Boyne Smelters

Economic Impact on the Gladstone Region and Queensland

Patrick O'Callaghan and John Mangan

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Outline   Australia is one of only three countries in the world with a fully inte-   5
grated supply chain for producing Aluminium ([15]). In particular, Bauxite from
Weipa, North Queensland, is refined and smelted in Gladstone, Central Queens-
land. Aluminium smelting is a highly energy intensive process with Boyne Smelter
Limited (BSL) in Gladstone consuming approximately one-sixth of the total elec-
tricity supply of Queensland. Like other regions that produce aluminium, Central   10
Queensland is energy-abundant. It has an active coal-mining and natural gas in-
dustry. The smelter is supported by a coal-fired power station. Its main purpose is
to supply power in the event of an extended blackout that would otherwise cause
costly damages to the smelter.

In this paper, we study the economic impact of closing down Boyne Smelter   15
Limited (BSL) on the Gladstone region over time. The key local variables of
interest are output, gross value added and employment. We model the broader
gladstone region and estimate the impact on the broader supply chain via imports
and exports. We present results for the standard 19 ANZSIC divisions and for the
economy on aggregate.   20

Summary of results   The sectors where there turns out to be an impact of sub-
stance are Agriculture, Mining, Manufacturing and Utilities. These are ANZSIC
divisions A, B, C and D respectively. Our presentation and analysis of results fo-
cuses on these sectors. In brief, manufacturing and utilities are both permanently
worse off relative to the no-closure status quo. In contrast, mining and, to a lesser   25
extent, agriculture are permanently better off with investment and employment
in these sectors increasing immediately after the shock. Relative to status quo,
when labour is mobile, the positive response by mining and agriculture reduces
the immediate shock to aggregate output to just under 1.5% and the economy has
fully caught up within 10 years. Relative to status quo, when labour is immobile,   30
the immediate shock to aggregate output is just under 6%, and the economy is still
1% smaller 35 years later. The truth is likely to lie somewhere in between. Still,
relative to status quo, the impact on consumption is small but positive for the
same reason that mining and agriculture respond positively: the price of utility
goods (such as electricity and water) permanently fall by 10% as a result of the   35
closure.

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Background to the shock   Prior to the closure of the smelter, we assume that all sectors of the economy grow at a rate of 1.5% to 1.8% and that their growth path is balanced. Thus the stock variable capital grows at approximately the same rate as flow variables such as output. This assumption is justified by virtue of the fact that BSL is forty years old, and much of the local aluminium industry was established in the sixties and seventies. The main exception is Gladstone's second alumina refinery, Yarwun Alumina Refinery (YAR), which opened in 2004.

Current capital.   Direct estimates of current capital per sector are unavailable at the regional level. To do so, we exploit the intertemporal features of our model to evolve the economy optimally and endogenously over a long period of time (approximately 70 years). This approach ensures that, at the time of the shock, the distribution of capital across sectors, at the time of the shock, is independent of the initial distribution of capital. Indeed, current capital depends only on the parameters of the model with our estimates of productivity factors and investment flows playing a key role.

Estimating the parameters

Our first source of data for estimating the share parameters of the model are the 2019 ABS input-output tables (5 and 8) for the Australian economy. Table 8 provides a full account of the individual flows from sector to sector and from sector to household and government. For example, the flow of goods (such as bauxite) from the mining sector to the manufacturing sector is a combination of local and imported goods and an estimate of the total value of this flow can be found on table 8. An estimate of the domestic share of this composite flow can be found on table 5 and imports are found by taking the difference between table 8 and table 5. For the present study, we aggregate the above tables from 114 IOIG industries to the 19 ANSIC divisions (A, B, C, ..., S).

The second source of data is the 1997 US "Make" and Capital/investment Flows tables from the Bureau of Economic Analysis in the US. This is a commonly used table that also features in the influential paper [1]. We were able to adapt this to the 2019 Australian economy on the basis of investment (Gross Fixed Capital Formation) data from the Australian input-output tables and the GFCF by Industry by Asset type tables, also from the ABS. With minor modifications, the traditional RAS method/algorithm works well to ensure row column balance for this table in isolation.

We regionalise the above tables using a combination of 2016 census data and Remplan so as to bring the economy as close as possible to the current Gladstone economy.[1] Regionalising national account data in a top-down manner is inherently imprecise and difficult. To ensure robustness of our results, we created three different versions of the Gladstone economy using two different methods which we now describe. Regardless of method, the main results all point in the same

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[1]We will replace this data in due course with data from latest census and local industry data from BLADE.

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direction. Our reasons for preferring the second method are that the resulting collection of tables not only look more reasonable, they also perform better with the model.

The first method is the traditional RAS technique where (given estimates of sectoral output, employment imports and exports for a region) one estimates the individual flows between sectors by minimising the *relative* entropy subject to row-column balance (a form of regional accounting).[2]

The second method is more targeted. It involves the assumption of constant returns to scale and, whilst keeping the Australian economy broadly intact, using accurate data on specific flows between sectors, households and exports, we make specific modifications to the table. In contrast with the first method, no attempt is made to ensure the table is balanced. Instead, we focus on ensuring that key transactions are in proportion to what we observe in available data. In particular, we obtain precise estimates for the cost structure of the Aluminium sector and scale up key transactions for electricity supply in accordance with data on output from the Rio Tinto annual accounts ([7]), electricity prices ([12]), export and import data from Gladstone port ([6], and well-known estimates of cost from sources on aluminium production such as [15] and [13]. We then run the "burn-in phase" for a variety of parameters and choose those that yield an economy that best matches the regional data we have. Our main concern with the second method is the risk that the tables we have generated paint a more diverse picture of the Gladstone economy than is in fact the case. That is to say, there is the possibility that some other sectors are more reliant on the smelter than our results suggest. We propose to deal with this concern by conducting systematic robustness checks for a wider variety of parameters.

The parameters in detail A sample of the productivity parameters that we calibrate through the burn-in phase are the following:

Table 1: Productivity parameters per sector

Divisions	A	B	C	D	E	...	I	J	K	L	...
No shock	31.2	31.7	32.6	21.9	31.6	...	31.4	31.1	21.8	21.9	...
Shock	31.2	31.7	26.1	21.9	31.6	...	31.4	31.1	21.8	21.9	...

Initially productivity parameters were simply set using standard approaches such as formulas for the minimum unit cost. Since this did not produce reasonable output values in the long run, we adjusted these values to reflect the higher output in sectors where output is higher. These modifications are relatively small on the whole. The only exceptions were to divisions D (Utilities), K (Finance) and L (Real Estate). These were set at 70% of the levels that were assigned using standard methods such as the minimum cost of producing a unit adjusted by regional output per sector. The reason for this is that otherwise these sectors become excessively large during the burn-in phase. Division L is where the exceptional IOIG sector "Ownership of Dwellings" is allocated. Ownership of dwellings

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[2]Relative to the Australian input-output tables mentioned above.

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constitutes 30% of all gross fixed capital formation as per ABS data. Arguably this is relatively unproductive capital given that it is essentially housing. ₁₁₅

In table 1 we see that the shock entails a 20% fall in the productivity of manufacturing (C). This, on the one hand, is necessary because otherwise the endogenous optimal investment process will simply return capital to its previous state as if the smelter had never closed. On the other, we argue that such a fall in productivity is reasonable given that the Aluminium sector is so well vertically-integrated. It can also be viewed as capturing perception of higher risk of investing in Gladstone manufacturing after the closure of the smelter.

To specialise the Australian table to Gladstone, the key transactions for which we adjust parameters are the following (all specialisation ratios are relative to Australia):

1. exports of Manufacturing are three times domestic usage.

2. the specialisation ratio for Mining purchases by manufacturing is 2.

3. the specialisation ratio for Manufacturing purchases by manufacturing is 1.5.

4. the specialisation ratio for Utility (electricity and water) purchases by Manufacturing is 7.

5. the specialisation ratio for imported Mining goods (such as bauxite) is 5.

6. finally, we include the subsidy as a payment to capital.

According to our calculations, the subsidy to aluminium amounts to $174M.

Subsidies   to aluminium smelting have been well-debated in Australia for over 20 years [4]. In 2015, the Government-Owned Corporation CS Energy described its contractual obligation to GPS as onerous [14, page 10].

In our calculations, we assume that BSL pays around $55 per MWH. This is significantly lower than the Queensland wholesale prices of around $80 in 2019. Assuming that BSL would pay wholesale prices in the absence of a subsidy, we estimate that the subsidy per MWH to aluminium production at BSL is $25. Using the fact that 14MWH are required to produce a single tonne of aluminium, and BSL produces 499KT, given this data, we are able to obtain a precise estimate of the subsidy to aluminium production at BSL, approximately

$$\$174.65\text{M} = \$25 \cdot 14 \cdot 499\text{K}$$

Summary of status quo economy   The final values for flows between sectors are intended to capture the key features of figure (ii) a table that we constructed for a previous report for QTC. Figure (ii) presents data of the same type as table 8: composite flows of domestic and imported goods. For the present study, we need to pair this data with estimates of a richer set of parameters which we derive from table 5 and US capital flows.

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Figure (i): The structure of the Interconnection and Power Pooling Agreement
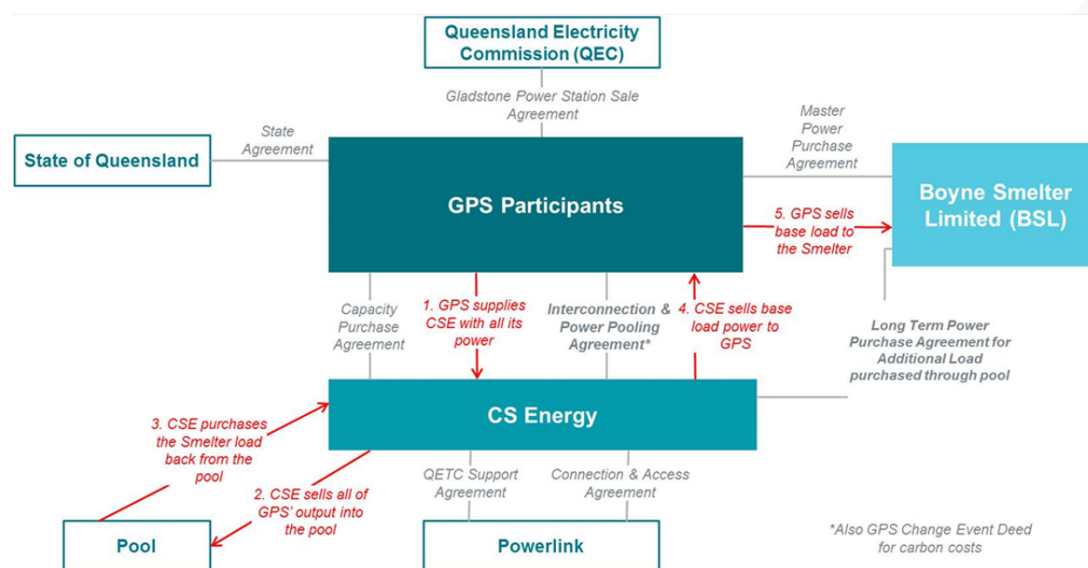
CSE sells GPS's Electricity output at wholesale prices ($80) and sells the base load quantity of approximately 7,000gwh per annum back to BSL (indirectly via GPS) at prices net of subsidy ($55). This has lead it to publicly describe its contract with GPS as onerous ([14]).

The shock   Aside from the 20% shock to productivity and the 25% reduction in manufacturing capital, the scenarios involve modifying status quo transactions as follows:

1. exports of Manufacturing goods decrease by 25%

2. purchases of Mining goods by Manufacturing decrease by 10%

3. purchases of Manufacturing goods by the Manufacturing sector decrease by 60%. This may seem high, but it is in line with the fact that, in Gladstone, most goods are manufactured for export.

4. purchases of Utility goods by the Manufacturing sector decrease by 85%. This significant part of the shock is in line with the fact that the smelter consumes one sixth of Queensland's electricity output.

More detailed analysis of results

Overview   Under the assumption that the Gladstone economy remains on a balanced growth path of 1.5% to 1.8% across all sectors, the main takeaway is that only Manufacturing and Utilities are significantly affected in a negative way. In fact, Mining and Agriculture benefit from the lower prices for Utilities and Manufacturing goods as well as an improvement in their relative productivity (relative to Manufacturing). On aggregate, although output, Gross Value Added, employment and exports all fall, consumption is weakly, yet positively (between 0% and 1%) improved as a result of lower prices.

Figure (ii): The transactions matrix (AUD millions) for the status quo Gladstone economy
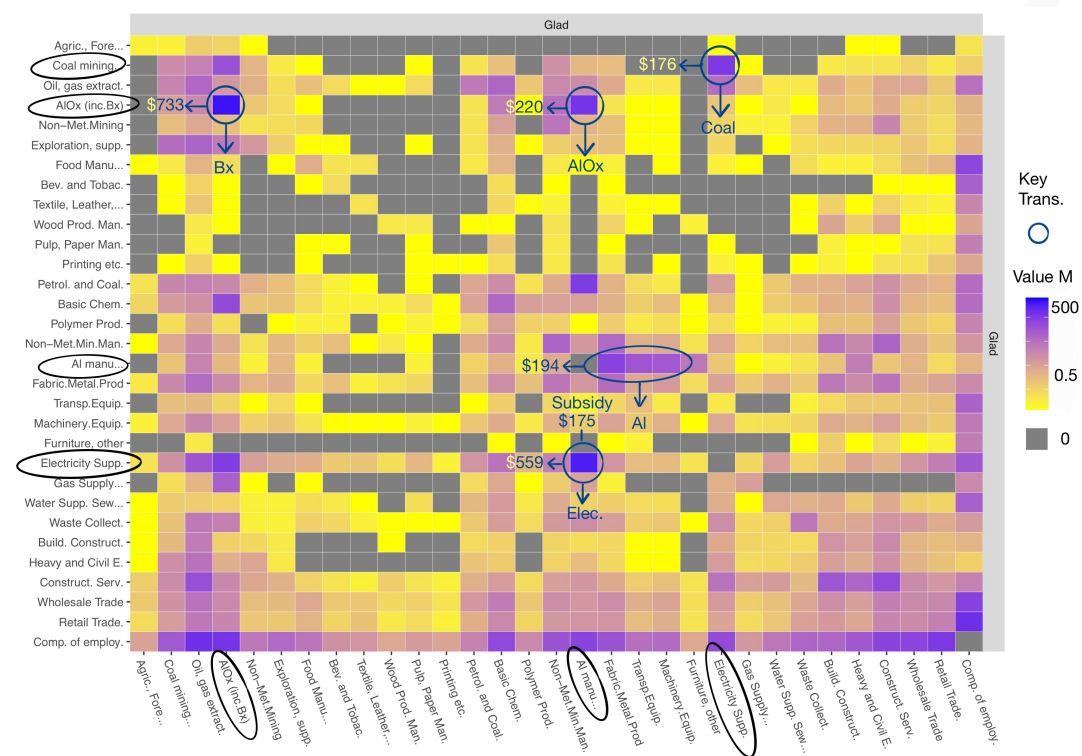
This heatmap provides a visual description of a fragment of the input–output table of transactions. Key, large transactions are represented by blue or violet squares. Yellow transactions are smaller. Grey stands for zero/no transaction.

Figure (iii): Aggregate: percentage change relative to status quo over time in years
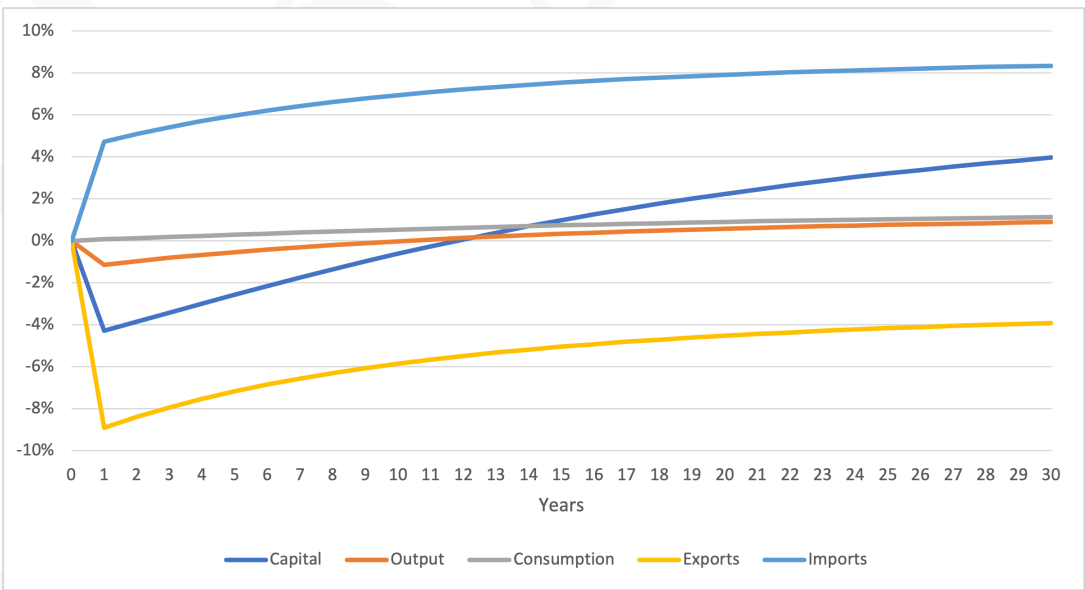
In practice, the 10% fall in Utilities price may be tempered by the fact that Gladstone is connected to the National Electricity Market and so the benefit of lower demand for electricity from the smelter would be spread over a much larger region and population. Indeed for the same reason, the impact on prices is likely to be smaller. This will temper the gains to aggregate consumption. The same holds for the gains to the Mining and Agricultural sectors.

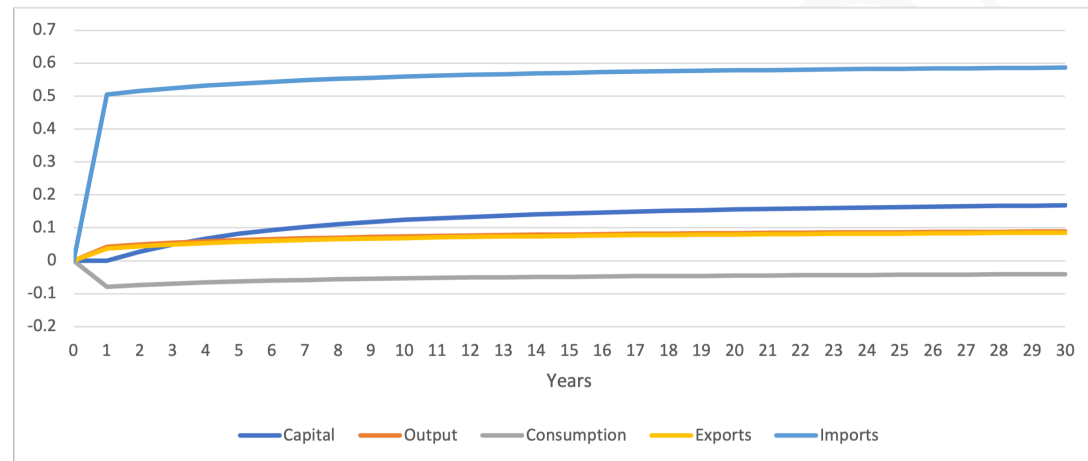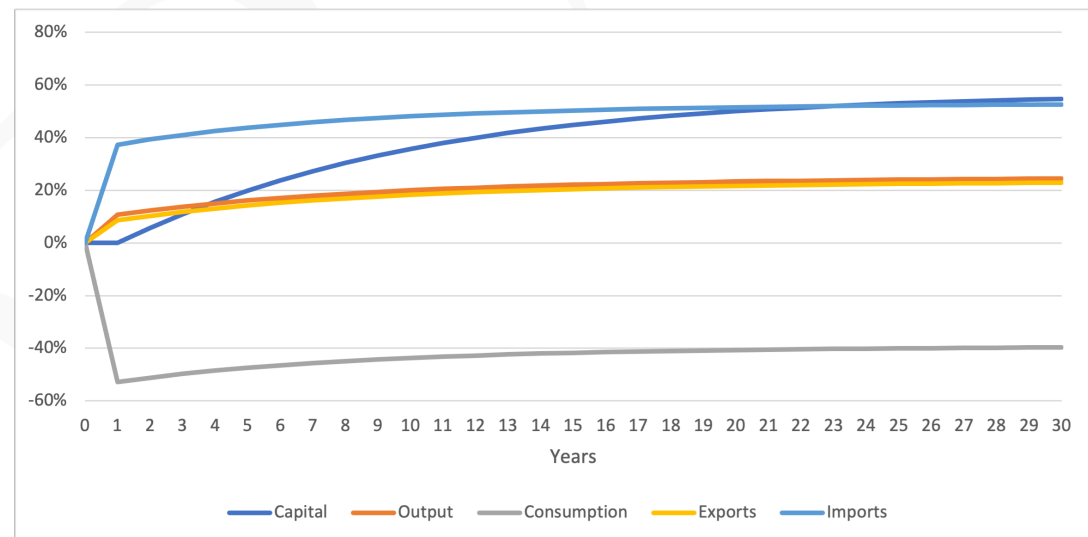**Figure (iv):** Agriculture: percentage change relative to status quo over time in years

Figure (v): Mining: percentage change relative to status quo over time in years

Note that although the change in consumption of mining is large, it is only a very small part of overall consumption

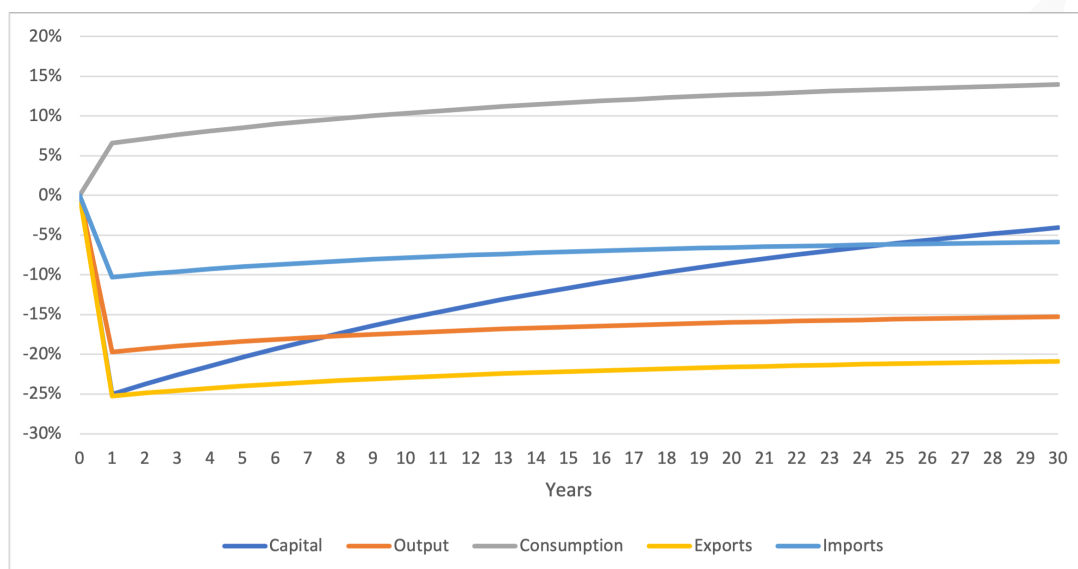**Figure (vi):** Manufacturing: percentage change relative to status quo over time in years
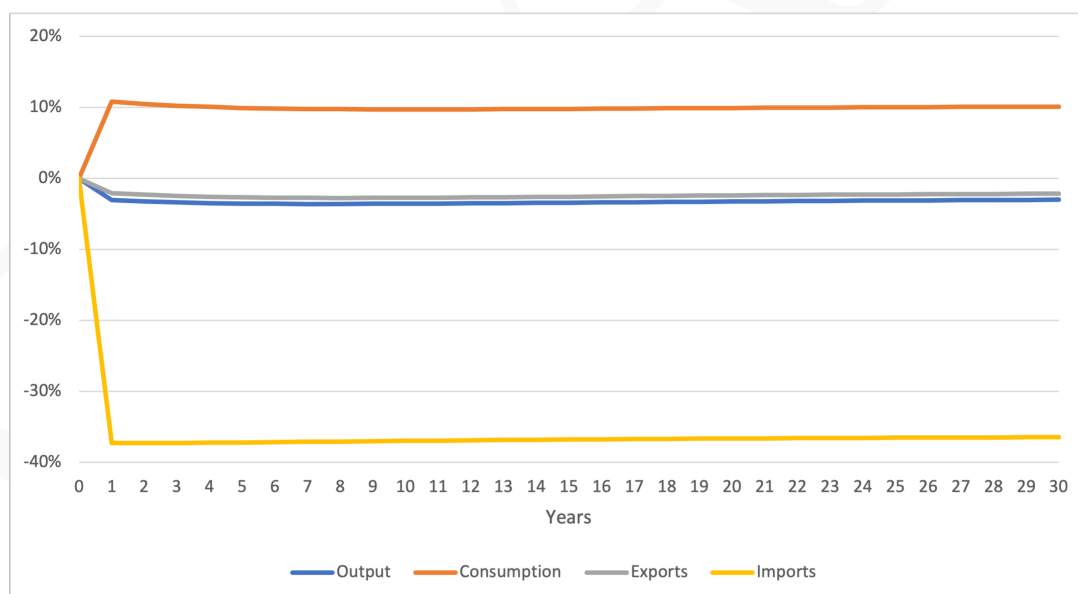

Figure (vii): Utilities: percentage change relative to status quo over time in years

Future work

Robustness checks   To ensure our conclusions are robust, we intend to run a [170] wider variety of shocks for a variety of parameterisations.

Other closures Smelter closures in the recent past (Kurri-Kurri, NSW in particular) have taken 5 years to decommission and begin the process of repurposing the facility for a gas-fired power station that is to open in 2022: a ten-year closure. In due course, we will look at future policy actions such as putting the smelter capital such as land to different uses. It could for instance become a hydrogen processing plant or some other green-energy facility. This could lead to a structural change and an increase in the productivity of Manufacturing. The model would be well-suited to studying this and with an emphasis on the cost of delaying such a policy.

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