

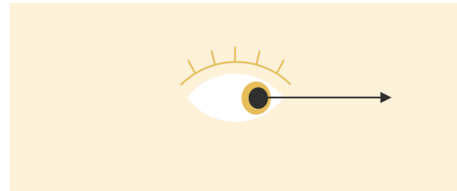
THE BOYNE ISLAND SMELTER:

A CASE STUDY

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Economic Modelling
with
Sector-specific Euler Equations

“emsee” model overview



CGE model with forward-looking dynamics:

General equilibrium: supply = demand at each region, sector, time, ...

Capital is optimally replenished using inputs from all sectors

Balanced growth paths: each sector grows in range 1% to 2%

Computable: sequence of overlapping nonlinear dynamic programs (Cai–Judd; Na et al.; 2021)

Sector-specific Euler Eq'ns:

When the SEE hold, capital is optimally allocated across sectors

Testable: “value capital today” = “expected value of capital in the future”

Absent: in intersectoral models such as CoPS; Atalay; Cesa-Bianchi et al; Baqaee and Farhi

Transition to net zero: lots of rapid change and uncertainty

Behavioural economics: decisions are hard in such settings, so some of the SEE will fail to hold.

When some of the SEE fail to hold:

- Sector-specific shocks more likely to spread/propagate
- **more capacity for adaptation:** more opportunities to nudge economy to new equilibria

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

Australia: energy-abundant with a fully integrated Aluminium supply chain

- One of only three countries in the world along with Brazil and Venezuela.

Qld: Weipa Bauxite 50% to Gladstone; AlOx refining; Al smelting at BSL

- Gladstone refineries (Qld Alumina and Yarwun Alumina): sell 15% to BSL
- *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+)

One of four smelters in Australia NSW, Victoria and Tasmania

- Kurri Kurri, NSW closed in 2012
- Tiwai Point, New Zealand, Rio Tinto *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 **output**: approx. 25% of Central Qld, 2% Qld

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



Gladstone is Qld's regional  manufacturing hub:

BSL represents approx. ¼ of Manufacturing activity (large energy consumption)

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

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

Data sources

We specialise the model to a 19 (ANZSIC division) Gladstone economy:

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 US data (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

Rio Tinto accounts

Studies on aluminium production e.g.

- Gagne and Nappi 2000
- Best Available Techniques 2017

Experiments and shocks

Experiment (1) *all 19 SEE hold*

1st phase: tune parameters to regionalise;

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 (2) *not all 19 SEE hold*

1st phase: tune parameters to regionalise;

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:

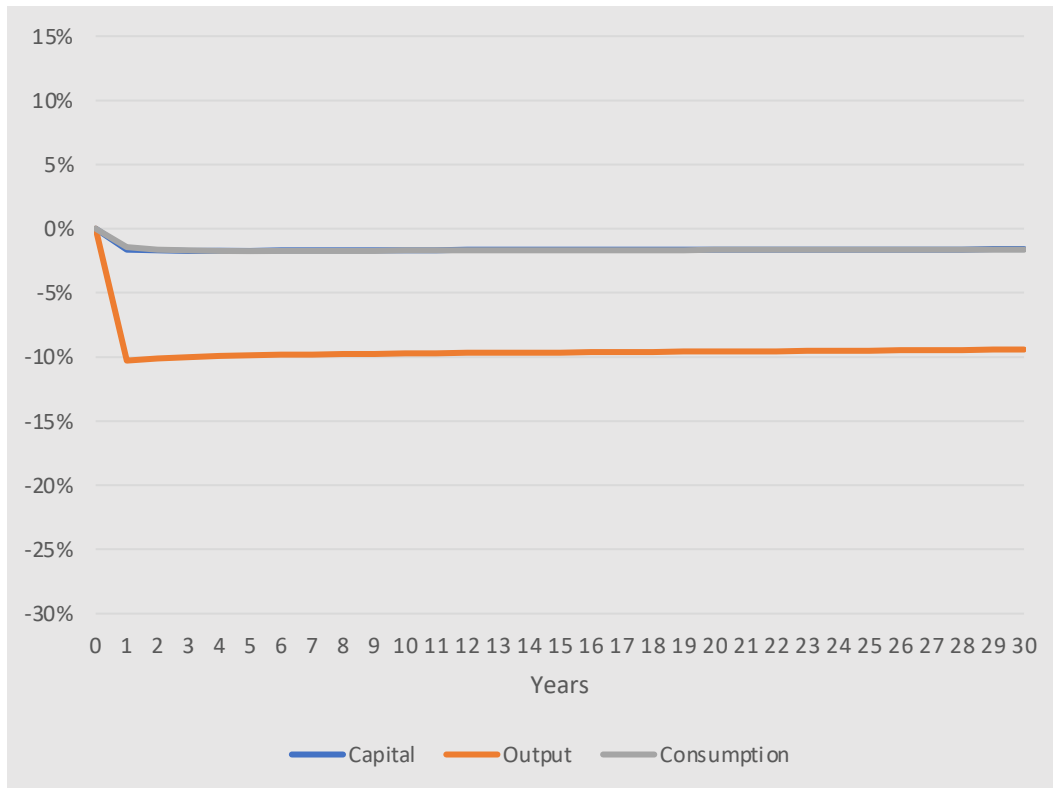
(1a)

All 19 SEE hold

(2a)

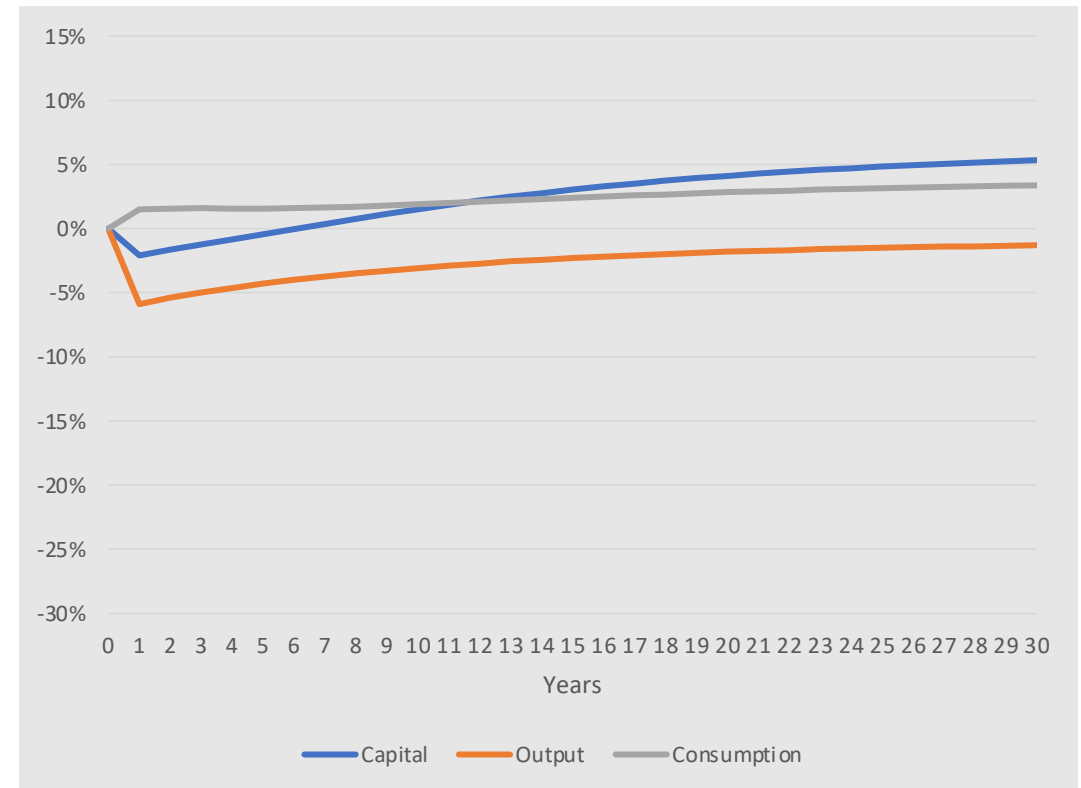
Not all 19 SEE hold

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



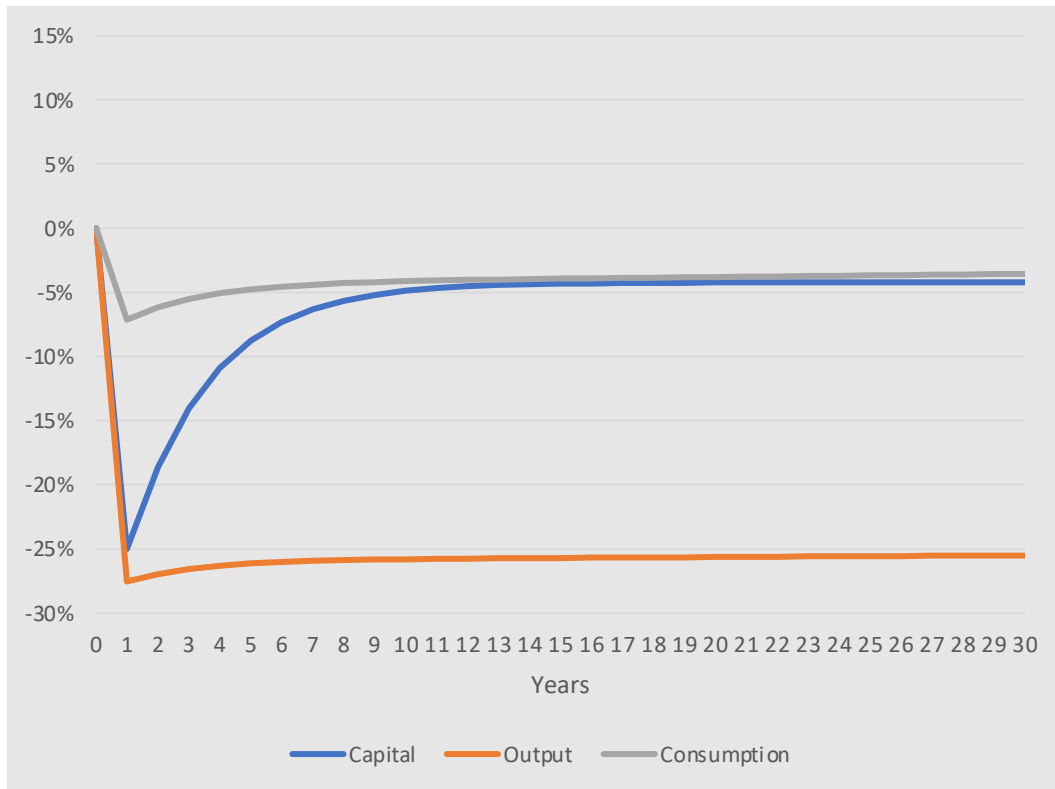
Aggregate Capital permanently down by 1.6-1.7%
Aggregate Output permanently down by 11% or \$1.7bn
Consumption falls as aggregate price levels rise

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

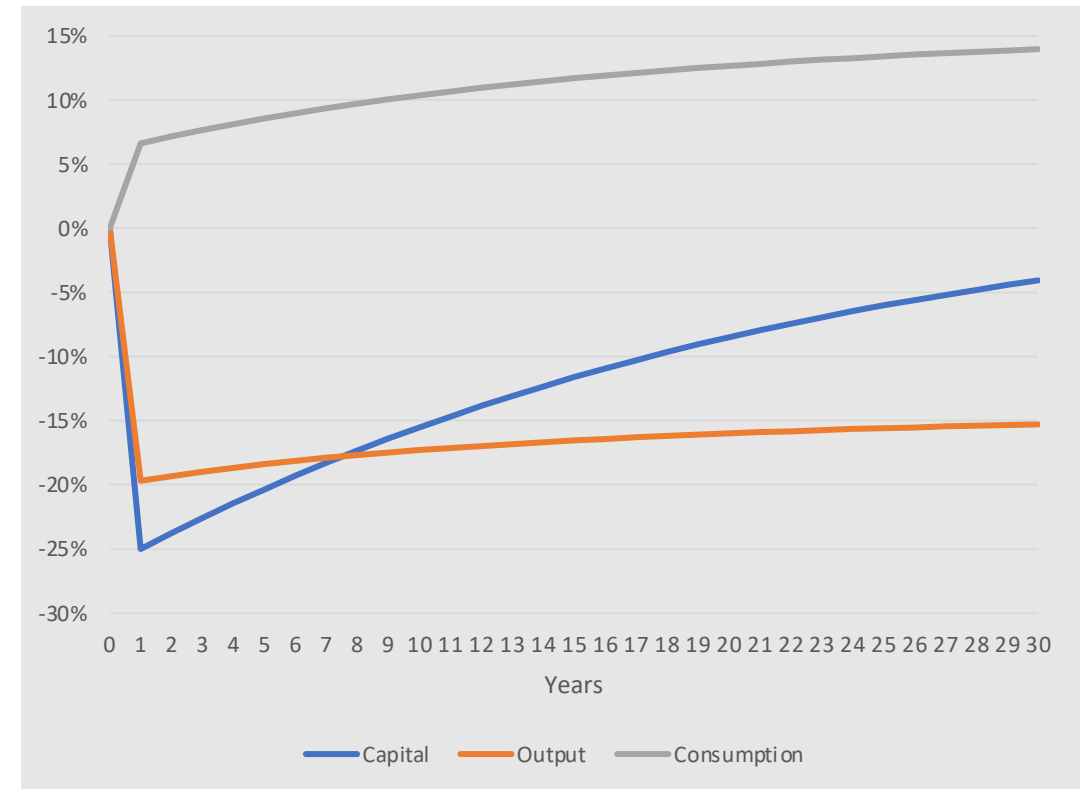


Manufacturing capital quickly recovers

Manufacturing output down by 27% or \$1.5bn

Consumption falls as Manufacturing prices rise.

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

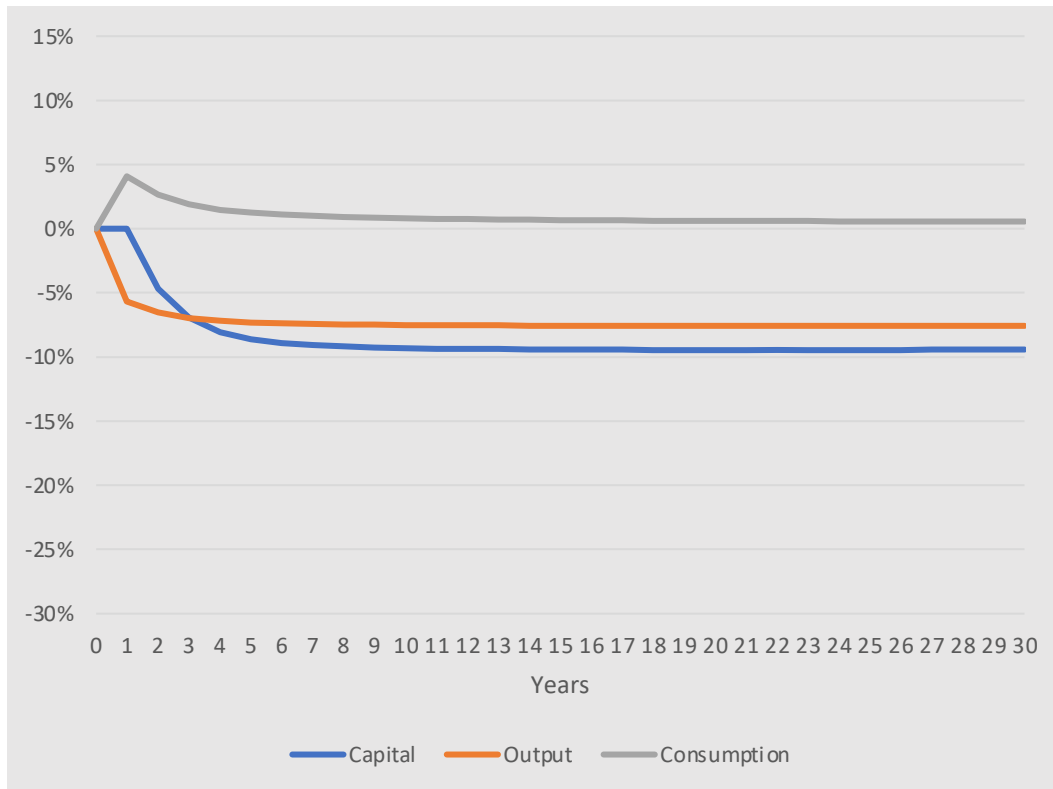


Manufacturing capital slowly recovers

Manufacturing output down by 20% or \$1.1bn

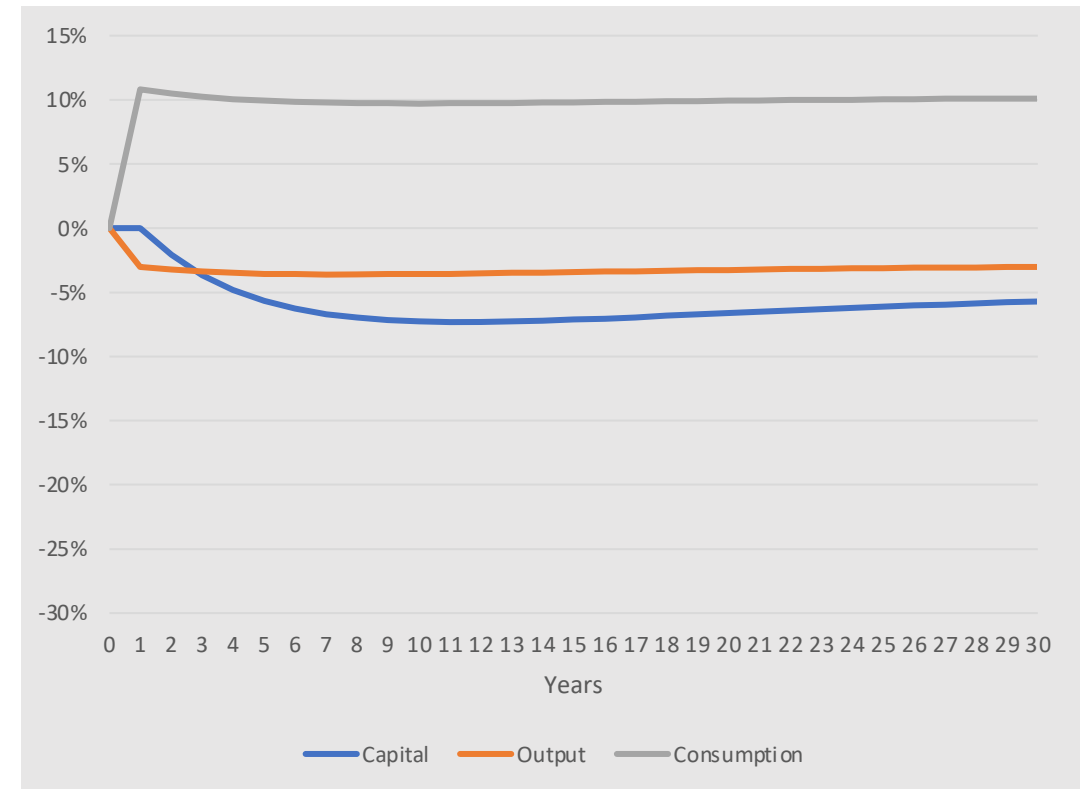
Consumption rises as Manufacturing prices fall.

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



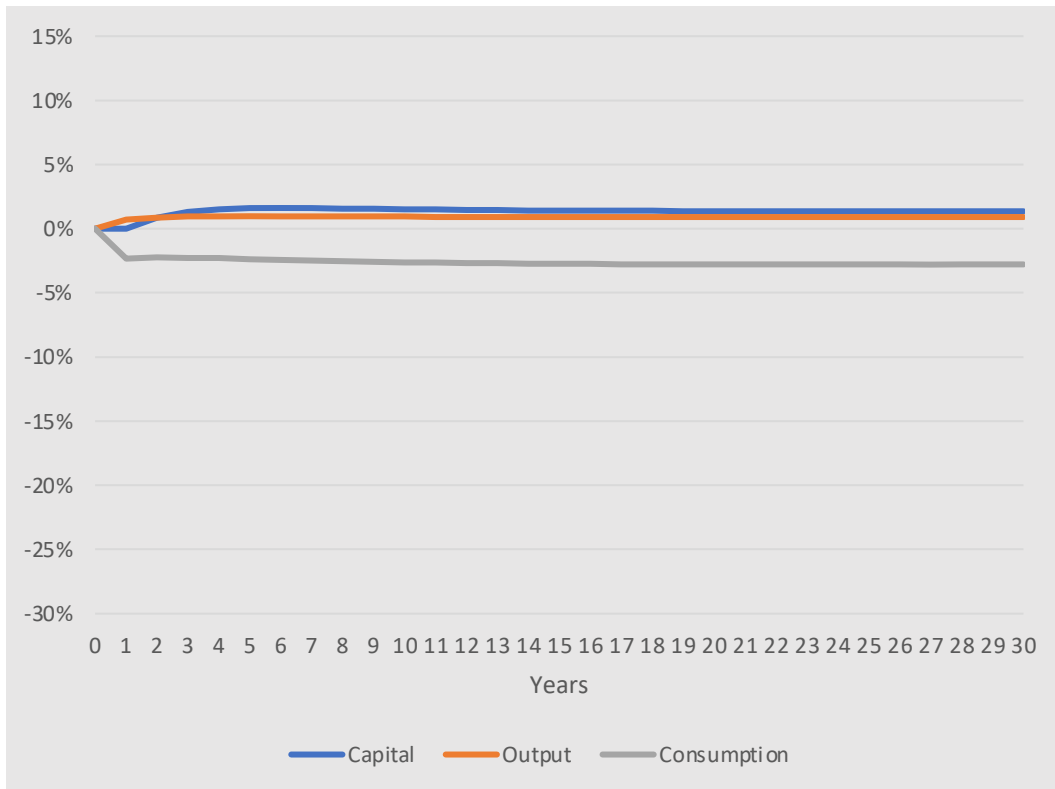
Capital down by 9% in the long run.
Utilities (Energy and Water) price initially fall by 4%;
Consumption up compensating for falls elsewhere;

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



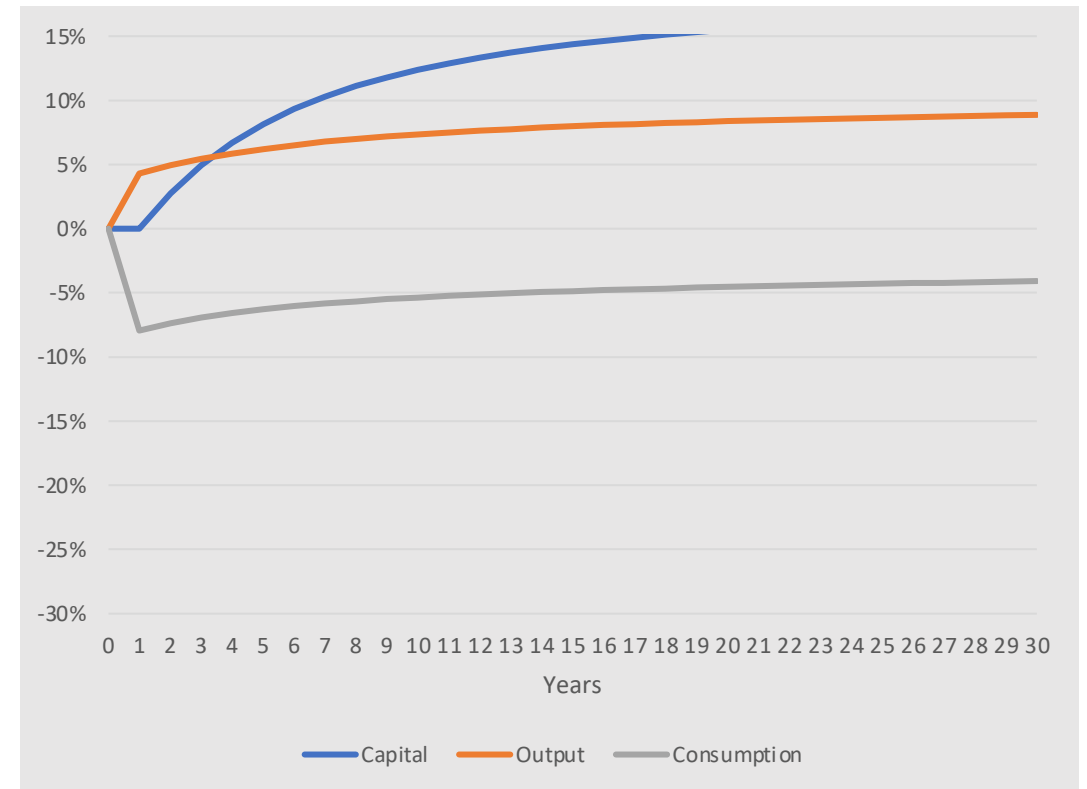
Capital down by 6% in the long run;
Utilities price down by 10% and remains there;
Consumption up and remains there

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 the overall 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 to net zero:

Some SEE will not hold (given high 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 economic transformation.

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