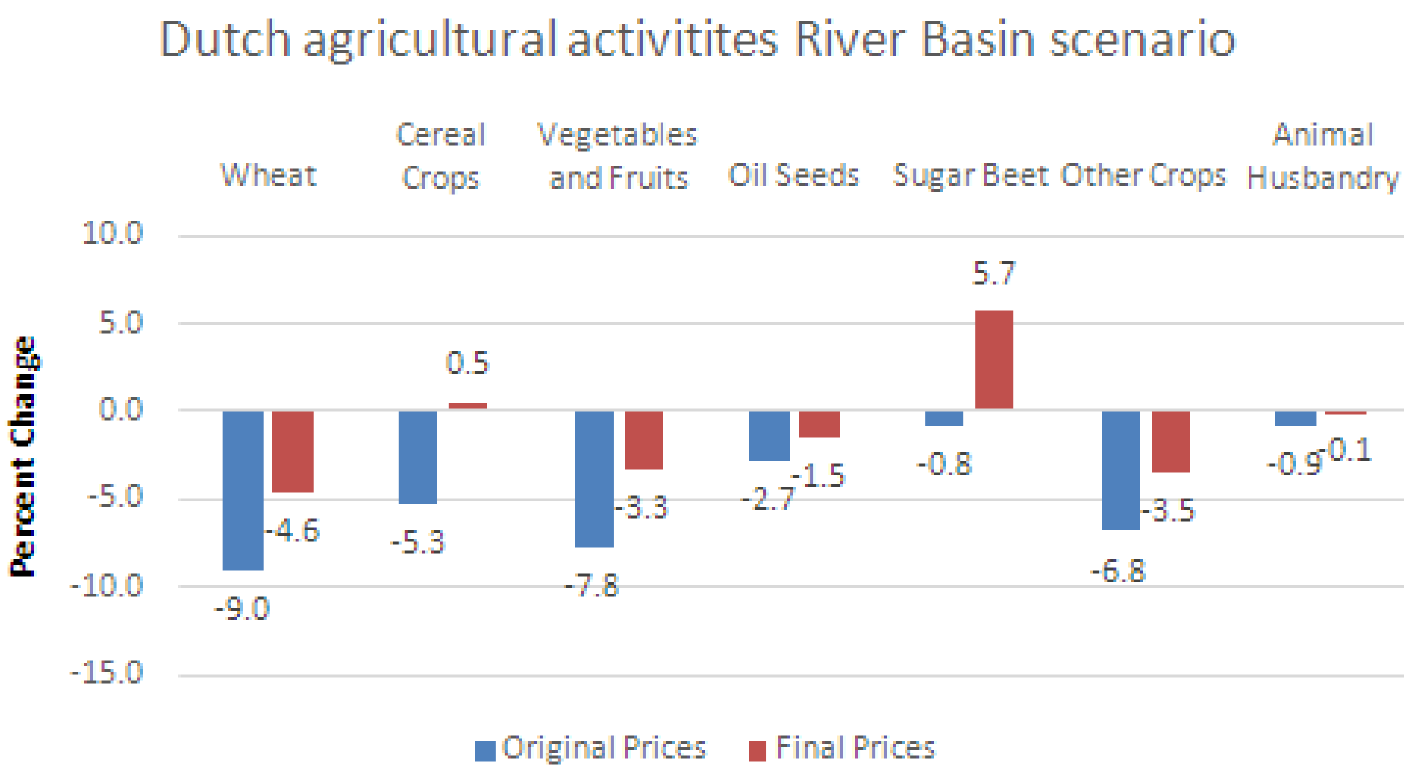
Loss of land productivity

Comparing climate change scenarios

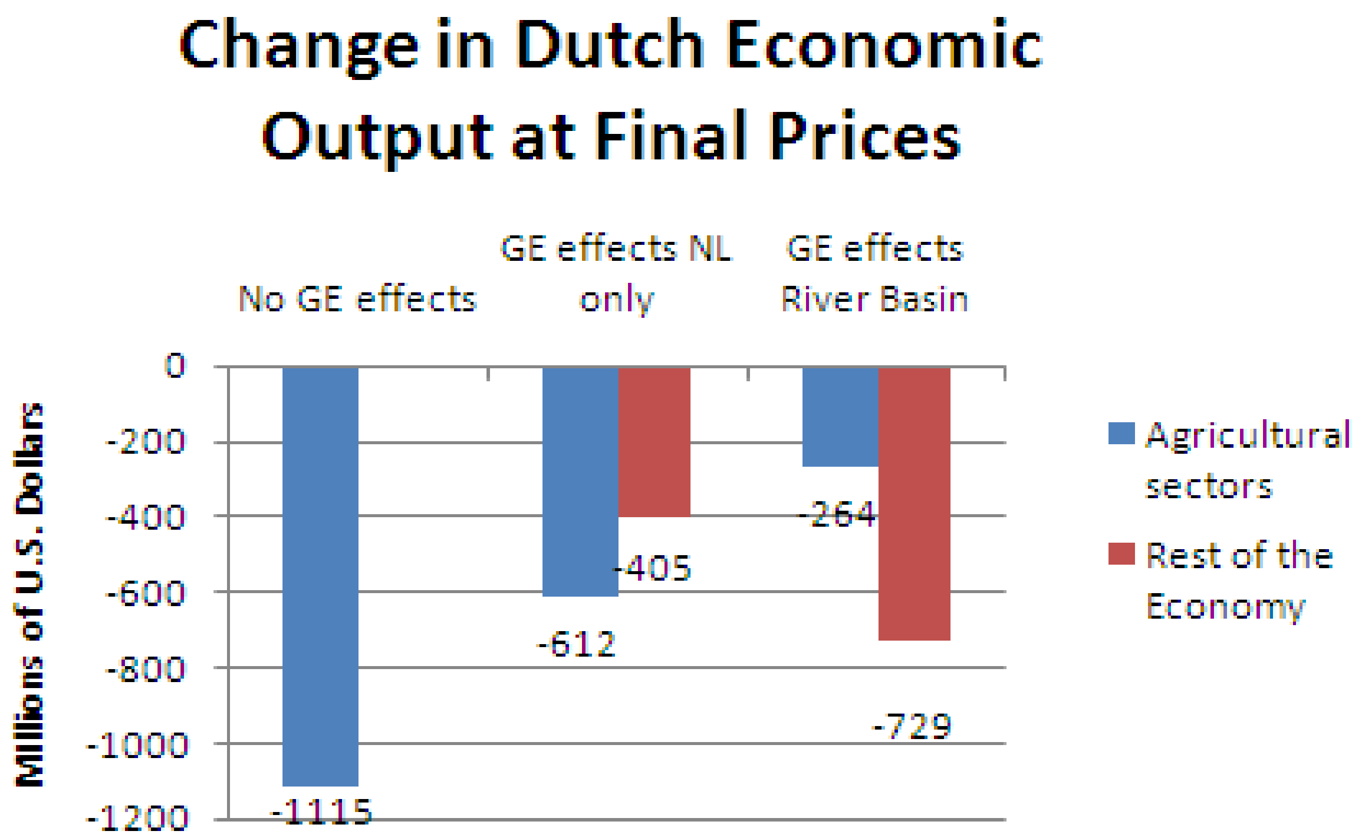


The 1976 climate scenario is extreme, but is reasonably close to the W+ scenario, in loss of output and loss of irrigation water.

Paper 1 results: Agricultural sectors



Paper 1 results: National



Goals and aims of the second paper

2nd paper

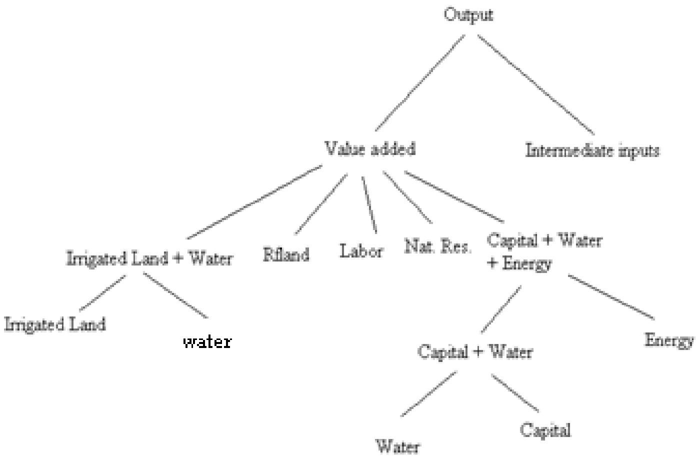
- Tentative title: *The effectiveness of using tax instruments to influence water consumption between industry and agriculture, in times of scarcity*

- Change the CGE model to include the effects of water scarcity directly in **manufacturing** and **shipping** in addition to agriculture

- Water scarcity as a described in the W+ climate change scenario, examine the cross sector impacts of water scarcity. Trading and no trading scenarios. How sensitive are the model results to taxes and subsidies?

Water in the production of shipping services and manufacturing

Use data on price per ton increases due to low water levels in the Rhine to determine the losses to shipping of low water levels. (Lobith in the Netherlands and Kaub in Germany)



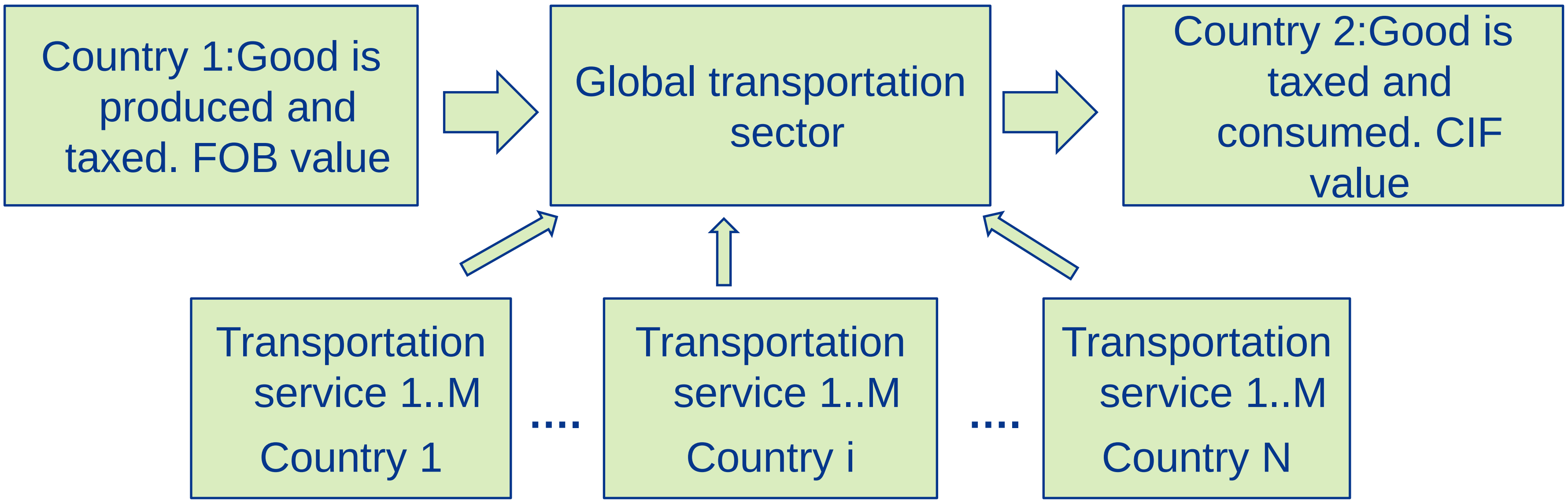
Water allocation between users

- Water trading and a non-water trading scenario: examines the benefits of allowing water to be traded between agriculture, industry and shipping.

- Examining the effectiveness of various water consumption charges to alter consumption patterns in the Netherlands paying particular attention to the spill over effects on national consumption patterns as well as the changes in the upstream countries demand for water.

Shipping: Methodology Transportation in GTAP

- In GTAP an international sector purchases transportation services for the transportation costs for trading between countries.



- Shipping companies from different countries travel the Rhine

Shipping: Methodology

- We reduce transport productivity specific to: mode, good, origin country, receiving country as opposed to the production of services from a specific country.

- This will have the effect of:
  - Increasing the demand for shipping (more boats are needed if each boat can move less goods).
  - Decrease the demand for shipping (if other transportation modes can offer cheaper alternatives). The first will dominate (Jonkeren 2011).
  - Increase the transportation costs. (Effects the price of imports).

Shipping: Data

- We need data on:

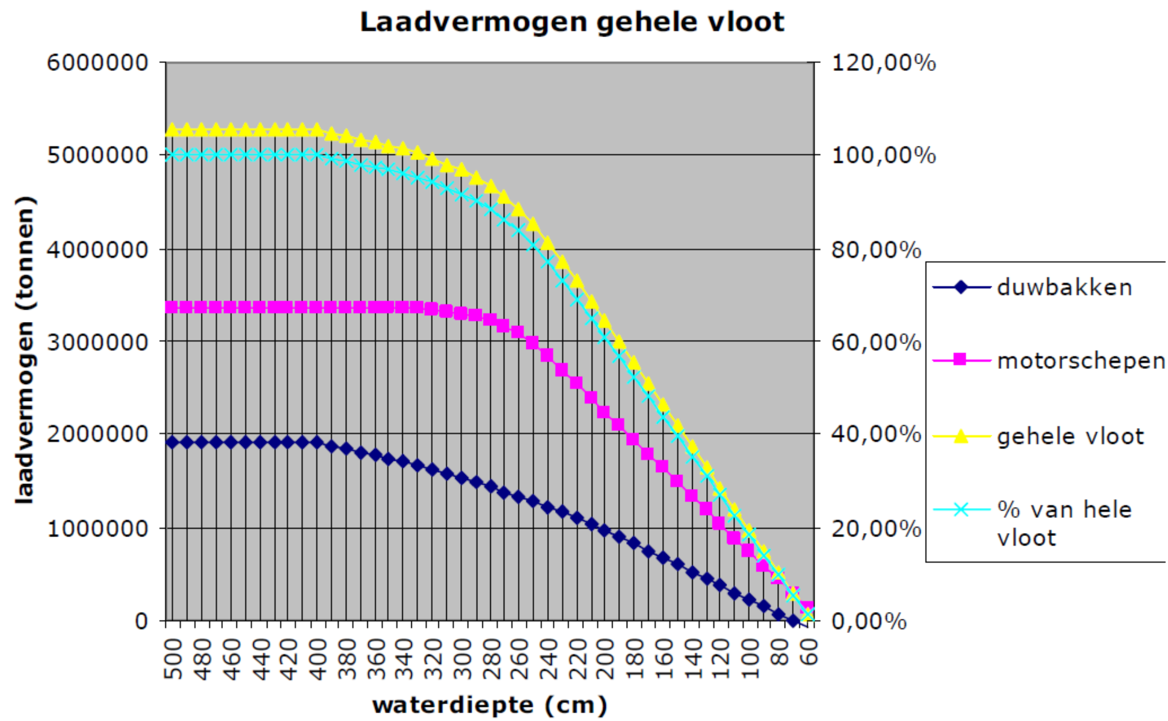
  - How low water levels affect shipping loads (Jonkeren for Kaub, and Bosschieter for Lobith).
  - Water discharge levels during summer periods for W+ scenario compared with current discharge levels (Te Linde: -35% Rhine discharge in W+)
  - Which goods are traditionally shipped along the inland rivers. (No data search yet: GTAP give which goods are shipped but does not specify the route.)

Shipping productivity level, data

Modeling shipping as a reduction in productivity instead of an input in production of shipping services is more realistic given the nature of transportation in GTAP. However the productivity shock will be exogenous.

Before we run the model we determine the available water for agriculture and industry given the climate scenario and the priority we give to shipping.

Then the model internally allocates the remaining water among agriculture and industry.



Bosschieter, 2005: Water levels at Lobith for shipping

Water in Industry: Methodology

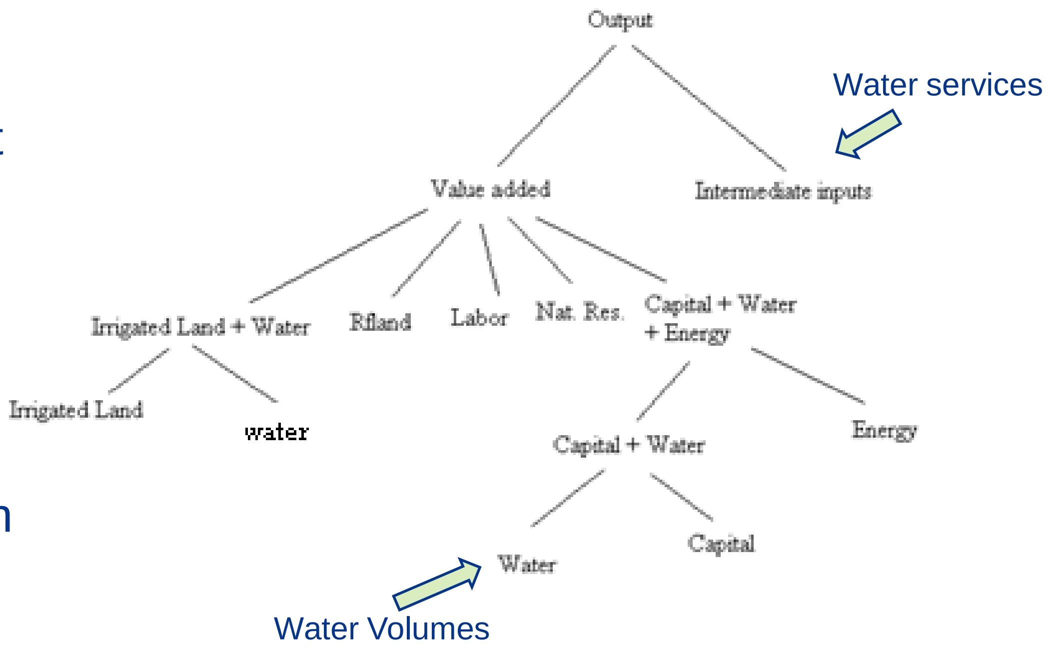
- Water is combined with capital in the production nest with an elasticity of substitution which varies per industry, i.e. intake water can be combined with recycled water, liquid cooling can be replaces by dry cooling. Beverage industry will have a harder time substituting.

- **Working assumptions about water**

  Water volumes are currently used but not paid for.

  Factory locations are chosen for their access to water and the price of permits reflect these preferred locations.

  Therefore the value of water is hidden in the value of capital.



Share of water in the industry production function

- We have data on firm behaviour with regards to water in the form of price-water and water-output elasticities.

- We have the industry production function from GTAP-W

- Therefore by changing the intake of water by one unit, we can estimate the share of value that water has in production. This is a non-obvious procedure and we are still refining our approach.

Theory

- Linear production function:

  Output = αWater + (1- α)Capital

- Two input CES function:

  Out = (αW^δ + (1- α)K^ δ)^ δ

  δ = (σ-1)/σ

- Firm chooses output to maximize profit w.r.t. prices.

GTAP: notation

- Percent change in demand

  w = out – σ(pW-pOut)

  k = out – σ(pK-pOut)

- Composite price equation

  pOut = shvW*pW+shvK*pK

  shv = share of value in output (P*Q)

w= out - σ(pW - shvW*pW)

Industry: Refining the model

- Any data on how industrial firms value water.

- Data on the amount of water withdrawn by various firms.

- Current allocation procedures? In times of scarcity?
  - What happened in 2003? Other drought years?
  - Is the verdringings reeks the only data/procedures on this?

Thank you for your attention