

Getting to Know Models:

A primer and critique on Input-Output and Computable General Equilibrium Models and their uses for policy and project analysis

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Generally,
an Economic Impact Assessment (EIA) is a quantitative analysis (specifically, an a-priori projection) of how a shock will impact economic indicators.

With reference to energy infrastructure, this shock takes two forms:

- 1 A demand related to construction inputs resulting in physical capital formation.
- 2 A demand fulfilled by the infrastructure itself during an operations phase.

How much can we trust broad claims regarding economic benefits of an infrastructure project when they are based on “Economic Impact Assessments”?

Are there fair grounds on which to judge economic impact assessment models?

A Critique of I/O Models

“There’s a joke among economists who look at economic impact studies, and we say ‘Define all costs as benefits, and double them’”

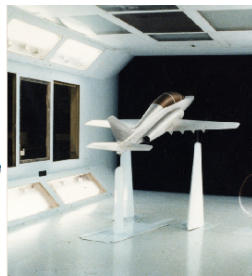
- Trevor Tombe

Academics have largely abandoned the use of Input Output models in favor of a “Computational General Equilibrium” (CGE) framework.

Why is this

Anytime we use a model, we need to think about what we want to actually do with it.

All models have some level of abstraction and



function should dictate form.

EIA models are used to make quantitative **a-priori** projections of the economic impact resulting from a policy change or capital project.

- “Economic Impact” is itself a vague term here.
- Generally, we interpret this as the impact on, or change in,
 - Labour (jobs and/or wages),
 - Capital (investment and/or earnings),
 - GDP,
 - Resource demands,
 - etc.

Determining the likely effect of a project or policy change on the above involves constructing and shocking an EIA model.



Monetary National Income Analogue
Computer (MONIAC)

EIA models can take many forms, but traditionally I/O models have predominant.

Many regulatory agencies require an Economic Impact Assessment accompany a major project application:

- Some don't mandate any specific EIA methodology.
- Others call for an I/O based analysis specifically.

The Economic value chain is complex.

- Demand in one sector drives demand in sectors supplying inputs to it,
- and the sectors supplying those sectors,
- and the sectors supplying those sectors,
- etc.

Leontief, W. (1951). Input-output economics. *Sci Am*, 185(4)

“With a table of ratios for the economy as a whole, it is possible in turn to calculate the secondary demand on the output of the industries that supply the auto industry’s supplier and so on through successive outputs and inputs until the effect of the final demand for automobiles has been traced to the last reverberations in the farthest corner of the economy.”

I/O models are basically just a bunch of ratios (multipliers) that relate final demand in any sector to all of the initial inputs required to produce that final demand.

The foundations of the CGE approach are actually much older than the I/O approach:

John Stuart Mill 1844 (conceptually) and Leon Walras 1874 (mathematically).

- Markets move towards an equilibrium price such that *quantity supplied = quantity demanded*.
- This is *Partial Equilibrium* when it occurs in one market.
- It is *General Equilibrium* when it occurs in all markets simultaneously
 - Recognizing the relationships between them.

CGE models are basically a bunch of supply and demand equations stitched together.

I/O models remain ubiquitous because they are easy to access, easy to use and

- More on that later.

In Canada, the StatCan I/O model is widely employed.

- \$939 to do a model simulation.
- StatCan conducts approximately 100-125 runs per year

There is no generally used CGE equivalent, although multiple consulting firms market CGE based services or canned models and associated training.

Prior to the 1970's, General Equilibrium models were “theoretical”

- Qualitative rather than quantitative
- X's and Y's, instead of actual numbers
 - $GDP = Y$ instead of $GDP = \$170B$

Increases in availability of computer power allowed for the Advent of quantitative CGE models.

- Lots of non-linear equations that need to be solved simultaneously.
- The “C” in CGE.

From AER Directive 023

(Guidelines Respecting an Application for a Commercial Crude Bitumen Recovery and Upgrading Project)

Article 3.3.3 states that any application must include

an assessment of **direct and indirect employment opportunities** for all groups associated with the product including:

(a) a projection of maximum and minimum **workforce demand by skill categories** in the construction (quarterly) and operating (annual) phases, and **an analysis of how these demands will be met**. this should identify the perceived shortages in any category of labour during the period concerned, the measures that could be used to alleviate the shortages, and overall consequences of labour shortages to the province as a whole.

The idea wasn't to measure the **size** of the economic impact, but rather the expected **distribution** of the impact, and to plan for it.

At some point (late 1990's ?) the goal or use of I/O based economic impact assessments seems to have shifted from “distribution and planning” to “magnitude of the impact” (specifically on labour).

Northern Gateway Pipelines Limited Partnership (2010) *Enbridge Northern Gateway Project Application: Volume 6C: Environmental and Socio-economic Assessment*

- 304 new jobs (direct)
- 3,629 new jobs (direct and indirect)
- 6,450 new jobs (direct, indirect and induced)

The function has shifted

- **From:** assessing the distribution of gross impacts
- **To:** making claims about net impacts

But the form of the model has not changed.

I/O models have come under criticism due to a view that:

- the underlying assumptions are unreasonable and
- the results are often misinterpreted.
- Alavalapati et. al. (1998); Grady and Muller (1988); Gretton (2013)

By comparison CGE models are generally presented as more reasonable abstractions.

- Borges (1986); Kehoe (2003); Partridge and Rickman (2010); West (1995)

Yet both rely on similar structures and are calibrated using similar (if not identical) datasets. So what exactly are the criticisms of I/O models based on and why might we think CGE presents a more reasonable abstraction?

In 2001 the Australian Bureau of Statistics discontinued its publication of annual I/O multiplier tables

From Gretton (2013): I/O model “limitations”

- 1 Lack of supply side constraints
 - perfectly elastic factor supply curves
- 2 Fixed Prices
- 3 Fixed ratios for intermediate inputs to production and outputs from production
- 4 Consumers don't respond to price changes
- 5 Absence of household and government budget constraints.
 - The model treats new spending as “mana from heaven.”

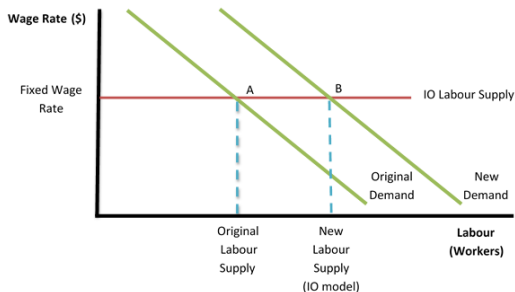
The most critical of these are # 1 and # 5.

- # 3 is also very important, but we don't have time to discuss it here.
- Read the chapter when it comes out!

#2 and #4 are actually additional manifestations of # 1 when it is paired with any CRS Production and Homothetic Utility functions.

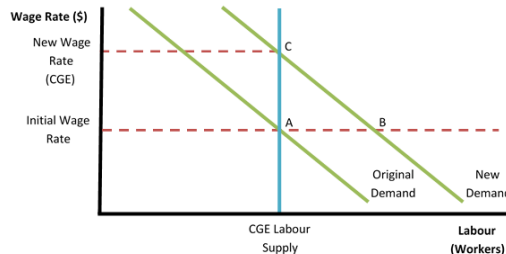
A rough sketch of the proof:

$$\left. \begin{array}{l} \textit{Perfectly elastic factor supply} \\ \textit{CRS production} \end{array} \right\} \implies \textit{Fixed Prices} \left. \begin{array}{l} \\ \\ \textit{Homothetic Utility} \end{array} \right\} \implies \textit{Fixed proportions consumption}$$



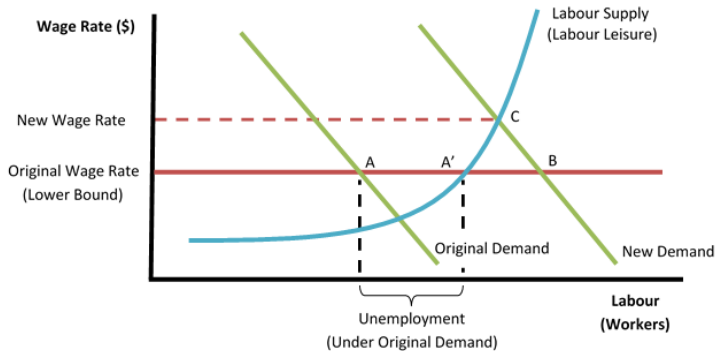
I/O model: perfectly elastic supply of Labour

- There is no scarcity of workers.
- Every job represents an economic gain.



CGE model fixed supply of Labour.

- There is scarcity of workers.
- Reallocation but no increase in net jobs.
 - But still an economic gain: the value of Labour increases.



The CGE model framework can accommodate other assumptions as well. Form should follow function

- If there is a specific reason to consider unemployment or other supply aspects, they can be considered under a CGE framework
- I/O models are not this flexible.

Demand Shocks In an I/O model need not come from anywhere

- Mana from Heaven
- What does it mean to have “new expenditure”

This is an issue because it means there is no acknowledgment of any “opportunity cost” that may be associated with the shock

- Is spending being reallocated from other sectors
 - In which case the gross expenditure to a sector far outweighs the net impact on the economy.
- Are funds being diverted from outside the economy?
 - In which case spending is “new” but may have other implications.
 - Consider that Canada’s exchange rate is sensitive to the value of crude oil exports.

The CGE model framework forces the modeler to consider where the shock comes from.

- This doesn't mean the model correctly specifies this
- the assumption has to be explicit which *should* make it more transparent.
 - Also, because a CGE model is able to accommodate price changes, it can project exchange rate effects.

Given the above, CGE models have technical advantages over IO models

Critiques of CGE models

- 1 “General Equilibrium” is a theoretical convenience and not an appropriate assumption.
- 2 CGE models require the modeller or user to make too many assumptions
- 3 CGE models are costly and unavailable compared to their IO counterparts

- Despite what we might deem as unrealistic assumptions, the I/O model (without induced effects) can generate results similar to a CGE model and is still (in my opinion) a useful model.
 - For small shocks, the difference can be quite small for overall GDP.
 - From a starting point at initial equilibrium, I/O is almost a linear approximation of CGE.
- I/O models are also relatively adept at identifying the distribution of induced demand across other sectors
 - Arguably inferior to CGE, but the modeled outcome can be produced at a much lower cost.
 - A key here is not to confuse gross impact with net impact

Key Takeaways

- 1 I/O results should generally be interpreted as a gross effect, not a net effect.
 - I/O results are more likely to produce a “rising tide lifts all ships” result.
 - A positive shock is accommodated with new labour, capital and resources, so there is no competition for factors of production (or any other input).
- 2 If significant resources are unemployed/idle, IO and CGE models should produce similar and reasonable projections.
- 3 CGE models are closer to established economic theory, and are more internally consistent (and consistent with contemporary economic theory) in their assumptions.
- 4 Use of a CGE model requires lots of assumptions (factor supply functions + many I didn't discuss today):
 - Modelers have discretion in which assumptions they rely on.
 - This flexibility is both a benefit and a liability of CGE models.