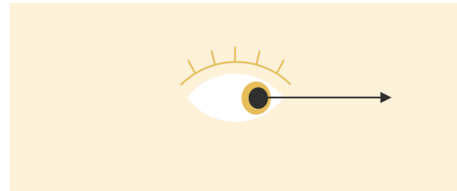# THE BOYNE ISLAND SMELTER:

A CASE STUDY

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Economic Modelling
with
Sector-specific Euler Equations

``emsee'' model overview

CGE model with forward-looking dynamics:

Supply = Demand (output = med + con + inv + xpo) at each time
Capital depreciates and is optimally replenished to grow the economy.
Output is a function of capital, labour, inter**med**iates (with imports) and a fixed factor.
Balanced growth paths: each sector grows in range 1% to 2%
Solve as a sequence of overlapping nonlinear dynamic programs (Cai–Judd; Na et al.; 2021)

Sector-specific Euler Eq'ns:

Testable condition: ``value capital today'' = ``**expected value** of capital in the future''
*When the **SEE** hold,* **capital is optimally allocated across sectors**
• Absent in intersectoral models: CoPS; Atalay; Cesa-Bianchi et al; Baqaee and Farhi

Transition to net zero: some SEE may fail to hold ∴
• sectoral shocks are more likely to spill over/propagate to other sectors
• the economy has more capacity for adaptation: chance to nudge economy to new equilibria

Aluminium Industry and
Boyne Smelters Limited (**BSL**)

Australia: energy-abundant and fully integrated Aluminium supply chain
- One of only three countries in the world along with Brazil and Venezuela.

Qld: Weipa Bauxite 🚢 Gladstone for AlOx refining and Al smelting at BSL
- Gladstone Bauxite imports less than half of Weipa production
- QAL and Yarwun: Alumina sales to BSL is 15% of total output
No obvious major threats to overall supply chain: Rio Tinto is majority owner

BSL: consumes 1/8 of Qld's electricity; large energy **subsidy** ($250m+)
- Like other smelters it is in close proximity of energy resources
- Recent smelter closures:
    - Kurri Kurri, NSW closed in 2012
    - Tiwai Point, New Zealand *almost* closed in 2020-2021

- Qld Energy and Jobs Plan:
    - Sustaining heavy industry in Qld is a key part of the transition

Gladstone, Central Queensland

Gladstone (2018-19 economy, SA3/LGA):

$15.5bn aggregate output: approx. 25% of Central Qld, 2% Qld

29k FTE: approx. 28% of Central Qld, 1.3% of Qld

63k population: highly skilled, but aging with 0.7% growth

- Multi-commodity deep-water port plus rail and road infrastructure

Gladstone is Qld's regional manufacturing hub:

$5.5bn to $6bn Manufacturing output: of which approx. $1bn is BSL

4k to 4.5k Manufacturing FTE employees: of which 1k at **BSL**

- **BSL represents approx. ¼ of Manufacturing** activity except in energy consumption

Other Heavy industry: Ammonia, Cement, LNG, Oil refinery

Growth industries: ag-tech, AlOx for batteries, aquaculture, Mining Serv., green {…}

Data sources

We specialise the model to the Gladstone region with 19 ANZSIC divisions:

Jobs in Australia ABS data: labour per sector for Gladstone 2019.

Input-output flows between sectors: ABS tables 5 and 8 for Australia

Investment flows between sectors: following Atalay (2017)

- Adapt investment flows tables from the US Bureau of Economic Analysis
- ABS Gross Fixed Capital Formation by Industry by type of Asset

BLADE *(and Remplan):* for output per sector for Gladstone 2019

Gladstone Port data for Bauxite, Alumina, Aluminium and Coal

- Eg. Bauxite imports

Rio Tinto accounts

Studies on aluminium production e.g.

- Gagne and Nappi 2000
- Best Available Techniques 2017

Experiments and shocks

Experiment Type (1):

1st phase: tune parameters to regionalise, ***all 19 SEE hold***

2nd phase: capital evolves towards a balanced growth path

3rd phase: continue along same path and generate

- ``status quo'' path
- ``shock'' (BSL closure) path

Experiment Type (2):

1st phase: tune parameters to regionalise; ***not all 19 SEE hold***

2nd phase: capital evolves towards a balanced growth path

3rd phase: continue along same path and generate

- ``status quo'' path
- ``shock'' (BSL closure) path

Shock type (a): one-off "MIT shock" agents don't see coming

- 1/4 decrease in Manufacturing productivity, capital and exports
- 5/6 decrease in Utilities (energy + water) purchases by Manufacturing
- No **exogenous** decommissioning or replacement activity

Experiment (1a) Summary of Results

Shock is sector-specific

Aggregate Output -$1.7bn	
Manufacturing	Others
-$1.59bn	-$0.1bn

Utilities prices ↓ by 4%

Agriculture, Consumption ↑

* But Gladstone is connected to NEM …

Manufacturing employment ↑ 6%:

- At 32% lower pay as economy strives to preserve current equilibrium.

Experiment (2a) *an example* of Results

Shock is more dispersed

Aggregate Output -$0.85bn	
Manufacturing	Others
-$1.14bn	+$0.29bn

Prices: Utilities ↓ 10%, Manuf. ↓ 3%

Agriculture, Mining, … ↑ Consumption ↑

* But Gladstone is connected to NEM …

Employment: Manuf. ↓ 1.5%:

- At 19% lower pay.
- Agric. employment ↑ 5%, Mining more
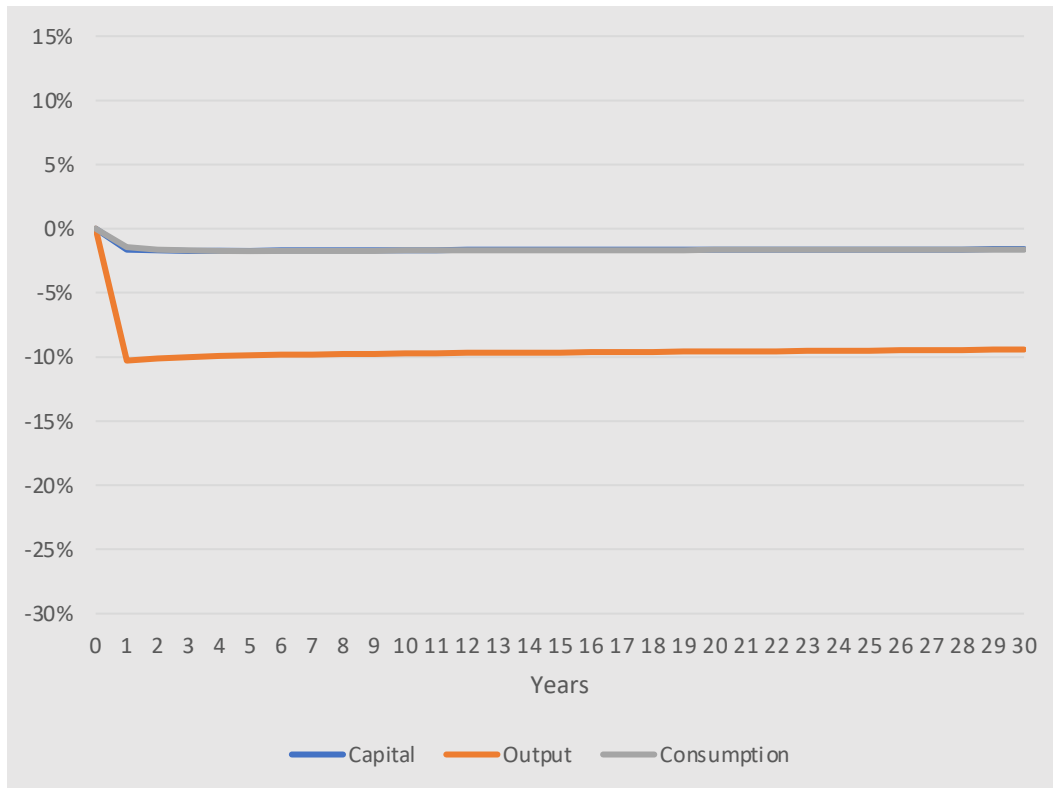
Comparison of experiments:

(1a)   (2a)
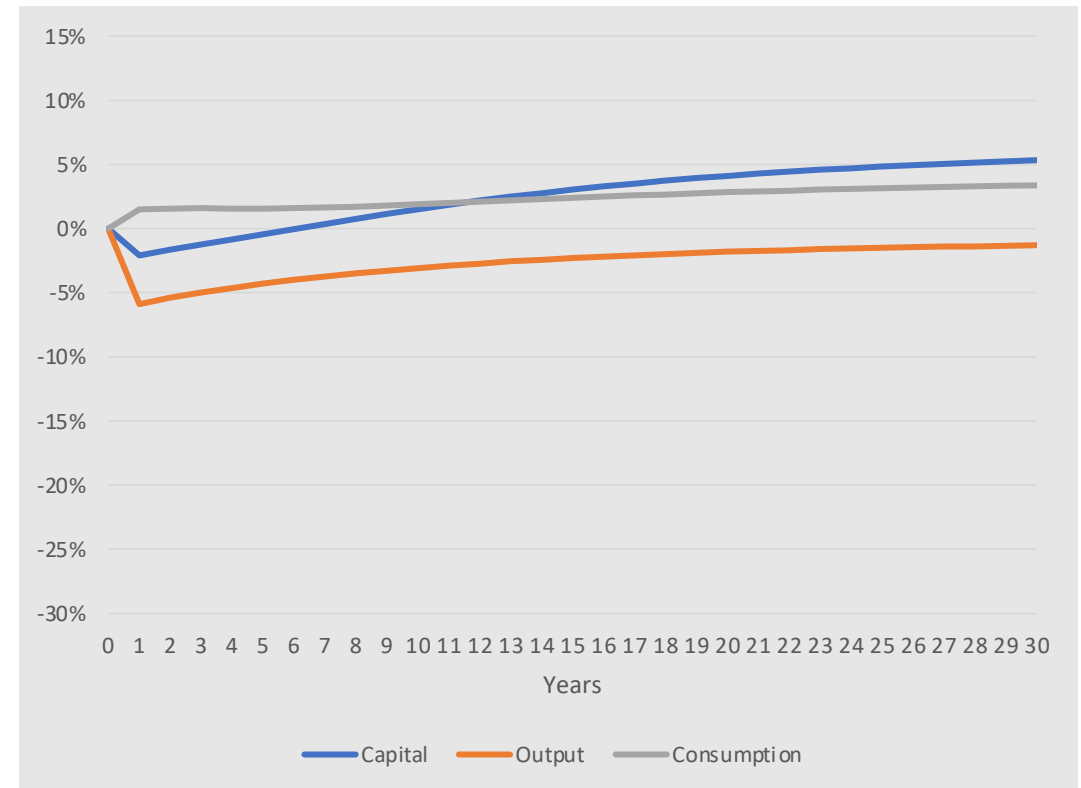
All 20 SEE hold   ***Not*** *all 20 SEE hold*

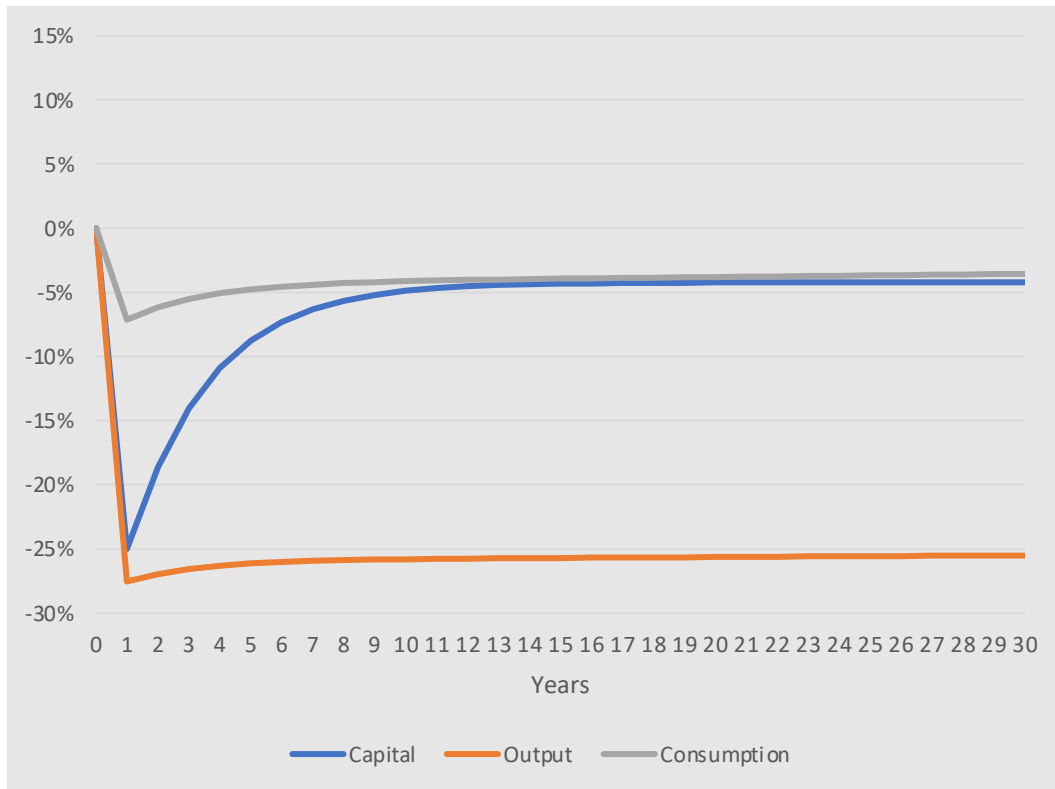Experiment-shock (1a): **% change relative to status quo, Aggregates**

Aggregate Capital permanently down by 1.6-1.7%
Aggregate Output permanently down by 11% or $1.7bn
Consumption falls as aggregate price levels rise

Experiment-shock (2a): **% change relative to status quo, Aggregates**

Aggregate Capital is higher than status quo after 7 years
Output initially falls by 6% or $0.85bn before rising;
Consumption is 3.5% higher in the long run.

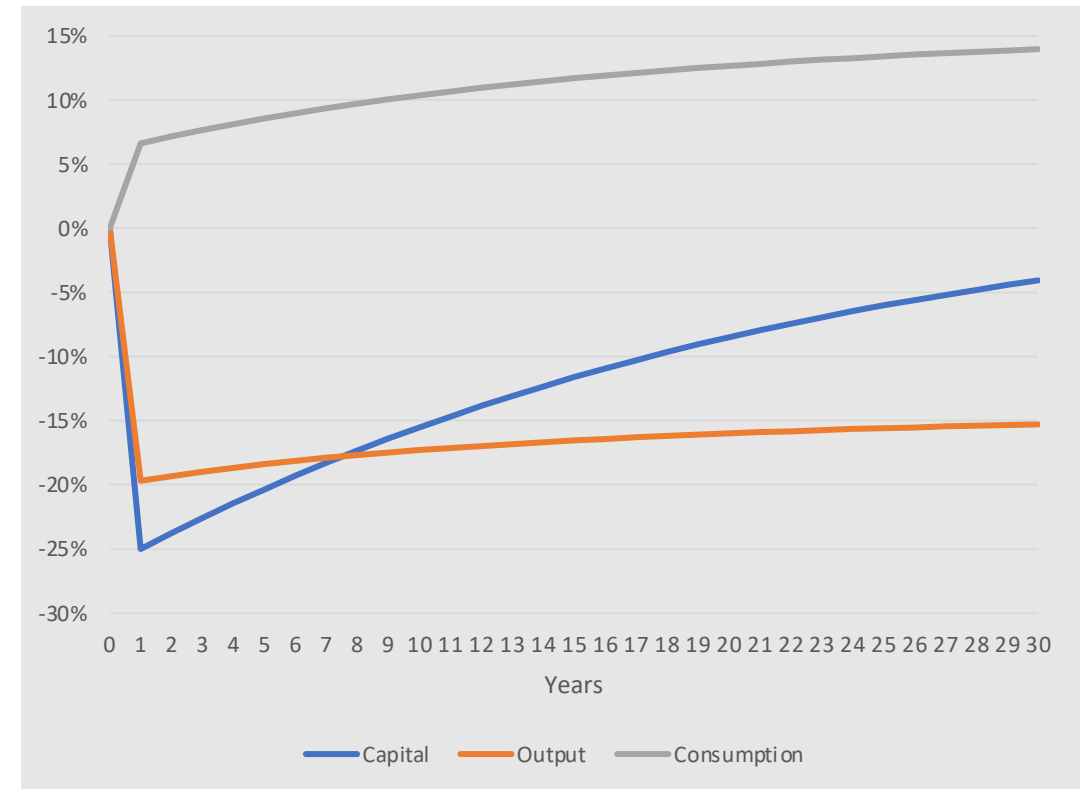Experiment-shock (1a): **% change relative to status quo, Manufacturing**

Manufacturing capital quickly recovers
Manufacturing output down by 27% or $1.5bn
Consumption falls as Manufacturing prices rise.

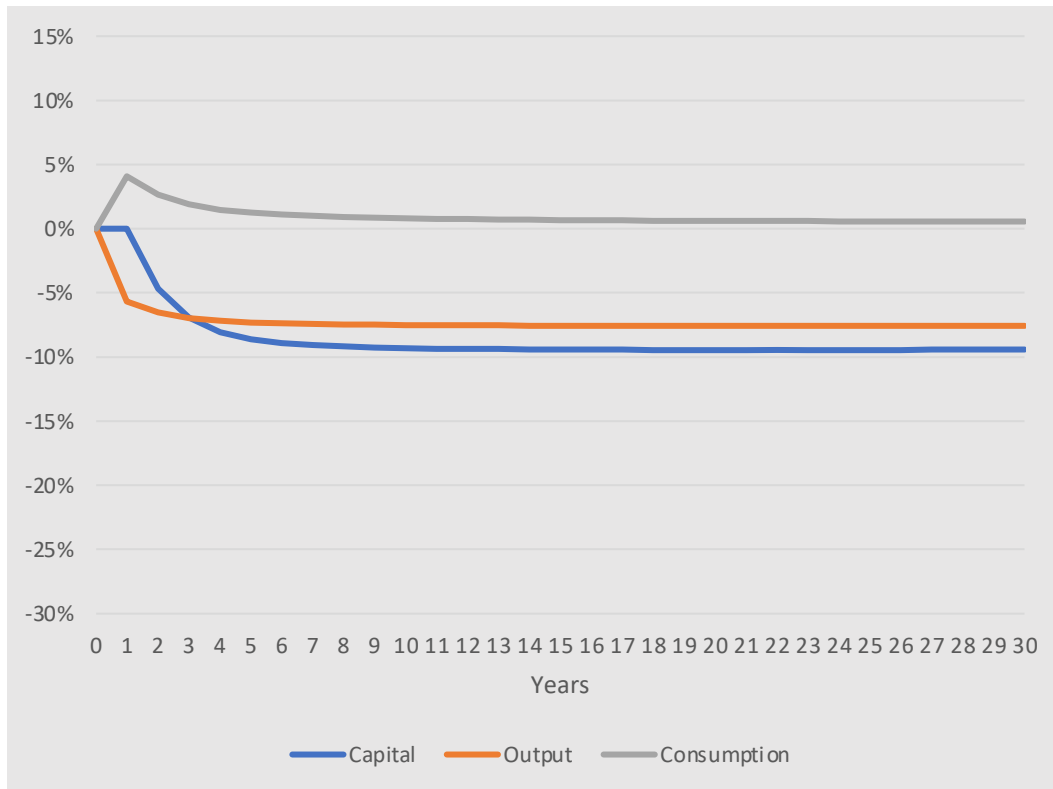Experiment-shock (2a): **% change relative to status quo, Manufacturing**

Manufacturing capital slowly recovers
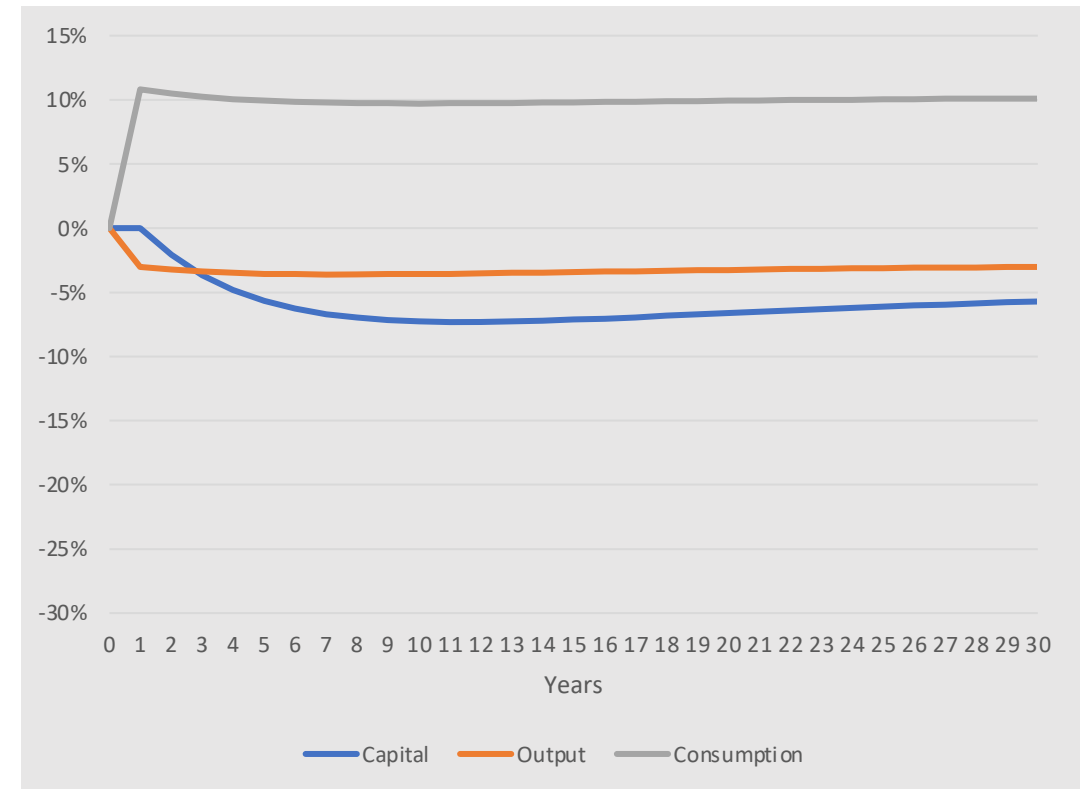Manufacturing output down by 20% or $1.1bn
Consumption rises as Manufacturing prices fall.

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Experiment-shock (1a): **% change relative to status quo, Utilities**

Experiment-shock (2a): **% change relative to status quo, Utilities**
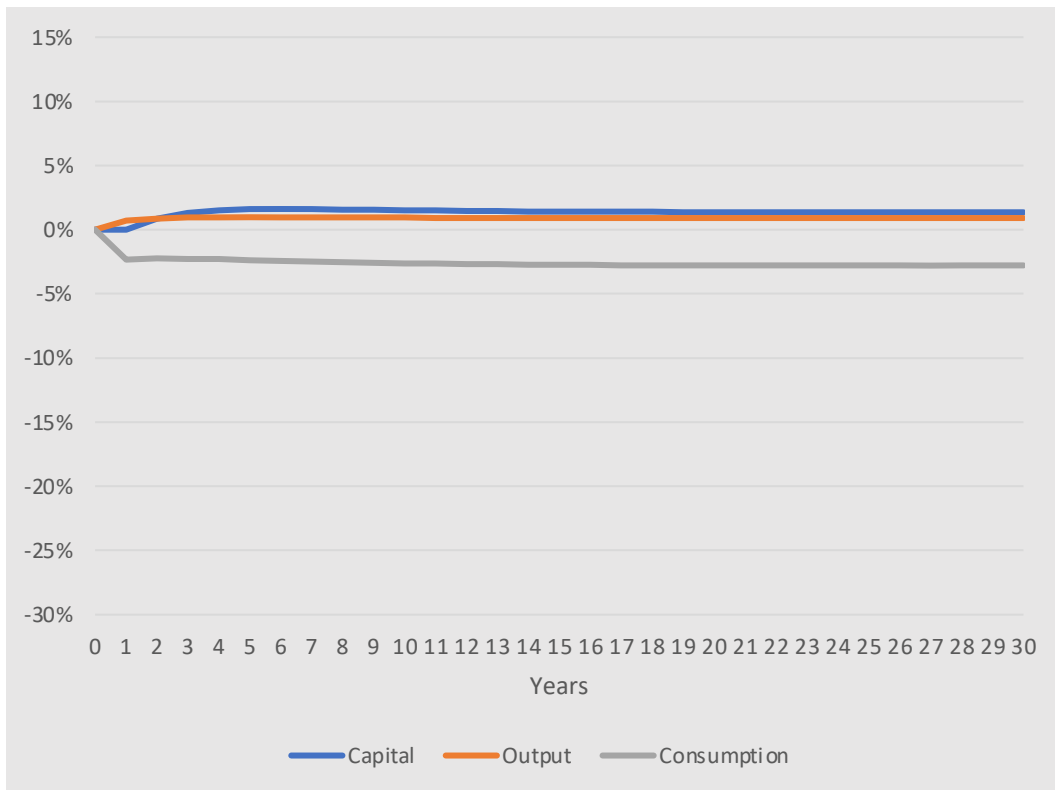

Capital down by 9% in the long run.
Utilities (Energy and Water) price initially fall by 4%;
Consumption up compensating for falls elsewhere;

Capital down by 6% in the long run;
Utilities price down by 10% and remains there;
Consumption up and remains there

Experiment-shock (1a): **% change relative to status quo,**
Agriculture (Similar pictures for Mining.)

Cheaper energy and water prices cause
Capital up, Output up and consumption down

Experiment-shock (2a): **% change relative to status quo,**
Agriculture
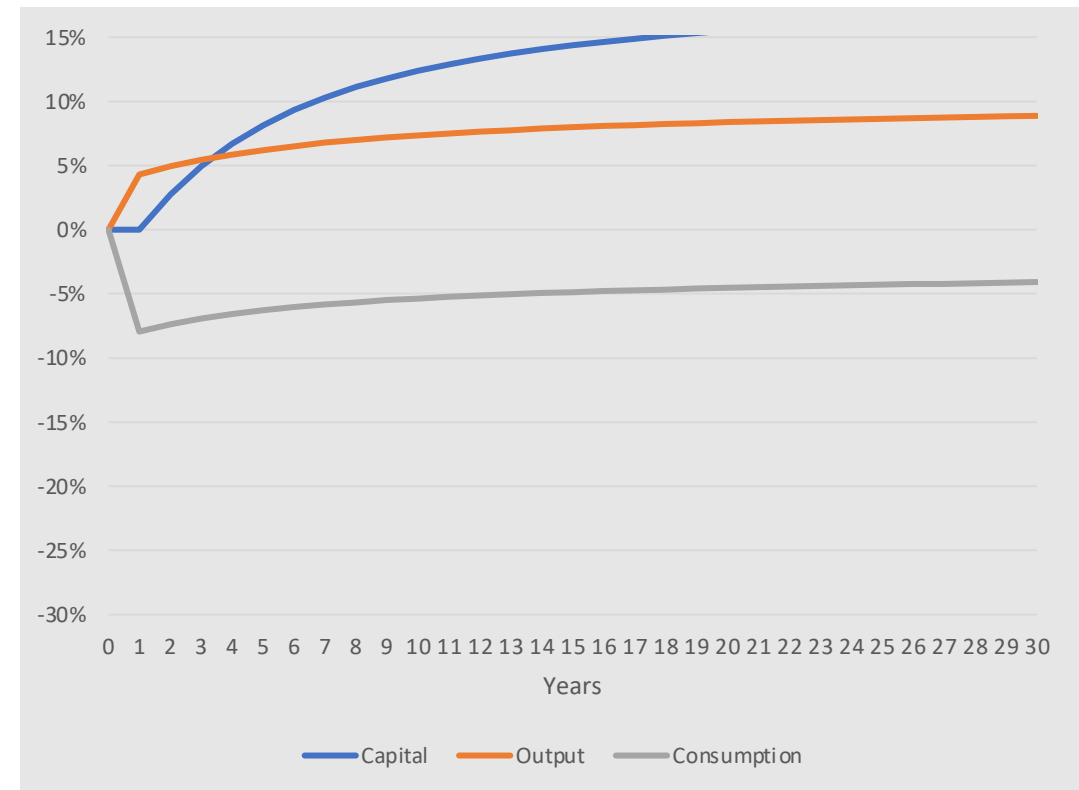
Similar, but more extreme:
Capital up by over 15% in the long run.

Key takeaways

BSL is important to Gladstone's economy and Qld's Al/AlOx supply chain

Transition needs to be handled with care: major consumer of energy and energy prices ↑

Gladstone Aluminium: internationally competitive (given right energy transition)

June 2022: Rio Tinto calls for clean Gladstone Aluminium by 2030.

September 2022, Qld Energy Plan: supergrid can keep Gladstone in proximity of power supply

Economic modelling with SEE:

Testable equations with long history in macroeconomics / finance (absent in CGE)

- If the SEE hold, then the shock is more sector-specific (less macroeconomic)

Transition: some SEE will not hold (given uncertainty and out-of-date capital)

Greater **propagation of shocks**, but also greater **opportunity for change**

Policy implications:

We can estimate how the SEE fail and identify paths of least resistance for transforming the economy

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