THE BOYNE ISLAND SMELTER:

A CASE STUDY

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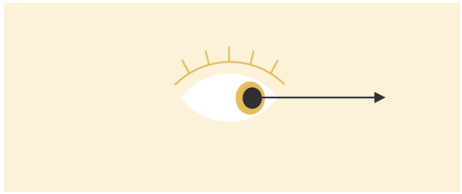
Economic Modelling
with
Sector-specific Euler Equations

``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%

Computation: **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 lead to corrections that spill over to other sectors
- 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:

- Other Heavy industry: Ammonia, Cement, LNG, Oil refinery
- **Growth industries**: ag-tech, AlOx batteries, aquaculture, Mining Serv., green {…}
- **BSL represents approx. ¼ of Manufacturing** activity (large energy consumption)

Data sources

Regionalisation to a 19-sector (ANZSIC divisions) Gladstone economy

Investment flows between sectors: method of Atalay (2017)

- Adapt investment flows tables from US data

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

Jobs in Australia ABS data: labour per sector for Gladstone 2019.
Input-output flows between sectors: ABS tables 5 and 8 for Australia
Gross Fixed Capital Formation by Industry by type of Asset: ABS for Australia
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/regionalise parameters

2nd phase: capital evolves towards a balanced growth path;

3rd phase: continue and generate

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

Experiment (2) *not all 19 SEE hold*

1st phase: tune/regionalise parameters;

2nd phase: capital evolves towards a balanced growth path;

3rd phase: continue 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 price falls by 4%:

Increases: Agriculture and Consumption

Economy preserves the status quo:

Manufacturing employment actually rises

(Compensation of Employees does indeed fall**)**

Experiment (2a) An example of Results

Shock is more dispersed

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

Utilities and Manufacturing prices fall

Increases: Agriculture, Mining, …, Consumption

Economy departs from the status quo

Manufacturing employment falls

(Agriculture and Mining employment rise**)**

Comparison of experiments:

(1a)

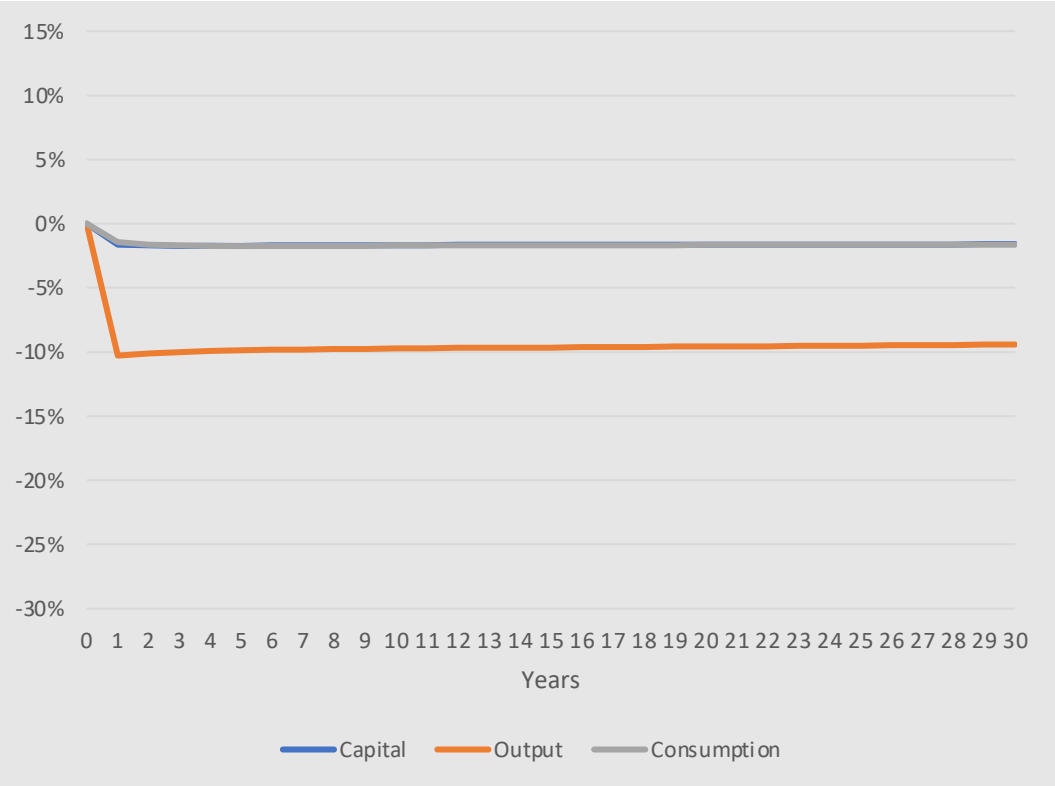
All 19 SEE hold

(2a)

Not all 19 SEE hold

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

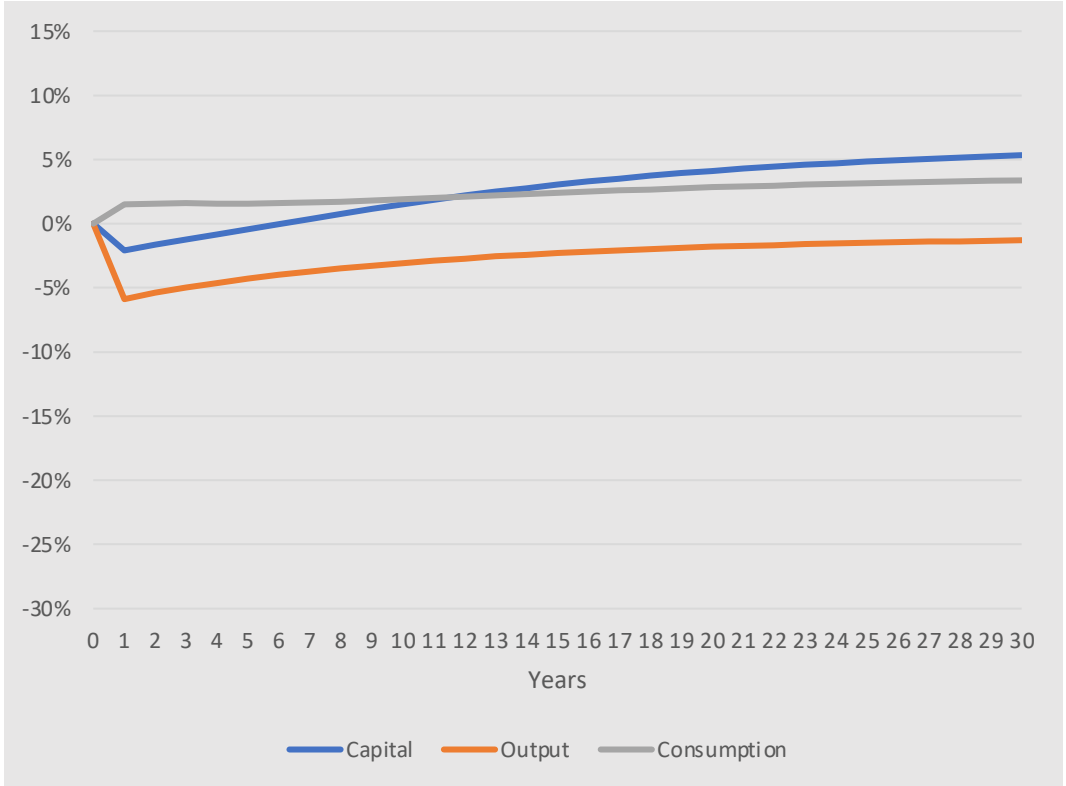
Aggregates



Aggregate Capital permanently down;
Aggregate Output permanently down by 10%;
Consumption falls as aggregate price levels rise

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

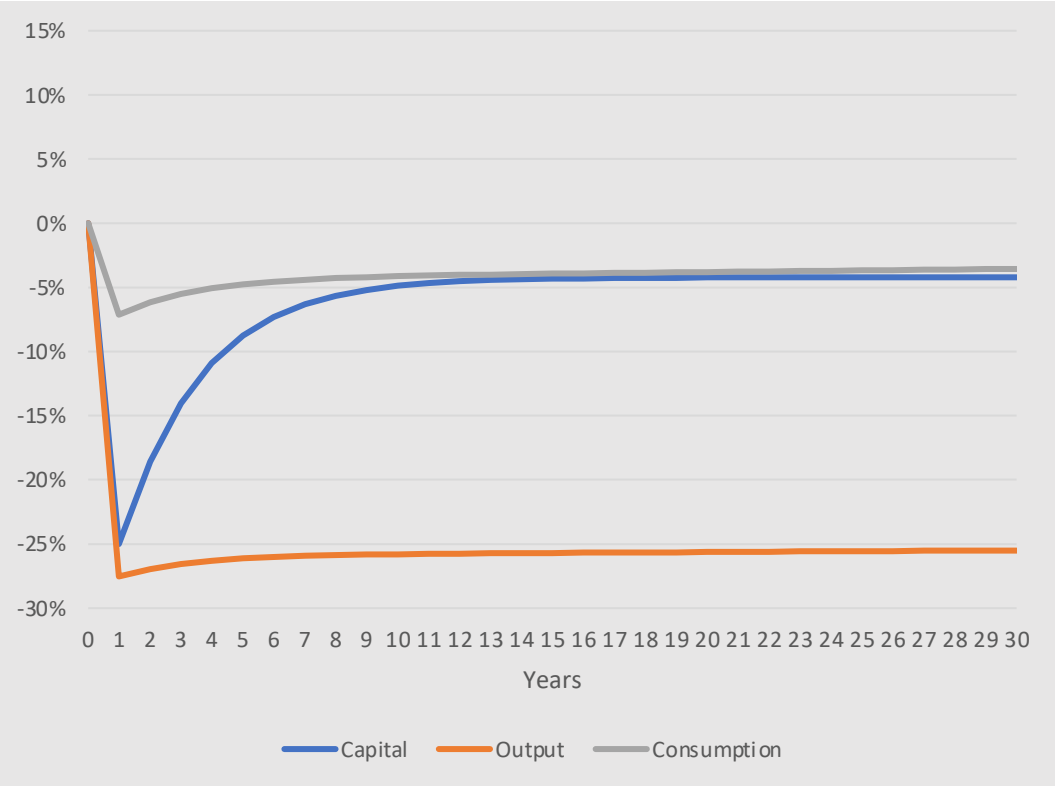
Aggregates



Aggregate Capital falls, but then rises above status quo;
Output initially falls by 6% before rising;
Consumption is 3.5% higher in the long run

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

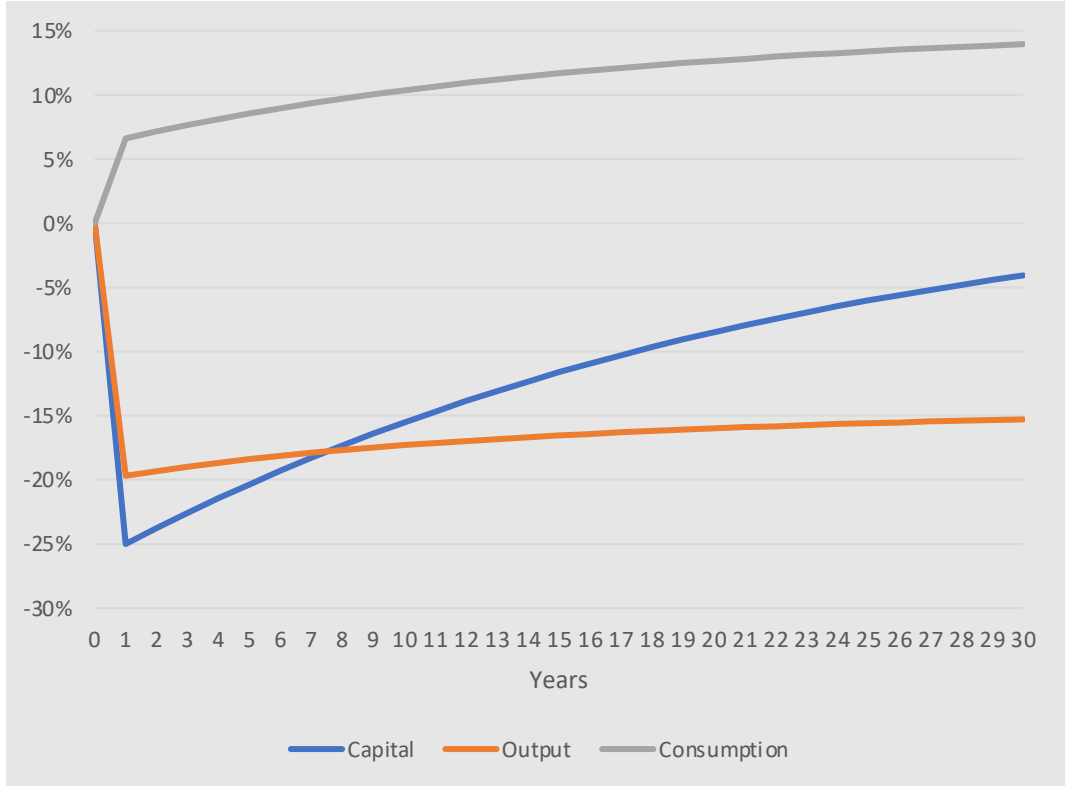
Manufacturing



Manufacturing capital quickly recovers;
Consumption falls (prices rise)

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

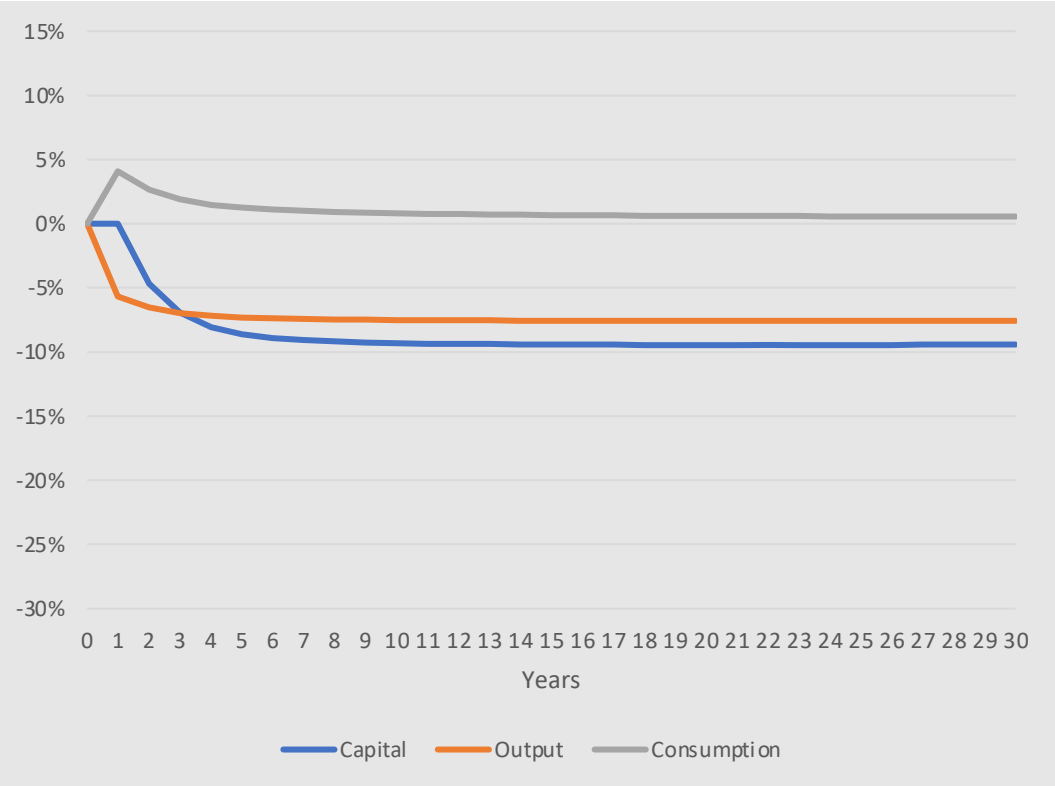
Manufacturing



Manufacturing capital slowly recovers;
Consumption rises (prices fall)

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

Utilities

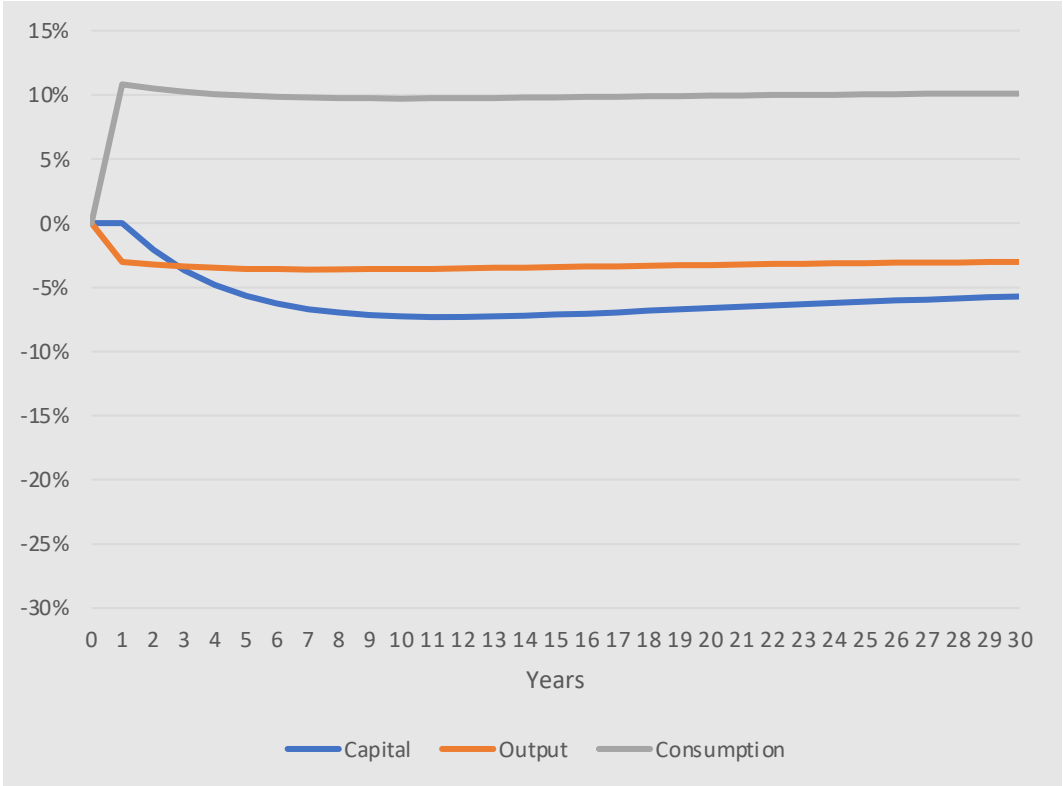


Consumption up (price down) temporarily

* Gladstone is connected to NEM …

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

Utilities

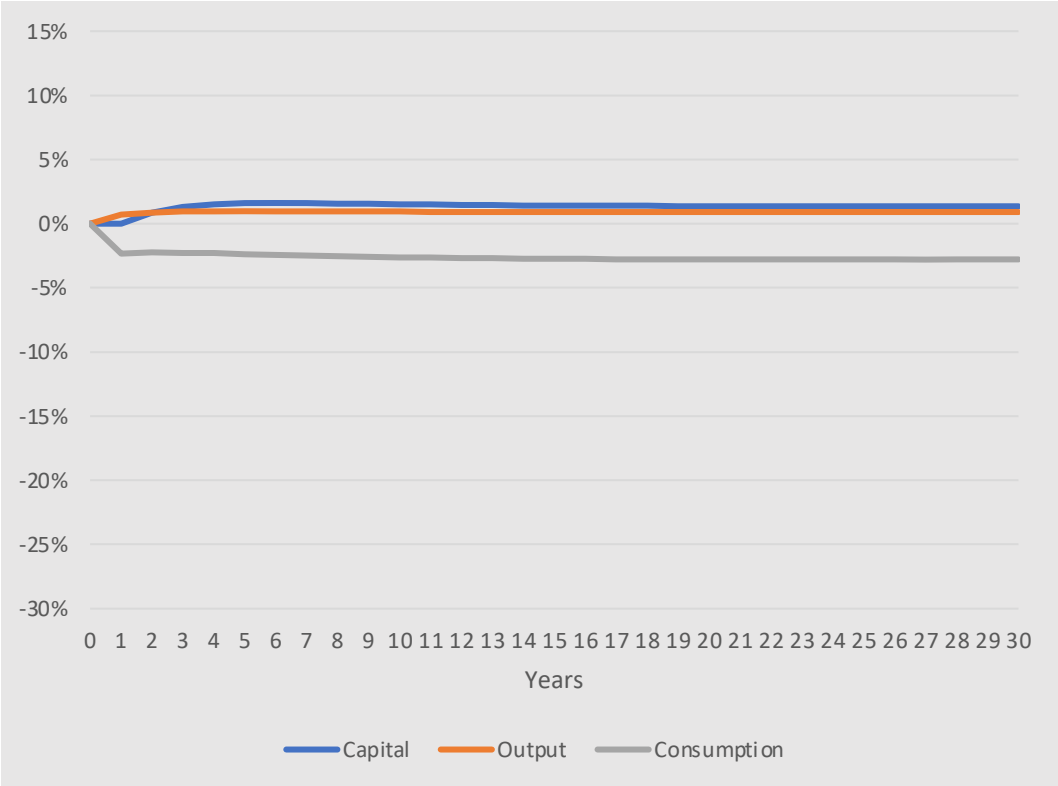


Consumption up (price down) permanently

* Gladstone is connected to NEM …

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

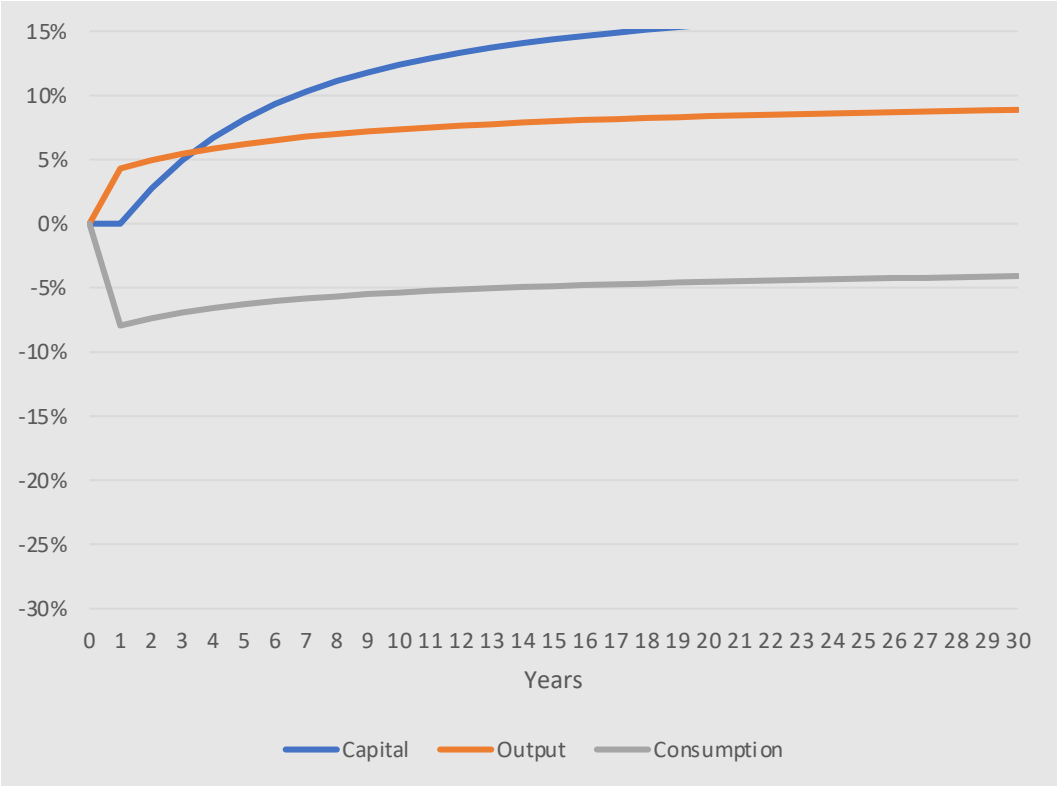
Agriculture (Similar pictures for Mining.)



Capital up, Output up and consumption down

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

Agriculture



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: BSL needs to be in close proximity of energy supply

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 energy 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.

References

Short list of Articles:

- Atalay, E. (2017). How important are sectoral shocks?. *American Economic Journal: Macroeconomics*, *9*(4), 254-80.
- Baqaee, D. R., & Farhi, E. (2019). The macroeconomic impact of microeconomic shocks: Beyond Hulten's theorem. *Econometrica*, *87*(4), 1155-1203.
- Cai, Y., & Judd, K. L. (2021). A Simple but Powerful Simulated Certainty Equivalent Approximation Method for Dynamic Stochastic Problems (No. w28502). National Bureau of Economic Research.
- Cusano, G., Rodrigo Gonzalo, M., Farrell, F., Remus, R., Roudier, S., Delgado Sancho, L. (2017). *Best Available Techniques (BAT) Reference Document for the Non-Ferrous Metals Industries. Industrial Emissions Directive 2010/75/EU (Integrated Pollution Prevention and Control)* (No. JRC107041). Joint Research Centre (Seville site).
- Dixon, P., & Rimmer, M. T. (2020). *Developing a DSGE consumption function for a CGE model*. Centre of Policy Studies (CoPS), Victoria University.
- Gagné, R., & Nappi, C. (2000). The cost and technological structure of aluminium smelters worldwide. *Journal of Applied Econometrics*, *15*(4), 417-432.
- Na, S., Anitescu, M., & Kolar, M. (2021). A fast temporal decomposition procedure for long-horizon nonlinear dynamic programming. *arXiv preprint arXiv:2107.11560*.

Data:

- Australian Bureau of Statistics (ABS), 2018-2019. *Tables 5 and 8: Industry by Industry Flow Table*. Released May 2021.
- Australian Bureau of Statistics, Business Longitudinal Analysis Data Environment (BLADE), 2018-2019, https://www.abs.gov.au/about/data-services/data-integration/integrated-data/business-longitudinal-analysis-data-environment-blade
- Bureau of Economic Analysis (2003). *Capital flow data for 1997*. https://www.bea.gov/news/2003/capital-flows-us-economy-1997
- Gladstone Regional Council. https://www.gladstone.qld.gov.au/downloads/file/3466/gladstone-region-investment-prospectus . Retrieved October 2022
- Queensland Government (2022). *Energy and Jobs Plan*. https://www.epw.qld.gov.au/energyandjobsplan . Retrieved October 2022
- Queensland Government. https://yoursayhpw.engagementhq.com/understand-qrez/news_feed/central . Retrieved October 2022
- Port of Gladstone, "Trade Statistics Data," https://www.gpcl.com.au/trade-statistics . Retrieved April 2020
- Rio Tinto, (2019). *Annual Report Production, Reserves and Operations*. Retrieved in April 2020.