Sustainability, Modelling and Regional Transition (in Queensland)

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Why are we here?

Brief discussion of the history of the project and why we are here.

- why the project is important to AIBE
- background of regional/sectoral economics at UQ
- Input-Output modelling
- the state of CGE modelling in Australia
  - CoPS, U Victoria (no uncertainty at all or proper dynamics)
  - Warwick McKibben (steady-state, no uncertainty either)

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How we arrived at Maiwar: methodology

Recent literature on macroeconomic production networks:

Baqaee–Farhi, . . .

- embeds network modelling in macro models (IO renaissance)
- main finding: nonlinear (beyond Cobb-Douglas) effects matter

Atalay has some good econometric estimates of elasticities

- elasticity of substitution for flows between sectors is about 0.1

Conclusion: nonlinear effects matter

- does not bode well for multi-sectoral steady-state approx.
- this includes Baqaee–Farhi, Atalay, CoPS, McKibben

How we arrived at Maiwar: methodology

How about "global" approximation e.g. Value Function Iteration?

Building on Scheidegger's machine-learning approach, we found

- grid approach is at least 1 order of magnitude more accurate than steady/ergodic-state approximations, even for 1-good models.

But:

- trouble with grid approach: 10^{12} points for 12 dimensions
- approximation is poor outside of grid
- VFI is also unstable (poorly suited to multi-sectoral flows)

How we arrived at Maiwar . . . the research question

My old supervisor (Herakles Polemarchakis) once told me that building a model without a question is *the kiss of death*.

Reading group: Aarushi, Marian, Patrick Duenow and I, late 2020.

- Economy-wide implications of mental health: with Patrick D
- COVID impact
- In 2022, settled on 2050 net-zero carbon emission targets.
  - Most economists think Australia will be better off, but
  - Adams 2021, CoPS: Qld -6% GSP and -100k jobs *rel. to base*.
  - What about Qld targets over and above those of Australia?

MAIWAR (Modelling Australian Industry With AMPL Regions)

1. Flexible yet Fast: without steady-state approx
2. Look-forward property: flow of state-action dependent rewards

$$V_0(\omega_0) = r_0(\omega_0, a_0) + \cdots + r_9(\omega_9, a_9) + V_{10}(\omega_{10})$$

3. Uncertainty: easy way to improve on CoPS
4. Investment/saving behaviour: Euler equations: CGE Dixon–Rimmer 2020
5. Data: BLADE, calibration, econometrics
6. Robust/Reliable: works with a variety of set-ups
7. Accurate/Accessible: John as end-user, as open source as possible
8. Modern yet Trustworthy: best-in-class knowledge, 2+ solvers
9. Scalable: at least to 8 regions and 20 sectors

Cai–Judd's SCEQ: Simple (yet Powerful) Certainty Equivalent Method

E.g. Irreversible risk: one-off, permanent shock to output.

Loosely resembles tipping points: each year, chance of ice-shelf . . .

Yields 28 paths to 2050:

- path where shock never happens
- path where shock happens in 2023;
- path where shock happens in 2024;
- . . .

Agent(s) make 10-year plans at each time t along a path:

Balance consumption today vs uncertain consumption tomorrow.

Once plan t is made, time reveals state $\omega_{t+1} \rightarrow$ new plan.

Our contribution: multi-sectoral flows

$$k_{t+1,j} = (1-\delta)k_{t,j} + s_{t,j}$$

where s_{tj} is a CES function of intermediate flows.

$$s_{t,j} = \left(\sum_i \sigma_{i,j} S_{t,i,j}^{\rho} \right)^{\frac{1}{\rho}}$$

From Atalay's model: $\rho = \frac{0.1-1}{0.1} = -9$.

Difficulty: for 20 sectors and 10 time periods, $20^2 * 10 = 4000$ flows.

Jacobi Equation:

$$S_{ij}/\sigma_{ij} =$$

The solution for each path for Investment, Kapital and Labour

Cai–Judd: under the bonnet

Why CGE modelling?

- "Old-fashioned", "black-box", "intractible", ...
- Yet industry demands "CGE" modelling and uses it as a basis for key decisions.
- A guide to quantifying the broader repurcussions of sector-specific shocks.
- A guide to analysing the implications of

Macroeconomics with networks

Why the focus on uncertainty?

There is pretty strong evidence that the rise in uncertainty is a significant factor holding back the pace of recovery now. [...] research shows that heightened uncertainty slows economic growth, raises unemployment, and reduces inflationary pressures. [...] There is no question that slow growth, high unemployment, and significant uncertainty are challenges for monetary policy.

Why not use a CoPS CGE model?

- Cost of software and of data for the model.
- CoPS already have a recent paper on 2050 targets

Moreover:

- no proper savings/investment: intertemporal behaviour
  - leads to strange "macro-closure conditions"
- no model of risk/uncertainty and associated behaviour

CoPS assume current economy is in *Deterministic Steady-State*.

Treasury Intersectoral Model (TIM, 2017)

Part of a new generation of Australian models

J. Miranda-Pinto of UQ had a hand in TIM (and in our choices)

TIM has a sister called EMMA (Macro-econometric forecasting)

- TIM has proper savings
- 114-sector model of Australia
- but no risk
- Deterministic steady state & we can't access

Adapting the Atalay model

Atalay assumes economy in (non-determistic) steady state

- pretty complete and quite good empirical foundations
- we have full access via Matlab & Stata

Our adaptation of Atalay is the first model in our suite.

- less than 1 second to solve a 20-sector model
- regionalise using LGA-level income data via Table Builder
- capital flows matrix by adapting a US flows table from 1997
- Social Accounting Matrix using Current and Capital Accounts

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Quote from Cai and Judd (Feb, 2021)

Macroeconomists [and CoPS] are often interested in obtaining solutions around the non-stochastic steady state.

However in reality, the initial state could be far away from the steady state, and a policymaker may be more interested in the solutions for the initial periods in the forward-looking model than the far future states that could be around the steady state.

For example, in environmental and climate change economics . . .

The current value function V_0

$$
\begin{aligned}
V_0(\omega_0) = \max_{a_\cdot} \quad & \mathbb{E}\left\{\sum_{t=0}^{27} \beta^t r_t(\omega_t, a_t) + \beta^{28} V_{28}(\omega_{28})\right\} \\
\text{s.t.} \quad & \omega_{t+1} = g_t(\omega_t, a_t, \varepsilon_t), \quad t = 0, \ldots, 27 \\
& f_t(\omega_t, a_t) \geq 0, \quad t = 0, \ldots, 27.
\end{aligned}
$$

With current state ω_t, action a_t, expectation $\mathbb{E}$, reward r_t, discount factor $0 < \beta < 1$, terminal value function V_{28}, transition law g_t, error ε_t and feasibility constraints f_t on actions.

- *Once approximated*, iterate over t to get *optimal policy* $a^*_\cdot(\omega_\cdot)$

Thanks for listening!

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