Econometric Model to predict the effect that various Water Resource Management Scenarios would have on South Africa’s Economic Development

Conningartrh Economists
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South Africa
CONTENT OF RSA PRESENTATION

- Overview of progress with the South African Inter-Industry Model (SAFRIM)
- The linkages to the Water Satellite Model (WSM)
- SAFRIM: Technical Presentation
- Demonstration
OBJECTIVE

- Development of an integrated macro-econometric model.

- Development of an appropriate analytical framework to examine effect of water policies.
RESEARCH PLAN

- Overall planning of research benchmark and theoretical conceptualization.
- Construction of model and collating of data.
- Technical validation of the model and scenario building.
- Final Report.
BASIC STRUCTURE OF SAFRIM

PRODUCTION BLOCK
- Production
- Productivity
- Employment
- Input/Output Matrix (A)
- Final Demand

MONETARY VARIABLES
- Disposable income distribution
- Direct taxes and transfers
- Government deficit
- Balance on current account

PRICE - INCOME BLOCK
- Private consumption expenditure
- Government consumption
- Fixed investment
- Inventory change
- Foreign trade

EXOGENOUS VARIABLES
- Wages and Salaries
- Profits
- Net indirect taxes
- Import taxes
- Value added
INTEGRATED WATER MODEL

- Integrating water sector into overall modeling.
  - See diagram 2

- Compiling Water Satellite Model
  - National Water Satellite Model.
  - Regional Water Satellite Model.

- Data requirements for Water Satellite Model.
INTEGRATED WATER MODEL

Diagram 1: Model Structure

INFORUM MACRO MODEL

BASE YEAR

- INFORUM macroeconomic Model
  - Sectoral structure
  - Value added and employment

FUTURE (FORECAST)

- INFORUM forecast
  - Revised INFORUM formulation

WATER SATELLITE MODEL

- [B] Water use by sectors and regions (base year)
  - Regional and industry data
  - Use by industry and region

- [C] Surface and groundwater resource
  - Water quality impacts
  - Future resource/supply
  - Future water use

Regional evaluation

Alternative scenarios
COMPONENTS OF INTEGRATED MODEL

- Demonstrating analytical capabilities of integrated model.
- Water Satellite Model
  - Water Coefficients
  - Elasticities
  - Tariff Changes
  - Drivers
- Conducting a benchmark for sectoral water demand for national and regional areas.
- Water Multipliers
  - Employment
  - Gross Domestic Product
  - Investment
  - Household Income
- Scenario setting
  - National and Regional
THE FORMAL STRUCTURE OF THE WATER DEMAND FUNCTIONS

Incorporating both average demand coefficients (water coefficients) and the price elasticities of the demand for water per sector/user, the following mathematical equation will be used for modelling purposes:

\[ D = [a + b(\Delta T)]C \]

where

- \( D \) = Total use for a category
- \( a \) = Average use per user unit
- \( b \) = Change in unit use due to a given tariff change
- \( \Delta T \) = Change in water tariff
- \( C \) = Total number of user units (driver/exogenous variable)

This kind of equation is widely used internationally mainly because of its theoretically sound foundations and the fact that it has found widespread practical applications. In the next chapter an analysis is given of the theoretical origin of the main elements of the above water demand function/equation, but in particular that of the price elasticity of demand.
THE FORMAL STRUCTURE OF THE WATER DEMAND FUNCTIONS

- Sectoral Distributions (Main Sectors)
  - Irrigation Agriculture
  - Mining
  - Manufacturing
  - Construction
  - Wholesale and Retail etc.
  - Transport
  - Communication
  - Financial Services
  - Other
  - Households
  - Total
THE FORMAL STRUCTURE OF THE WATER DEMAND FUNCTIONS

- Price elasticities of demand for water
- Water coefficients
  - Average water use (million cubic meter) per demand unit per annum.

<table>
<thead>
<tr>
<th></th>
<th>A (million m³)</th>
<th>B</th>
<th>AT (p.a.)</th>
<th>ΔC (%)</th>
<th>Number of users</th>
</tr>
</thead>
<tbody>
<tr>
<td>Irrigation</td>
<td>0.007</td>
<td>-0.01152</td>
<td>0.2%</td>
<td>Hectares</td>
<td></td>
</tr>
<tr>
<td>Agriculture</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>Hectares</td>
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<tr>
<td>Forestry</td>
<td>0.00032</td>
<td>0.00</td>
<td>0.2%</td>
<td>Hectares</td>
<td></td>
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<tr>
<td>Livestock</td>
<td>45</td>
<td>0.00</td>
<td>0.2%</td>
<td>Stock Population (LSU)</td>
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<tr>
<td>Households - High</td>
<td>101.8</td>
<td>-0.35</td>
<td>0.9%</td>
<td>Population</td>
<td></td>
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<tr>
<td>Households - Medium</td>
<td>20.3</td>
<td>-1.12</td>
<td>0.9%</td>
<td>Population</td>
<td></td>
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<tr>
<td>Households - Low</td>
<td>20.3</td>
<td>-0.12</td>
<td>0.9%</td>
<td>Population</td>
<td></td>
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<tr>
<td>Mining</td>
<td>0.00202</td>
<td>-0.01589</td>
<td>0.9%</td>
<td>Production</td>
<td></td>
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<tr>
<td>Manufacturing</td>
<td>0.000724</td>
<td>-0.01589</td>
<td>0.9%</td>
<td>Production</td>
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<td>Electricity and Water Supply</td>
<td>0.0014</td>
<td>-0.00022</td>
<td>0.9%</td>
<td>Production</td>
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<tr>
<td>Tertiary Sector</td>
<td>0.007247</td>
<td>-0.01436</td>
<td>0.9%</td>
<td>Production</td>
<td></td>
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<tr>
<td>Parks</td>
<td>74.64</td>
<td>-0.91</td>
<td>0.9%</td>
<td>Population</td>
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**SCENARIO SETTING**

- **Base Scenario**
  - 3% per annum growth
- **High Growth**
  - 6% per annum medium to long term
- **High Tariff**
- **Location Constraint**
ACTUAL AND ESTIMATED SECTORAL PRODUCTION FOR SOME WATER INTENSIVE SECTORS (AGRICULTURE)
ACTUAL AND ESTIMATED SECTORAL PRODUCTION FOR SOME WATER INTENSIVE SECTORS (COAL MINING)

Coal Mining

Production Water Intensive Sectors: Actual & Estimated

<table>
<thead>
<tr>
<th>Year</th>
<th>Actual Production</th>
<th>Estimated Production</th>
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<tbody>
<tr>
<td>1996</td>
<td>20620</td>
<td></td>
</tr>
<tr>
<td>1998</td>
<td>24734</td>
<td></td>
</tr>
<tr>
<td>2000</td>
<td>28847</td>
<td></td>
</tr>
<tr>
<td>2002</td>
<td></td>
<td>c.outU2</td>
</tr>
<tr>
<td>2004</td>
<td></td>
<td>b.outU2</td>
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ACTUAL AND ESTIMATED SECTORAL PRODUCTION FOR SOME WATER INTENSIVE SECTORS (GOLD AND URANIUM ORE MINING)

Gold and Uranium Ore Mining

Production Water Intensive Sectors: Actual & Estimated
ACTUAL AND ESTRIMATED SECTORAL PRODUCTION FOR SOME WATER INTENSIVE SECTORS (PAPER AND PAPER PRODUCTS)

Paper & Paper Products
Production Water Intensive Sectors: Actual & Estimated

b.outU13  c.outU13
ACTUAL AND ESTIMATED SECTORAL PRODUCTION FOR SOME WATER INTENSIVE SECTORS (COKE AND Refined PETROLEUM)
ACTUAL AND ESTIMATED SECTORAL PRODUCTION FOR SOME WATER INTENSIVE SECTORS (BASIC CHEMICALS)

Basic Chemicals

Production Water Intensive Sectors: Actual & Estimated
ACTUAL AND ESTIMATED SECTORAL PRODUCTION FOR SOME WATER INTENSIVE SECTORS (BASIC IRON AND STEEL)
ACTUAL AND ESTIMATED SECTORAL PRODUCTION FOR SOME WATER INTENSIVE SECTORS (BASIC NON-FERROUS SECTORS)

Basic Non-Ferrous Metals
Production Water Intensive Sectors: Actual & Estimated

- Actual Production: 22456, 16473, 10490

Graph showing the production values over the years.
BASELINE SCENARIO
LOCATION CONSTRAINT SCENARIO

![Graph showing Demand/Supply Ratio Mm^3 (Base), Historic Benchmark, and Demand/Supply Ratio Mm^3 (Location Constraint) over the years 2004 to 2020. The graph indicates a growing trend in the ratio, with the Location Constraint scenario showing a slightly higher trend compared to the Base and Historic Benchmark scenarios.]
### SUMMARY OF SCENARIOS – ECONOMIC IMPACT

<table>
<thead>
<tr>
<th>Economic Levels</th>
<th>Standard</th>
<th>Scenario 1</th>
<th>Scenario 2</th>
<th>Scenario 3</th>
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</thead>
<tbody>
<tr>
<td>Water (Million m3)</td>
<td>3 289</td>
<td>3 718</td>
<td>3 132</td>
<td>3 186</td>
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<tr>
<td>GDP (R million)</td>
<td>408 255</td>
<td>518 804</td>
<td>408 255</td>
<td>396 776</td>
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<tr>
<td>Employment (Number)</td>
<td>3 728 023</td>
<td>4 735 363</td>
<td>3 728 023</td>
<td>3 554 059</td>
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**SUMMARY OF SCENARIOS – WATER EFFICIENCY**

<table>
<thead>
<tr>
<th>Level change of Economic Aggregate</th>
<th>Scenario 2</th>
<th>Scenario 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water (Million m³)</td>
<td>Standard</td>
<td>Scenario 1</td>
</tr>
<tr>
<td>(Level)</td>
<td>High Growth Increment</td>
<td>(Increment)</td>
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<tr>
<td>3 289</td>
<td>429</td>
<td>-157</td>
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<tr>
<td>GDP (R million)</td>
<td>408 255</td>
<td>110 549</td>
</tr>
<tr>
<td>Employment (Number)</td>
<td>3 728 023</td>
<td>1 007 340</td>
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</table>

**Efficiency Criteria**

<table>
<thead>
<tr>
<th>Efficiency Criteria</th>
<th>Scenario 2</th>
<th>Scenario 3</th>
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<tbody>
<tr>
<td>ΔGDP/Δwater (ΔMm³)</td>
<td>124</td>
<td>258</td>
</tr>
<tr>
<td>ΔEmpl/Δwater (ΔMm³)</td>
<td>1133</td>
<td>2 348</td>
</tr>
</tbody>
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### SUMMARY OF SCENARIOS – HISTORIC LEVELS OF AGGREGATES

<table>
<thead>
<tr>
<th>Economic Aggregates</th>
<th>Standard Scenario 2004</th>
<th>Scenario 1 High Growth 2020</th>
<th>Water Tariff Increase 2020</th>
<th>Constraint of Location 2020</th>
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</thead>
<tbody>
<tr>
<td>Water (Million m³)</td>
<td>2 920</td>
<td>3 744</td>
<td>4 742</td>
<td>3 559</td>
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<tr>
<td>GDP (R million)</td>
<td>328 568</td>
<td>483 218</td>
<td>737 650</td>
<td>483 218</td>
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<tr>
<td>Employment (Number)</td>
<td>3 039 371</td>
<td>4 387 214</td>
<td>6 697 240</td>
<td>4 387 214</td>
</tr>
</tbody>
</table>

Note: The above table represents the historic levels of aggregates under different scenarios for the years 2004, 2020, and 2020. The scenarios include Standard, Scenario 1 with High Growth, Water Tariff Increase, and Constraint of Location.
WAY FORWARD

- Appropriateness of IMS.
- Important results of IM/WSM Model application.
- Possible future steps to improve on model capabilities:
  - Expansion of regional reach of WSM.
  - Primary research needs on price elasticities of demand.
  - Location of model.
  - Data archiving.
- The way forward.