Boyne Smelters and Gladstone Power Station

Economic Impact on the Gladstone Region and Queensland

Patrick O'Callaghan and John Mangan

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Outline

In this study, we consider the economic impact of shutting down Boyne Smelter Limited (BSL) and the Gladstone Power Station (GPS). To disentangle the effects of each closure, we study two main scenarios: the one where only the smelter closes; and the one where both the smelter and the power station close. To ensure our conclusions are robust, we study different subscenarios that capture various economic response by key agents in the economy. For instance, in one subscenario, local refiners of Aluminium Oxide (AlOx) that supply BSL are able to increase exports in response to the closure of BSL, so that their revenue is unaffected. By implicitly allowing our economic agents to respond and, implicitly allowing prices to move, our analysis goes well beyond a basic multiplier analysis.

The Gladstone region is home to both BSL and GPS. For this reason the Gladstone region (Statistical Area Level 3, SA3) is at the center of our model. Yet the closure of BSL and GPS would have potentially significant repercussions outside of Gladstone, both upstream (Bauxite (Bx)) and downstream (fabrication of aluminium products, vehicle manufacturing as well as the National Electricity Market (NEM) itself). In our analysis of economic inputs and outputs, we therefore include some relevant transactions from the wider Queensland economic network. In particular those that relate to aluminium. Although we do model scenarios where GPS remains open and supplies various amounts of electricity to the grid, and we do so with implicit movements in electricity prices in mind, a key exclusion from our analysis is the likely broader impact on electricity prices of the closure of BSL or GPS on the National Electricity Market.

Whilst the broader effect of a BSL closure on Queensland electricity prices is likely to be welfare increasing, the immediate downside would be 920 direct job losses in the Gladstone region. Based on US estimates, high-level research by QTC suggests that total job losses (direct plus indirect effects), might be as high as 3,000: that is 10% of the SA3 Gladstone workforce.

Our analysis suggests that job losses would only be reach this figure in the scenario where both BSL and GPS were closed or in the worst-case scenario where exports fail to absorb key transactions in AlOx and Electricity. If only the smelter were to close, then the most likely outcome would be somewhere in the vicinity of

2000 total job losses. If both the smelter and the power station were to close, then total job losses would indeed be in the vicinity of 3500. Both of these estimates are for a broader definition of Gladstone than SA3, as discussed above.

We arrive at these figures through *extraction analysis*. This involves removing all the purchases (inputs) and all the sales (outputs) associated with BSL from the local economy. This extraction of BSL goes beyond a shock to final demand: every link that connects BSL to the rest of the economy is deleted. In the likely intermediate-case scenarios, exports almost fully replace the key transactions in AlOx and Electricity and BSL sales to downstream sectors are almost fully replaced by imports of aluminium. For GPS, given that it employs approximately one third of the total employees of the Electricity Supply sector, we extract one third of the latter sector. Though we also fully extract a key purchase of thermal coal.

The magnitude of the subsidy to BSL (via CS Energy and electricity prices) is significant. An important proviso is that the present study does not account for any change in government spending other than the removal of this subsidy. What we do find is that our results are sensitive to proportion of the subsidy that we treat as endogenous to the economy. We assume $40M of the subsidy is endogenous to the economy and part of Gross Value Added. The removal of this subsidy to BSL amounts to an increase in GVA has knock-on effects via the public sector multiplier. If half or more of this subsidy is treated as endogenous, its removal swamps the negative effects of the closures. If the endogenous portion of the subsidy significantly smaller than $40M, then the effect is to magnify the multpliers. These findings are robust to whether the subsidy enters via the Aluminium or Electricity sectors. We take this to mean that there is a significant role for public policy in the transition of the Gladstone economy.

In summary, the key output of the current work is to provide a working model of the broader Gladstone economy. This model is built on the basis of the latest input-output tables from the Australian Bureau of Statistics, Gladstone regional data and a careful reconstruction of the following cost functions: BSL; the two Gladstone Alumina refineries QAL and Yarwun; and GPS. We run various scenarios through model to study and estimate the likely impact of the shutdown of BSL and GPS.

Aluminium smelting in Australia

Although Australia is the 5th largest producer of Aluminium in the world, Australia's aluminium smelting industry is in long-term decline. In part, this is due to increased global supply of (unwrought) aluminium, but it is also because Australia has lost one of its comparative advantages: low energy prices. This loss is a consequence of two key underlying countervailing forces in electricity markets

- the deregulation of the Australian electricity market that began in 1998
- the absence of investment in new and genuinely cheap sources of energy.

Cheap energy is the basis of a thriving manufacturing industry and deregulation made it harder to justify subsidies to smelters. Over the last two decades, market prices for electricity have pushed Australian smelters from the top quartile to the bottom quartile in terms of international competitiveness.

Smelter closures

These conditions have already led to the closure of two smelters: Kurri-Kurri in 2012 and Point Henry in 2014. In addition to Boyne Island, there are now three other remaining smelters in Australia: Bell Bay, Tasmania; Portland, Victoria; and Tomago, NSW. In the last six months the potential closure of the Portland smelter has been in the news.

Between 2014 and 2019, factors such as a weaker Australian dollar and restrictions on winter production in China have provided smelters with a short-to-medium term buffer. But, even before the recent coronavirus outbreak, global aluminium prices were around USD1,800 and close to the short-run minimum average cost of producing aluminium for BSL.

Boyne Island vs Tomago

BSL accounts for 25% of Australian annual production of Aluminium. Tomago is very similar to BSL in terms of size, age, salary and other input costs, and it is also majority owned by RT. In contrast with Tomago, BSL produces significantly below its annual capacity of 584KT. In each of 2017, 2018 and 2019, BSL produced 500KT . Under the Interconnection and Power Pooling Agreement (IPPA), BSL is allocated 810MW (per hour) of GPS output. At 500KT per annum, the implied quantity of electricity consumed is 798MW (per hour). Since BSL has restricted its output to the base load supply, thereby avoiding electricity purchases at wholesale prices (see [2, slide 10] for further details of events that lead to this situation).

Our recommendation is that, before deciding the joint future of BSL and GPS, the QLD government should have a clear understanding of the subsidy that NSW provides the Tomago smelter. The subsidy seems to be the only plausible explanation for the difference in output between BSL and Tomago.

Subsidies

Subsidies to aluminium smelting have been well-debated in Australia for over 20 years [3]. In 2015, the Government-Owned Corporation CS Energy described its contractual obligation to GPS as onerous [13, 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

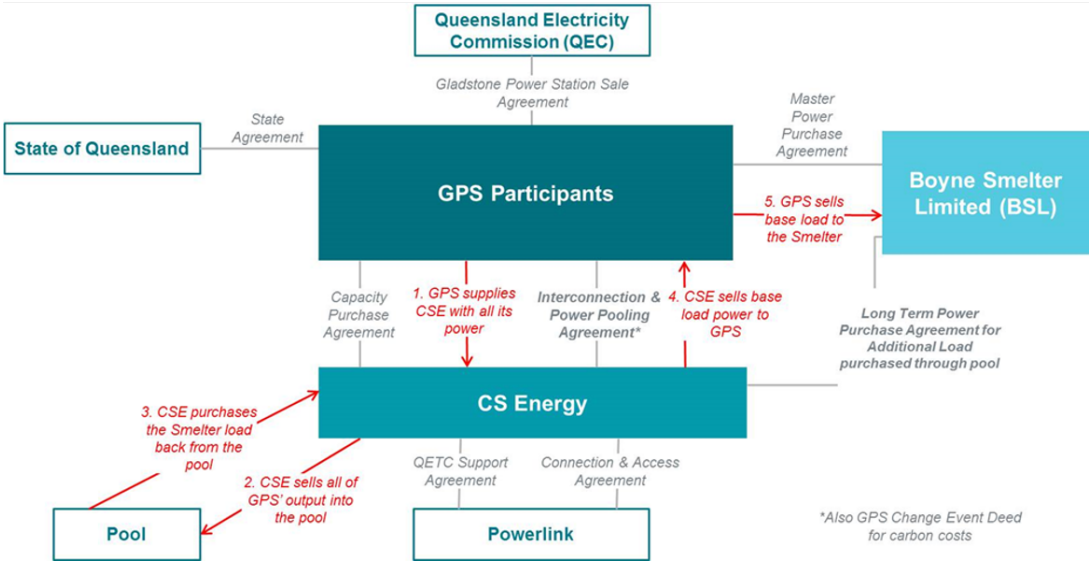
$$\$174.65\text{M} = \$25 \cdot 14 \cdot 499\text{K}$$

We note that even if the subsidy is only \$20 per MWH, it does not significantly affect our results. Nor does it matter whether we model this key purchase of 6,986GWH of Electricity net of the subsidy or gross:

$$\$558.8\text{M} = \$80 \cdot 14 \cdot 499\text{K}.$$

What does matter is the extent to which the subsidy is endogenous to the economy

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.

(see discussion below). This sensitivity is a result of the public-sector multiplier, suggesting that, if enough of the subsidy were to remain in the economy after shut down of BSL, then it would reverse any negative effects.

Gladstone (and Queensland) aluminium exports

There has been a marked decline in the diversity of the export market relative to the period 2000-2010. Since 2014, four countries, all long-term political allies of Australia, account for almost all the exports of Gladstone aluminium. In order of magnitude Japan, the Republic of Korea, the US and Taiwan. Japan purchases over 200KTPA. The Republic of Korea then follows with purchases typically ranging between 50 and 100KTPA.

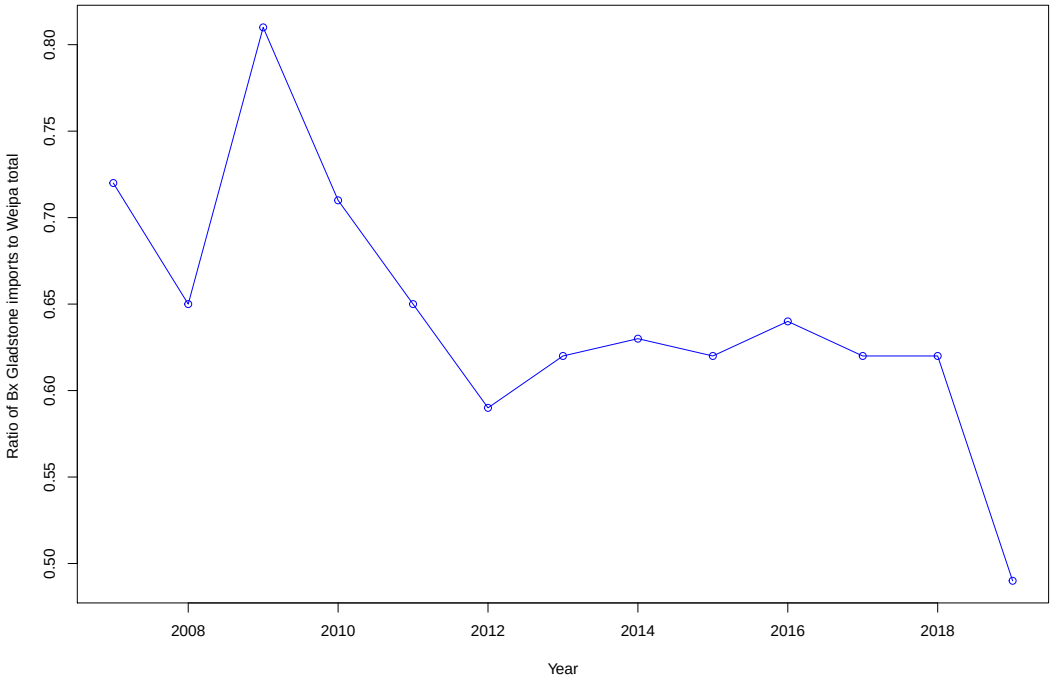
This absence of diversity in Aluminium exports stands in contrast with Queensland exports in the upstream markets of Alumina and, more recently, Bauxite.

Key upstream markets

For many years, Gladstone has been an integral part of RT's vertically integrated approach to aluminium production in Queensland. From bauxite (Bx) mining in the Weipa region of Far North Queensland, to alumina (Aluminium Oxide, AlOx) refinement, electricity (El) generation and aluminium (Al) smelting, all in the Gladstone region.

At regular intervals during the last decade (2011, 2015 and 2018), RT has unsuccessfully attempted to sell its Pacific Aluminium portfolio of assets. With the completion of the commissioning of the $1.9 billion Amrun bauxite mine at Weipa in March 2019, RT has established independence of bauxite production [6]. On the demand side, the main driver of the recent increase exports of Weipa Bauxite is demand from China.

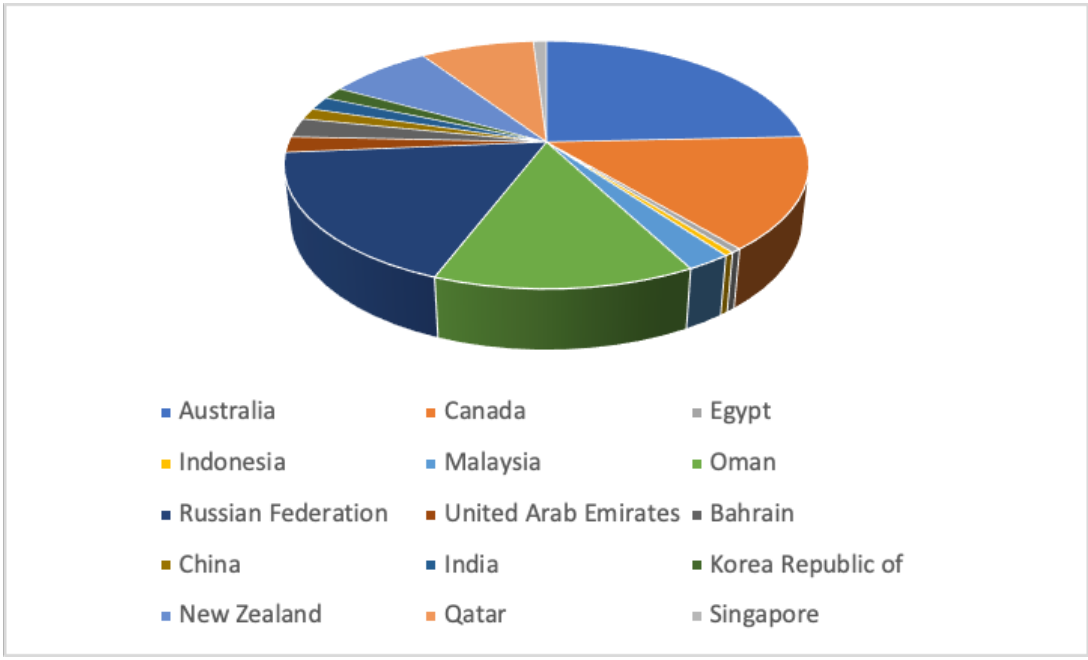
Figure (ii): Gladstone imports of Bauxite as a proportion of Weipa production (Gladstone Port Data)



Over time, Weipa Bauxite production has become less dependent on Gladstone Alumina refining. Since the Amrun mines opened in 2019, less than half of Weipa Bauxite arrives at Gladstone

Via Gladstone Port data, in 2019, imports of Bx to Gladstone from Weipa stood at 17,397.6KT. According to the RT 2019 Annual Report, this Bx is then refined into 6,545KT of AlOx at Gladstones two refineries: Queensland Alumina LTD and Yarwun Alumina Refineries. (RT owns 80% and 100% of these respectively.) Of this total Gladstone output of AlOx, 15% (1000 KT) is sold to BSL for smelting into unwrought Al. The rest is shipped to a wide range of international destinations.

Figure (iii): Gladstone exports of Alumina (AlOx) (Gladstone Port Data)



The diversity of this export market suggests that Alumina refining in Gladstone is largely independent of BSL. (For an interactive version of this chart see the slides.)

This diversity of export destinations bodes well for the upstream sector in the event of a BSL closure. Yet 15% is a significant volume of sales, and the potential for a small fall in revenues cannot be dismissed. Thus, in the intermediate economic scenarios that we model below, we specify a 50KT fall in quantity sold that is 5% of the amount of AlOx that BSL currently purchases. In other words, just under 1% of Gladstone total sales of AlOx. In the worst case scenarios, partly as a matter of completeness and partly in view of the current Covid-19 crisis, we suppose that RT fails to replace the BSL purchase, so that Gladstone AlOx sales volumes fall by 15%.

Further evidence of the likely resilience of Gladstone AlOx production to a BSL closure is the fact that RT recently moved its Alumina and Hydrates research facility from Brisbane to Yarwun at Gladstone. The University of Queensland participates in that research. In early 2020, mineral development company Alpha HPA (High Purity Alumina) announced that it will open a $200M plant in Gladstone with the growing demand from market for batteries in mind.[1] This shows that there is a clustering of businesses that are seeking to build on the existing expertise in the area.

Local sales of aluminium

We are able to obtain a coarse picture of the local downstream purchasers of Aluminium by looking at the difference between international exports (via the

[1] www.australianmining.com.au/news/gladstone-welcomes-200m-alumina-plant/

Gladstone port data) and BSL production. On average, over the last 15 years, BSL production has exceeded international exports by 189KTPA. Assuming local demand is more-or-less constant, this implies that almost two-fifths of BSL production is sold to downstream manufacturers in the Gladstone region, and more broadly in South-East Queensland. The desire to capture the impact on these sectors as well motivates our slightly broader definition of Gladstone.

Although global prices are unlikely to move as a consequence of a 25% reduction in Australian capacity for smelting, local prices for aluminium may well rise as a consequence of BSL's closure. It is often the case that smaller industries cluster around large producers of basic products. As a consequence, we will include a small knock-on effect on local aluminium prices as one of the economic scenarios we model.

Electricity generation in Gladstone

At 14% of existing capacity, GPS is Queensland's largest power generator. It is therefore a key part of Queensland's coal-fired fleet of power stations which, altogether, provide three-quarters of existing supply. Since the closure of Hazelwood (coal-fired) generator of Victoria in early 2017, Queensland has been a net exporter of electricity to NSW. Eastern Australia's dependence on Queensland coal will increase further following the upgrade to an existing interconnector in late 2021. This upgrade is part of the Australian government's broader strategy to secure energy supplies in time for the closure of the Liddell (coal-fired) power station of NSW in early 2023.

Although GPS will turn fifty in 2026, recent investment in upgrades by GPS operator NRG (a US firm) ensure that it has the capacity to remain beyond 2029 [10]. Indeed, the Draft Integrated System Plan [11, page 71] of Australian Energy Market Operator (AEMO) states

> "After the closure of Gladstone Power Station (currently expected in 2035), network upgrades are required to supply loads in the Gladstone area."

A variable-load, coal-fired power station

Most coal-fired power stations are of base-load type. That is they do not have the machinery in place to vary output in response to supply and demand shocks. This is the case for the other coal-fired power stations in Queensland (Kogan and Callide). In contrast, GPS is a variable-load power station making it well-suited to accommodating possible intermittencies that arise due to renewable energy supply.

In isolation, the immediate closure of BSL would have a significant downward impact on the price of electricity in Queensland. This impact is measured both in terms of a reduced average price on the one hand, but increased volatility on the other. Although BSL consumes approximately half of GPS energy capacity, because GPS operates well below capacity (between 50% and 60% of capacity on

average) the proportion of BSL electricity consumption to GPS output is perhaps close to 75%. Whilst this alone would suggest that GPS is entirely dependent on BSL, GPS in fact supplies the grid in open competition with other suppliers. In other words, the subsidy flows to BSL, not GPS. The key transaction BSL_Electricity is between the grid and BSL, not GPS and BSL.

We conclude this section reiterating that the potential increase in variation in electricity prices or potential blackouts that might arise if the capacity of GPS were removed from the East coast grid plays no role in the input-output analysis of this report. The potential disruption caused by such events (if any), should be seen as over-and-above the impact that we calculate.

The Input–Output Model

The challenges of "scrubbing" the data

Perhaps the most challenging task is that of scrubbing the data and building the appropriate Input–Output table. Our initial table is the latest Australian Bureau of Statistics (ABS) "Industry by Industry Flow Table (Direct Allocation of Imports)" for Australia [4]. One key observation is that this table subsumes Alumina Refining into Non-ferrous Metal Mining. Since there is no other mining in Gladstone of this form, we convert this Australian sector into Gladstone AlOx refining. We also convert Non-ferrous Basic Metal Manufacturing into the BSL sector for closure. We then estimate the cost functions for these two key sectors, on the basis of "hard" micro-level data such as Port of Gladstone Trade Statistics [5], Annual Reports (of RT in particular, [6]). We also obtain key output, capacity, possible exports and cost information concerning GPS with some of the information coming from QTC including two reports: [1] and [2].[2] In contrast with AlOx and Al production, which are each allocated their own dedicated sectors, we model a single Electricity Supply with GPS as an important part. We also pulled in key aspects of upstream and downstream sectors, use Location Quotients based on Queensland Regional Profiles data [7] and Gladstone Regional Council Data [8].

Software

In addition to Excel and Numbers, we use both The R Package (and RStudio in particular) for Input–Output modelling and the IO8 software to cross-validate our calculations; and Emacs for producing the report using the Latex mark up language.

The Local Economy: Gladstone-plus

We refer to the local economy of our model as Gladstone-plus. This is the *SA3 Gladstone region plus key sectors in Queensland that are upstream and downstream of BSL*. That is, we subsume key parts of the production of upstream Bx

[2]We thank Graham Phelan and Liam Ramke for their help in this process.

production, and the downstream South-East Queensland sectors for Aluminium Product Fabrication, Transport Manufacturing and Equipment Manufacturing, in our definition of "local economy". For Bx, this inclusion is modelled by adding Bx imports to the main diagonal of the intermediate production matrix and reducing imports accordingly. For the downstream sectors, we expand relevant intermediate transactions and exports for these three sectors.

Once these inclusions have been made the IO table needs to be rebalanced so that, for each sector i, Total Inputs (the vertical sum on an IO table) is equal to Total Output (the horizontal sum on an IO table). We do this by holding the columns for AlOx, Al and El constant whilst calibrating the rest the table to these parameters in an iterative process that resembles an implicit form of equibration. This rebalancing process brings the proportions of the table into line with the original data that we started with: the 2019 release of the ABS 2016-2017 IO table for Australia (see section for details). In particular, Gross Domestic Value Added as a proportion of Total Output (net of imports) for the Australian table is approximately 33%. This roughly matches our ratio of 31.6%. Small differences are inevitable because of our inclusion of upstream and downstream sectors as part of our effort to model the impact on the wider Queensland economy.

As per the Australia Table, we define Gross Value Added (GVA) as the sum of Employee Compensation, Gross Surplus and Tax (minus subsidies) on Production.[3] For Broader Gladstone, this is

$$\$7{,}782.5\text{M} \approx 3{,}392 + 3{,}398.5 + 402.4$$

In the table that follows, percentages are relative to

$$\text{Net Local Output} = \text{Intermediate Production} + \text{GVA}.$$

For Gladstone-plus, this number is \$13,295.4M, and, for Australia, it is \$3,060,572M.

Table 1: Comparison of aggregate figures

	Gladstone-plus		Australia	
	\$ M	%	\$M	%
Total Intermed.	5,669.9	42.7	1,416,011	46.3
Employ. Comp.	3,382.9	25.4	833,249	27.2
Gross Surplus	4,022.6	30.3	752,565	24.6
Tax on Prod'n	220.0	1.65	58,747	1.9
Gross Value Added	7625.5	57.4	1,644,561	53.7

On aggregate, these proportions for Gladstone-plus are sufficiently similar to those of Australia. Gladstone-plus is specialised in manufacturing and, for this reason, Labour's Share of GVA, at 44.3%, is relatively low compared to regions with labour-intensive sectors [9]. The trend towards low Labour shares is a long-term one that is currently the subject of intense debate and research the current economics literature. Since Gladstone is a relatively small region, the proportion

[3]The sum of P1, P2 and P4 on the Australian IO table.

of Imports to Regional Output is \$4,225.6M (31.8%) is between five and six times higher than that of Australia. This number is actually lower than the NIEIR figure (via economy.id.com) for Gladstone of \$7,373.4M because we have pulled dependent upstream and downstream industries into the economy of Gladstone-plus. If, for instance, we were to treat Bauxite as an import to Gladstone-plus, rather than as part of the internal economy, our imports would rise to approximately \$5,000M.

For this extended definition of the Gladstone regional economy, we obtain an implied or *effective workforce* of approximately 31,700 FTE employees. This is approximately 1,700 higher than QTC estimate of 30,000 in [1, page 16].[4] The Regional Profile figure for 2016 was 26,594 of which only 17,603 are full-time. Our figure therefore includes contractors and commuters to Gladstone from South East Queensland, as well as representative component of related upstream and downstream employment. It is relative to this benchmark that we measure changes in employment in the scenarios we study.

The Input–Output matrix of transactions

In figure (iv), we present part of the status quo transaction matrix. All scenarios involve modifying this transaction matrix and then comparing with the status quo.

The scenarios

The two overarching scenarios we consider correspond to the closure of BSL alone and the joint closure of BSL and GPS.

1. Full extraction of BSL from the local economy plus the following upstream and dowstream pricing subscenarios:

   (a) Full replacement of key BSL purchases (of AlOx and El) by exports; downstream manufacturing parameters are uneffected.

   (b) Partial replacement of key BSL purchases by exports (95% of AlOx and 80% of El); downstream manufacturing faces 5% extraction;

   (c) Nonreplacement of BSL purchases by exports; downstream manufacturing faces 5% extraction.

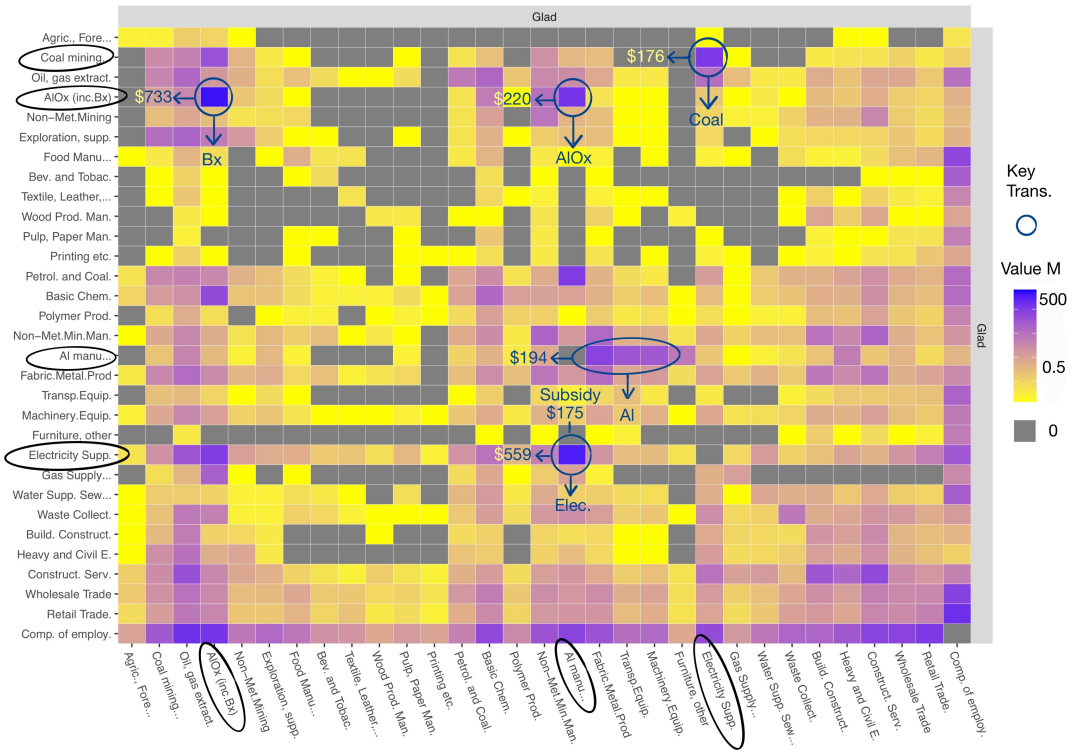
2. Full extraction of BSL and one-third extraction of El from the local economy, moreover, both exports of El and El purchases of coal are set to zero; and, finally, we consider the following pricing subscenarios

   (a) Full replacement of key purchases (BSL_AlOx and GPS_Coal) by exports; downstream manufacturing parameters are uneffected.

   (b) Partial replacement of key purchases (95% of BSL_AlOx and 95% of GPS_Coal) by exports; downstream manufacturing faces 5% extraction;

[4] This is a 2018 estimate by the National Institute of Economic and Industry Research

Figure (iv): The transactions matrix (AUD millions) for the status quo Gladstone-plus economy: sectors 5–34 and Compensation of Employment



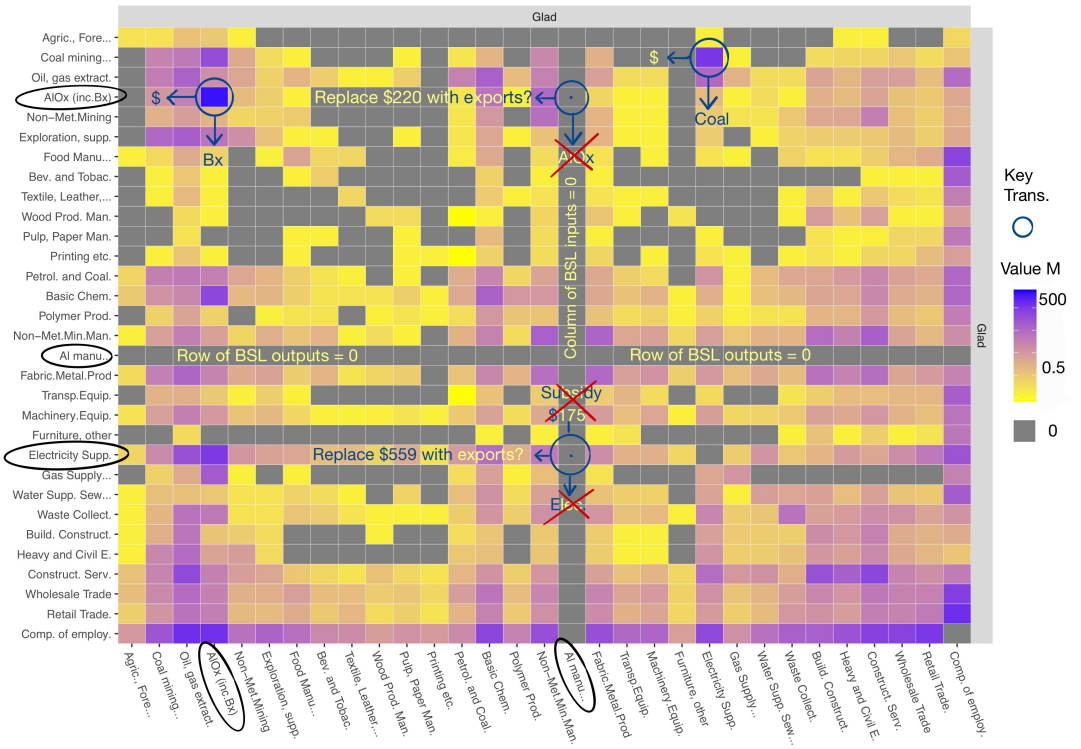
This heatmap provides a visual description of a fragment of the Input–Output table of transactions. Key, large transactions are represented by blue or violet squares. Yellow transactions are smaller. Grey stands for zero/no transaction. When we extract BSL from the economy, we assign a zero to every entry in the row and column indexed by "Al manu...". (It is the only Basic Nonferrous-Metal Manufacturer in the region.)

(c) Nonreplacement of purchases by exports; downstream manufacturing faces 5% extraction.

In all scenarios, we we impose a full extraction of BSL from the local economy and compare this to the status quo. BSL is extracted from the economy by setting both the row and column associated with BSL in the transaction matrix A to zero (see figure (v)). By setting the BSL row to zero, we are implicitly saying that all purchases of Al are now imported and therefore no longer part of the economy. By setting the BSL column to zero we are implicitly saying that BSL no longer purchases any goods or services from other sectors. The final step in the extraction is to set the final demand parameter of BSL to zero: this means that there are no exports of Al from Gladstone.

In scenarios (2a), (2b) and (2c), the one-third extraction of Electricity Supply from the local economy is modelled as setting every transaction in the row and column associated with Electricity Supply to two thirds of the status quo value. This partial extraction reflects the fact that many aspects of the provision of electricity will continue to be supplied locally. For instance, maintainance of cables

Figure (v): The modified matrix of transactions (AUD millions) for scenario (1a) where the Aluminium sector is extracted.



and measuring of meters will continue to take place after GPS is shut down. We choose to extract just one third of the Electricity Supply sector because that is a conservative estimate of the role of GPS and because it matches the proportion of GPS employees to employment in the sector $\frac{1}{3} \approx 192/600$. The fact that the exports are set to zero reflects the fact that Gladstone will no longer export power once GPS closes. Finally, the fact that, in scenario 2, GPS purchases of coal are set to zero needs no explanation.

Scenario Analysis of (exogenous) Exports

Let us consider the possible responses that agents in the economy might have a closure of BSL alone. As discussed above, it would seem reasonable for RT to seek new buyers for the Alumina that BSL is no longer buying. These potential buyers are necessarily outside of Gladstone (and indeed Queensland) and are enter the model via exports. If RT were successful in fully replacing the BSL_AlOx purchase of $209.6M with exports, then the revenues of Gladstone's AlOx refineries would not change and a significant part of the upstream effects of a BSL closure would be mitigated.[5]

Now suppose that, in addition, for the scenario where GPS remains open and

[5]We thank Brian Carrick and Liam Ramke for sharing their view that this would be a likely outcome during early discussions.

price movements in electricity and coal markets are such that it can maintain its current level of sales. Thereby fully replacing the BSL_Electricity purchase of $558.8M and, in effect, exporting this amount to rest of Queensland and the NEM. That is, GPS exports approximately 7,000GWH at wholesale prices of $80 thereby replacing both BSL and the lost subsidy. In this case, which is captured by scenario (1a), although the Gladstone economy has lost $744.5M in aluminium exports, the net decrease in Total Exports is

$$209.6 + 558.8 - 744.5 = -\$24\text{M}.$$

(A negative decrease is an increase.) This compensation via exports amounts to a significant *automatic stabiliser* for the economy as we will see in the scenario analysis of GVA and employment below. In scenario (2a), where the BSL_Electricity purchase is not replaced by exports, but where the GPS_Coal purchase is, total exports are

$$209.6 + 176.25 - 744.5 = \$359.6\text{M}$$

The percentage decreases in the following table are computed relative to status quo total exports of $7,279.6M.

Table 2: Decrease in Total Exports ($M) per scenario

	(a) Full	(b) Part	(c) None	Full	Part	None
(1) BSL	-24.0	110.8	757.0	-0.3%	1.5%	10.4%
(2) BSL & GPS	359.6	391.4	758.0	4.9%	5.4%	10.4%

For scenario (1b), total exports decrease by $110.8 relative to the status quo. This figure is calculated as follows:

$$95\% \cdot 209.6 + 80\% \cdot 558.8 - 744.5 - 5\% \cdot 250,$$

where $5\% \cdot 250 = \$12.5\text{M}$ represents the decrease in exports by downstream Fabrication of Aluminium Products, Transport Manufacturing, etc. due to the increased costs of importing Al from further afield. Clearly the main change relative to scenario (1a) is that GPS is only able to replace 80% of the BSL_Electricity transaction. Since the BSL_El purchase accounts for 75% of GPS output, in this scenario, we are modelling a fall of 15% in total GPS revenue. This fall is motivated by potentially lower prices that arise following the closure of BSL. For scenario

For scenario (1c), the fall in exports is simple to calculate: the large fall of $744.5M in Al exports plus the downstream fall of $12.5M. Although it is difficult to motivate the scenario where there is no response, it is worth bearing mind that this would be in keeping with a standard IO analysis. Moreover, it facilitates a comparison with scenario (2c), where there is also no response and both BSL and GPS shut down: because the shock to final demand is similar.

In all scenarios, the export multiplier is equal to 1 as exports are exogenously determined by external demand. This amounts to assuming that there are no indirect effects of the shock outside the local economy. This is a reasonable assumption given the fact that Gladstone-plus is small, and we are modelling the relevant upstream and downstream sectors endogenously (part of Gladstone-plus)

Scenario Analysis of Gross Value Added

We now present results for the endogenous measure of economic activity, GVA. As per table 1, the status quo level of total GVA is \$7625.5M. Percentage decreases in the following table are computed relative to the status quo.

Table 3: Total Decrease in Gross Value Added (\$M) per scenario

	(a) Full	(b) Part	(c) None	Full	Part	None
(1) BSL	252.1	392.2	942.3	3.3%	5.1%	12.4%
(2) BSL & GPS	739.6	788.1	1121.3	9.7%	10.3%	14.7%

Even in the best scenario (1a), GVA falls by approximately \$250M. A substantial part of the difference between the central scenarios (1b) and (2b) is explained by the Electricity Sector (which has status quo Value Added of \$262.8):

Table 4: Total Decrease in Electricity Sector Value Added (\$M) per scenario

	(a) Full	(b) Part	(c) None	Full	Part	None
(1) BSL	1.1	35.1	173.9	0.4%	13.4%	66.2%
(2) BSL & GPS	221.1	221.3	223.8	84.1%	84.2%	85.2%

Note that the 84% to 85% loss in Electricity Sector Value Added in scenarios where GPS also closes is unsurprising given that the BSL_Electricity purchase represents 63% of sector revenues. Indeed it is the loss of this and other transactions explains the higher GVA multiplier in scenarios (1c) and (2c) (see table 6).[6]

Table 6: Gross Value Added multiplier per scenario

	Full	Part	None
(1) BSL	1.9	2.9	6.9
(2) BSL & GPS	3.4	3.5	5.0

In the present paper, the subsidy is run through the Aluminium Manufacturing sector. If instead we were to run the subsidy through the Electricity Sector, although the aggregate effects would be similar, we would see an increase Value added for the Electricity Sector in scenarios (1a)–(1c). For expositional purposes, we present the result for that treatment of the subsidy in figure (vi).

[6]We define this multiplier as total (direct plus indirect) effect divided by the direct effect, where the direct effects on GVA are

Table 5: Direct Decrease in Gross Value Added (\$M) per scenario

	Full	Part	None
(1) BSL	130.5	136.3	136.3
(2) BSL & GPS	218.1	223.9	223.9

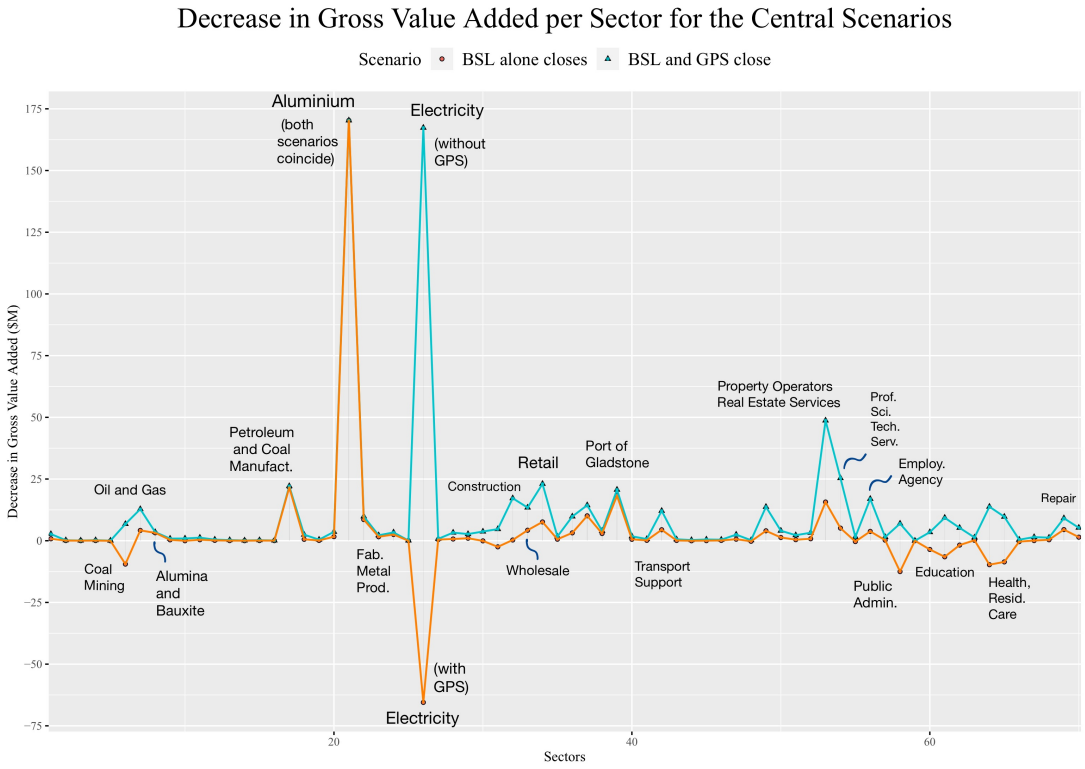


Figure (vi): In this figure, for our central scenarios (1b) and (2b), the subsidy instead runs through the Electricity Sector. In scenario (1b), Electricity Sector Value Added increases (the downward spike). We also see small increases in VA in other sectors due to the public sector multiplier. We observe similar effects following the closure of the Kurri Kurri and Point Henry smelters.

Scenario analysis of aggregate employment

Recall that there are 920 employees at BSL and 192 employees at GPS. Following consultation with QTC, we model these jobs as premium, with average (mean) annual employee compensation of just over $117K (including superannuation). The average annual compensation for the rest of the broader Gladstone economy is taken to be $107K.[7]

For our broader definition of Gladstone, with an *effective workforce* of 31,694, we obtain the following table of direct job losses.

Table 7: Direct decrease in employment (FTE) per scenario

	(a) Full	(b) Part	(c) None	Full	Part	None
(1) BSL	920	955	955	2.9%	3.0%	3.0%
(2) BSL & GPS	1112	1147	1147	3.5%	3.6%	3.6%

Table 7 confirms that in scenario (1a) the only job losses those in the employment of BSL. In (2a), the figure 1,112 = 920 + 192 is the sum of the losses at BSL and GPS. In the other four scenarios, the additional 35 job losses are coming from the downstream sectors (Fabrication of Metal Products, Transport and Equipment Manufacturing and Machinery Manufacturing). This minor effect is the result of our 5% extraction of these sectors to capture the impact of a small but significant rise in the local price of aluminium. We argue that this is plausible given that these sectors will have to source their purchases from further afield in absence of BSL.

Table 8: Indirect decrease in employment (FTE) per scenario

	(a) Full	(b) Part	(c) None	Full	Part	None
(1) BSL	356	927	3120	1.1%	2.9%	9.9%
(2) BSL & GPS	2190	2392	3570	6.9%	7.6%	11.3%

Table 8 shows that the extent to which exports respond is vital in explaining indirect effects. In scenario (1a), exports of AlOx and Electricity fully compensate and as a consequence, the indirect job losses are less than half of direct losses. In scenario (2a), although exports compensate for the BSL_AlOx transaction and the GPS_Coal transaction, the absence of GPS means that the economy suffers a total loss of the BSL_Electricity transaction. As a consequence, indirect job losses are almost twice direct losses.

In our central subscenarios, a similar, but less stark conclusion holds. In scenario (1b), where exports compensate for 95% of the BSL_AlOx transaction and 80% of the BSL_Electricity transaction, indirect job losses are just similar to direct losses. In scenario (2b), where exports compensate for 95% of both the BSL_AlOx

[7]According to Regional Profiles Data, the ratio of the median worker in Gladstone to the median worker in QLD is 1.213. The average (mean) employee compensation (including superannuation) for QLD is very close to $107K/1.213 ≈ $88K.

and the GPS_Coal transactions, but the BSL_Electricity transaction is lost, indirect job losses are more than twice direct losses.

Finally, in the worst case, where exports do not compensate at all, we see that indirect job losses are rather similar: the ratios of indirect to direct job losses are both above 3 and in fact higher in scenario (1c) than in (2c).

These ratios are also reflected in the following employment multipliers.

Table 9: Total Employment (FTE) multiplier per scenario

	Full	Part	None
(1) BSL	1.4	1.9	4.0
(2) BSL & GPS	2.8	2.9	3.8

We conclude the analysis of aggregate employment for the Gladstone economy with the total (direct plus indirect) impact on employment.

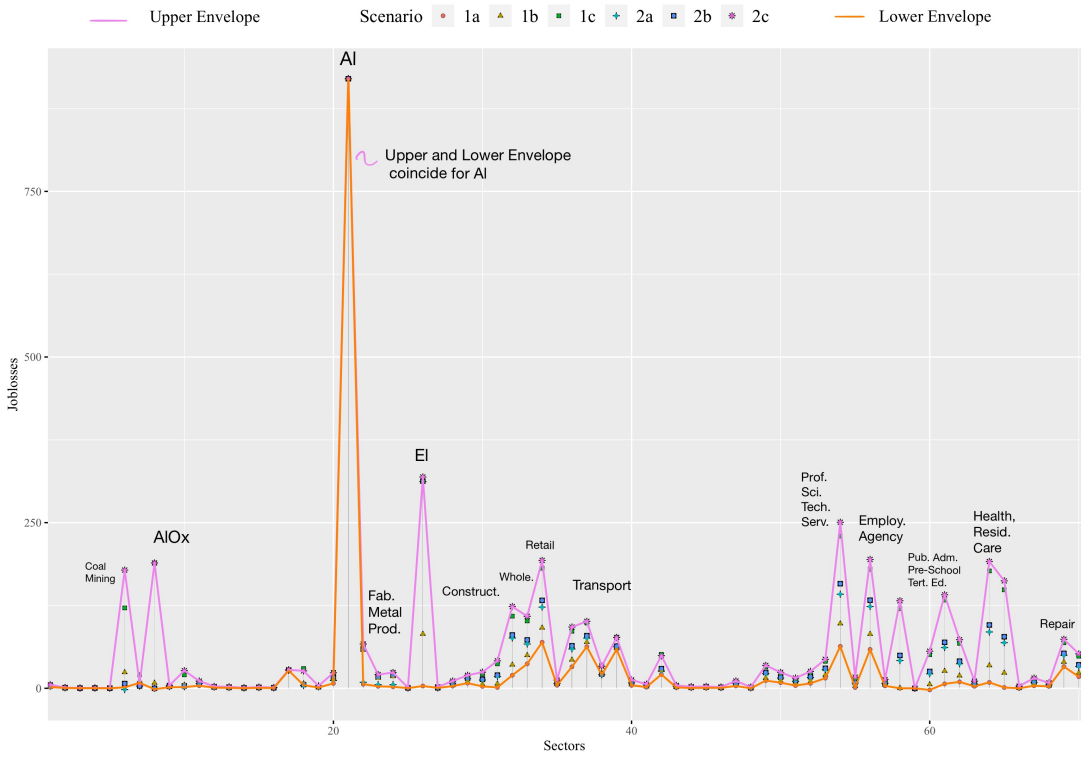
Table 10: Total decrease in employment (FTE) per scenario

	(a) Full	(b) Part	(c) None	Full	Part	None
(1) BSL	1276	1882	4075	4.0%	6.0%	12.9%
(2) BSL & GPS	3302	3539	4717	10.4%	11.2%	14.9%

Analysis of employment by sector

In section , we showed that the indirect effects on aggregate employment for the combined closure of BSL and GPS. One reason for this relatively large indirect effect is that, Employee Compensation for Electricity Supply in scenario (1a) is essentially the same as the status quo. This implies no job losses to the sector in that scenario with employment at approximately 600. In scenario (2a), employment in Electricity Supply falls to around 100. Given the basic inelasticity of demand for electricity and the services associated with the delivery of electricity such as cable mainenance and electricians, it seems unlikely that employment in Electricity Supply would indeed to fall to such a low level. The overshooting of the model is an artifact of the linearity of the present model and its inability to capture inelastic demand for electricity. One solution would be to run a nonlinear version of the present model, but due to time constraints this is beyond the scope of the current modelling exercise. Instead, we reallocate job losses from Electricity Supply to other sectors that remain open on a pro rata basis (depending on its original level of employment). Since there are 68 other sectors, the change for each sector relative to its original size is negligible. This ensures that, in all scenarios, job losses to Electricity Supply are no higher than half the total for the sector. Figure (vii) shows that there are approximately 300 job losses to Electricity Supply in every scenario except (1a) and (1b). It also highlights the other sectors that are likely to suffer large job losses.

Figure (vii): Total job losses across all 70 sectors and all six scenarios. The two main losses are to the smelter and the power station. In scenario (1a), there are no losses to Electricity Supply, AlOx, Coal Mining or Fabrication of Metal Products.



For scenario (2a), beyond Aluminium production and Electricity Supply, indirect job losses in other sectors number 500 in total. The sector with the next highest number of job losses is sector 54 (Professional, Scientific and Technical services) is the sector with the next highest job losses at 198. Beyond this, sector 56 (Employment, Travel Agency and Other Administrative Services) sees job losses of 130 and sector 34 (Retail) a further 111 job losses.

As figure (vii) shows, the job losses in these sectors increase further in scenarios 1c and 2c, where exports do not compensate for the loss of the other key transactions (BSL purchases of AlOx and GPS purchases of Coal). (The impact of these two transactions is visible as smaller spikes to the left of the figure.)

Conclusions

In our view, BSL purchases of AlOx are likely to be replaced by exports in the event of a shut down. High elasticity of demand in international markets would ensure that the upstream producers of Bx and Alumina would recover quickly. In the short run at least, given the volume of coal that passes through Gladstone port, GPS purchases of (thermal) Coal would also recover quickly. In other words, scenarios (1c) and (2c) are unlikely to materialise.

It is less obvious that GPS "exports" would replace BSL purchases of Electricity in the event that it remained open. Support for the idea that GPS would

comes from the observation that GPS currently competes with other participants to sell its electricity to the grid. On the other hand, the fact that GPS is currently operating below capacity (at around 60%) is a consequence of inefficiencies associated with the age of the power station. But it also reflects subsidies to other, cleaner forms of energy. It is important to note that, in the present setting, the subsidy that CS Energy provides to BSL, is indirect. If BSL were to close, the likely fall in electricity prices would render GPS less competitive.

- The central scenarios capture what we view as the most plausible outcomes.

Given that GPS is a variable load power station with significant capacity provides the East Coast electricity market with insurance (a put option) against volatile electricity prices and potential blackouts. Indeed, assuming that BSL were to shut down, this option value suggests that there may be a smaller subsidy that might be worthwhile to keep GPS open at least until a genuine replacement source of power is established. If for clean energy reasons, a coal-fired power station in Queensland is to shut down, it is worth considering other power stations as the opportunity cost of closing GPS is high. Even if the economic impact of a GSP closure on Gladstone itself (as opposed to Gladstone-plus) is less smaller than the impact we identify here, it is bound amplify the impact of the closure of BSL. Closing a coal-fired power station in a different region of Queensland might help to spread the burden across a wider geographical area.

What we do not measure in this study is the benefit to consumers of a fall in electricity prices that would follow the shut down of BSL. A more complete social welfare analysis would entail measurement of the likely movement in electricity prices, something that is beyond the scope of the present study.

Planning is the key to transition and a successful transition would make all the difference in event that BSL and, eventually, GPS close. The Kurri Kurri smelter in NSW is still in early stages of decommissioning and the local Hunter Region community is still in the process of planning *8 years* after the smelter initially closed down. Although aggregate employment has almost-fully recovered, the manufacturing sector for the Hunter Region is significantly smaller than it was in 2011.

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