The future of Australia's thermal coal industry in a low carbon environment

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This paper provides projections of the transition ahead for Australia's thermal coal industry under the global effort to keep global warming below 2°C. The study uses a Computable General Equilibrium (CGE) model with a bottom-up representation of the regional economies where thermal coal mining is concentrated, linked directly with the surrounding national and global economies. The database of the model is constructed from the latest global and regional input-output data and has a comprehensive emissions accounting module covering CO2 and non-CO2 emissions from all sources.

A range of sensitivity analysis is conducted to account for the inherent uncertainty in assumed behaviour. The results show the industry is facing a persistent and severe contraction with knock-on effects for regional economies. This underscores the need for proactive and forthright planning by policymakers to help ease the transition of local workers and populations.

Introduction

This paper investigates what the global transition to a low-carbon future means for Australia's thermal coal industry and the regions in which the industry is found. Thermal coal is usually Australia's second largest export commodity by value (Cunningham et al 2019), but the industry has a high degree of foreign ownership (so much of the return on capital is not captured directly) and it is relatively capital intensive (so employs relatively few people, compared with many other industries of similar size). However, the thermal coal industry is concentrated in a small number of areas where it makes up a high share of employment. Policymakers have shown a keen interest in how the coal industry, and the regions it is found, will fare in a low carbon future.

A number of Australian studies have looked at the potential impact of transitioning to a low-carbon future on the Australian economy and as part of that, the coal industry (Adams, Parmenter & Verikios, 2016). Other studies which have looked at the transition facing small regional economies in the face of various economic shocks (for example, Corden and Neary 1982).

As yet, no study has brought together these two strands of literature together to investigate the impact of transitioning to a low-carbon future on the parts of Australia where the thermal coal industry is actually located.

Literature

A rich literature exists on the transition required by the Australian economy as part of a global movement toward decarbonization, with the best recent example being Adams, Parmenter & Verikios (2016). These authors project a sustained contraction ahead for Australia's coal mining industry, driven by global efforts at decarbonisation and the effect this has in constricting the demand for fossil fuels.

In general, this literature has employed economy-wide models, like computable general equilibrium (CGE) models. A good summary of the development and use of these models can be found in Dixon and Jorgenson (2013).

There is also a rich literature regarding how resource-dependent economies react to demand shocks (for example, Corden and Neary 1982). Again, this literature has commonly employed CGE modelling to help understand phenomena like 'Dutch disease', see for example Forsyth et al (2014).

Another stream of literature relevant to the this paper is that concerning the use of CGE models to model specific developments in or policies aimed at the coal mining sector. Once again, there is no shortage of work on this topic. van Heerden el al (2016) and Glomsrød and Taoyuan (2005) provide good examples from opposite ends of the world (South Africa and China). In Australia, Waschik (2015) gets closest to the central focus of this paper in analysing the potential impacts of a carbon tax on the coal mining sector with differentiated products, increasing returns to scale and heterogeneous firms.

There is no existing literature on the potential reaction of those areas in Australia which are dependent on coal mining to a change in demand consistent with a global move toward decarbonisation. This is the central contribution of this paper, drawing together the innovations in work like Waschik (2015), the insights from work like Corden and Neary (1982) and the overarching policy framework of Adams, Parmenter & Verikios (2016).

Model

The Deloitte Access Economics regional general equilibrium model (DAE-RGEM) belongs to the class of models known as recursive dynamic regional computable general equilibrium CGE models. Other examples of models in this class are the Global Trade and Analysis Project Dynamic (GDyn) model (Ianchovichina and McDougal, 2000), the Victoria University Regional Model (VURM, Adams, et. al. 2015) and The Enormous Regional Model (TERM, Horridge et. al. 2004).

Like all models, DAE-RGEM is reliant on a number of simplifying assumptions. Two high-level examples include the market clearing assumption and zero pure profit condition, meaning that any shock will lead to adjustment in prices such that all markets clear at the end of each period (one-year). These assumptions are ubiquitous amongst CGE models with Norway's multi sectoral growth (MSG) model being a notable exception (Holmøy and Strøm, 2013).

Each region within the model is populated by a representative household who receives all income and seeks to maximise utility subject to a budget constraint and an assumed fixed savings rate. This is done under recursive expectations. The household's utility function is Cobb-Douglas, with starting budget shares and parameterized cross-price, own-price and income elasticities governing the response to changes in relative prices. Energy is treated as a composite in the consumption bundle with a second level nest allowing substitution between fossil fuels (oil, gas, etc.) and electricity. This allows a transition in the electricity grid toward renewables to decarbonise energy consumption.

There is also a representative firm in each sector of each region which draws on factors of production (land, labour, capital and natural resources) along with intermediate inputs in producing goods for sale to either domestic, interstate or international purchasers. Where this sale is to a firm or household outside it's region, the transaction is treated as an export.

Land is used only for agriculture and is assumed to be in fixed supply with very limited substitution between sectors as part of a constant elasticity of transformation (CET) function. Non-agricultural land is part of the capital stock and is sluggishly mobile between sectors.

Labour is supplied by local households who are assumed to follow an upward sloping supply curve so that shifts in the real wage can shift affect the aggregate level of employment with labour moving sluggishly between sectors in response to relative wages.[1]

Capital is relatively more mobile between sectors than other factors and accumulates as a function of last period's investment less depreciation. Investment is wholly debt-based and occurs as each region's households allocate their savings on international bond markets in response to relative rates of return with some allowance of country-risk.

Natural resources are specific to the sectors who use them (mining, forestry and fishing) and follow a baseline path whereby the quantity of natural resources used adjusts to keep its relative price constant at the base-year level. In policy simulations this assumption is relaxed so that firms can extract increased amounts at higher costs as demand increases.

There are a full suite of production, income and consumption taxes in the model as well as trade duties. These taxes are ultimately recycled to households as part of regional income, and government consumption is assumed to move with regional income also, so there is a balanced budget via a lump sum transfer.

In order to appropriately capture the impacts of changes to environmental policies – including emissions reductions – DAE-RGEM has been supplemented with an environmental module. This requires the addition of a supplementary set of accounts which track emissions by each agent (i.e. firms) and associated with each use (i.e. combustion of fossil fuels) and of each gas. This set of accounts is linked to the economic accounts underlying the core version of the model, so that the emissions are associated with an economic flow. These flows can then be altered through changes in relative prices (i.e. introducing a tax), imposing policy constraints or improvements in efficiency. Integrated in this way, the model can be used to gain insights as to the economic impacts, and effectiveness of different emissions-reduction policies.

Data

The core economic data underpinning DAE-RGEM - the social account matrix (SAM) - is sourced from the Global Trade Analysis Project (GTAP) database (Walmsley et. al., 2013). In this instance, that economic data is supplemented with specific data on electricity differentiated by power generation type (i.e. coal, gas, solar, etc.) from the GTAP satellite database GTAP-Power as well as CO2 and non-CO2 emissions data.[2] The behavioural parameters are also sourced from GTAP for the most part with some exceptions as discussed below. This data is transformed in two key processes.

[1] Migration occurs in response to shifts in the real wage gap between regions.

[2] In this version of the model the 11 distinct generation types specified in the GTAP Power database are aggregated to 7 (coal, gas, oil, wind, hydro, solar and other) with transmission and distribution seperately identified.

The first transformation involves splitting of the national level data from GTAP such that Australia is comprised of five sub-national regions including the coal mining regions within Queensland (Bowen) and New South Wales (Hunter). Alongside these two regions of focus sit the rest of each state (i.e. rest of Queensland and rest of New South Wales) and the rest of Australia (an amalgam of the other States and Territories). Each sub-national region becomes a distinct regional economy with its own SAM. The data is apportioned by calculating appropriate shares to split the national SAM, based mainly on data on place of usual residence and industry of employment drawn from the 2011 Census of Population and Housing.[3] This is used in combination with estimates of labour's share of production to determine a share of total production (or value added) for each sector in each region and these industry specific shares are used in conjunction with macro shares like that concerning the total resident population. Discrepancies in production (determined primarily by workers) and consumption (determined primarily by population) are used as first-best estimates for intra- and inter-state trade with a version of the gravity assumption used in prioritising trade between a sub-state region and its parent. As an example of the results of this process, the Hunter economy is estimated to be around 4 percent of the size of the NSW economy but accounts for over 70% of coal production meaning that sector is the most significant one in the Hunter whereas it accounts for less than 1% of the NSW economy outside the region.

The second transformation is to split the coal mining sector into metallurgical and thermal coal. This is done using information on how coal is used, the share of global production, Australian production and seaborne trade so as to maintain the following stylised facts:

1. thermal coal is used in the production of coal-fired electricity and accounts for around three quarters of global production;
2. metallurgical coal is used primarily in the production of steel but is processed first in the 'petroleum and coke' sector and accounts for around 13 percent of global production;
3. Australia produces more thermal coal but exports more metallurgical coal;[4]

There is scope for further refinement of this process drawing on more detailed data to help get a better picture of production, consumption and export, specifically at the detailed regional level. As flagged at the beginning of this section, there are a number of parameters in DAE-RGEM which are sourced directly from GTAP. These include the Armington trade electicities, the elasticity of substitution of primary factors and those parameters governing the household consumption response both in terms of the income and price elasticities.[5] However, given the structure of DAE-RGEM differs from GDyn there are some parameters which are taken from elsewhere in the literature. Appendix A lists these alongside a sensitivity analysis.

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[3] More recent census data from 2016 is available and will be incorporated when a full suite of updated GTAP data becomes available.

[4] Some coal is also used for cement production and other industrial uses.

[5] There are some exceptions or alterations made, notably to the newly created sectors thermal and metallurgical coal. These two sectors are assumed to have the same production function and thus have the same parameters governing substitution of primary factors, however, they have different trade elasticities reflecting the fact that Australia has more market power in metallurgical coal than in thermal coal.

Scenarios

As with all CGE models, DAE-RGEM is run in two steps with insights being drawn from the deviations between a policy scenario, where something is shocked, and a business as usual or baseline scenario, which makes assumptions regarding the growth path of the economy in the absence of the change of interest (in this case, a global transition to a low-carbon economy).

The baseline of DAE-RGEM is calibrated to match historical data where available, as well as official projections. For example, the growth rate of GDP, population and labour supply are all targeted in each year of the baseline to track official history from the ABS for Australia and the IMF for the rest of world. Projected growth rates are taken from the IMF for both Australia and the rest of the world.

The baseline scenario includes representation of decreases in costs of renewable electricity generation technologies like wind and solar, sourced from CSIRO (2019).

Projections for Australia's emissions in the baseline match Australian Government projections (SOURCE) and global emissions are assumed to follow a pathway consistent with representative concentration pathway six (RCP 6.0) from the intergovernmental panel on climate change. There are no damages from the climate change which would ensure from this assumed baseline emissions path.

Table 2 (over the page) displays the historical and projected growth of key variables.

Table 2 - Baseline assumptions

Variable	Historical	Projected	Source
Australia			
GDP	2.58	2.63	IMF
Population	1.60	1.60	UNPD
Labour supply	0.94	0.77	UNPD
Renewable learning	5.0 - 7.0	0.5 - 3.0	CSIRO
World			
GDP	3.56	3.56	IMF
Population	1.14	1.12	UNPD
Labour supply	1.11	1.01	UNPD
Renewable learning	5.0 - 7.0	0.5 - 3.0	CSIRO

It is against this baseline which policies to curb global emissions are evaluated. The policy environment both domestically and globally is far from certain, especially in the long-run. However, the 2015 Paris accord provides some guidance on Australia and other countries' planned actions over the next decade. This frames the assumed policy response evaluated in this paper with Australia projected to meet the 28% end of its 2030 target and the globe following a similar trajectory.

In both cases this is done through the imposition of an economy-wide constraint on emissions with a shadow price forming to drive the relative price changes which lead to decarbonisation. This is not a policy currently in place or planned to be adopted by a broad range of countries. However, in Australia's case, the projected emissions reductions are not far from those that one might envisage under a policy suite which focuses first on the energy sector and then onto other 'lower hanging fruit' like agriculture and industrial processes.

Results

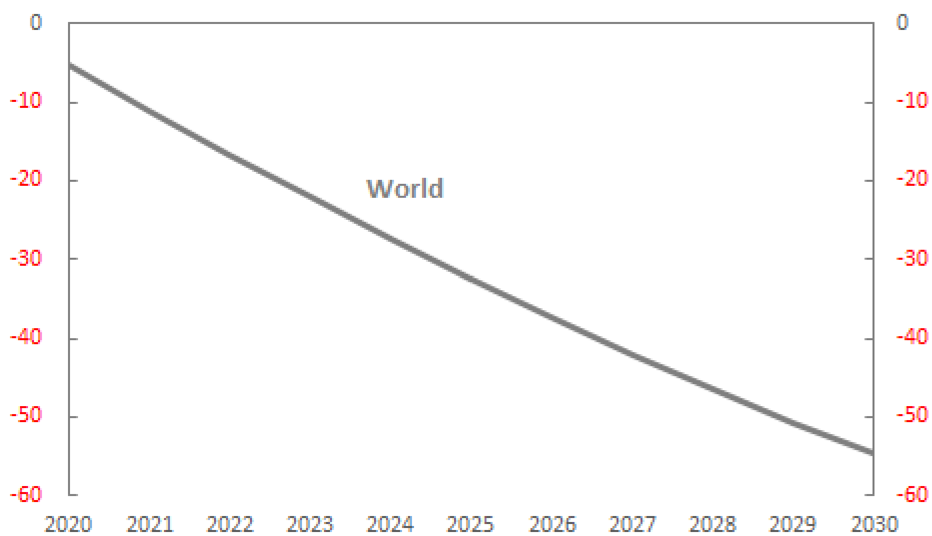
This section will present the results from the policy described previously on the global thermal coal market, then that of Australia and specific regions before moving to a discussion of the potential macroeconomic impacts on the coal-dependent regions and the Australian economy as a whole.

As can be seen in chart one below, global production of thermal coal is projected to decline steadily over the period from 2020 to 2030.[6] The combustion emissions from coal fired electricity generation are a significant part of the global emissions inventory. The global effort to decarbonise leads to fuel switching within fossil fuels (i.e. from coal to gas) and away from them on the whole, towards renewables.

It is a significant contraction given the assumed path of global action is modest to 2030 with faster emissions reductions assumed to occur afterwards. As is explored in Appendix A, the extent of this shift is a function of the assumed flexibility in electricity production and consumption but the direction and broad magnitude is robust to parameter choice.

A significant uncertainty exists around the ability of electricity generators to utilise carbon capture and storage (CCS) technologies to allow fossil fuels to continue in use under emissions constraints. No such technologies are assumed to become commercially viable in the period shown here.

Chart 1 - Deviations in global thermal coal production

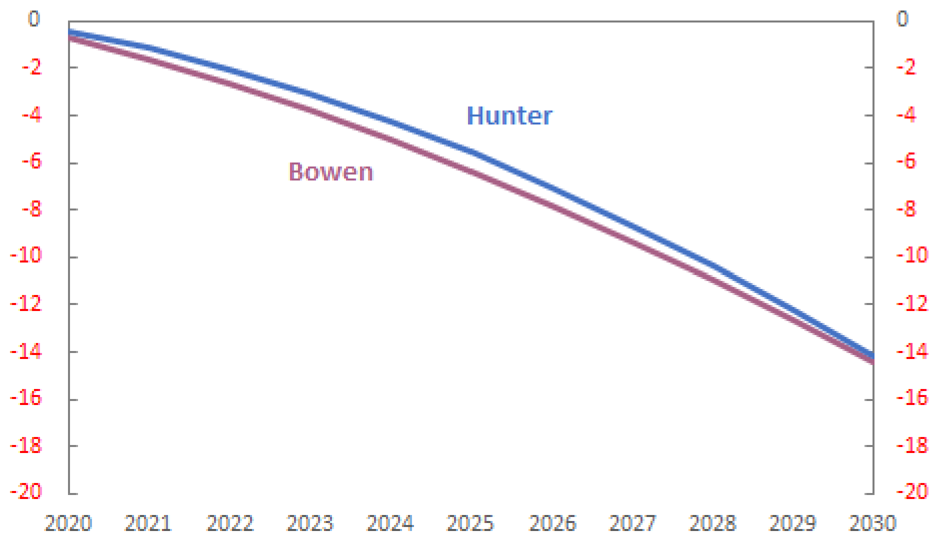


The decline in global demand and production of thermal coal does not translate one-for-one to a reduction in Australian exports (see chart 2 below).[7] Australian coal has a much higher energy content than is found in most other countries and so it is more efficient for the rest of the world to continue to use Australian coal under an emissions constraint. However, this does not mean that one would expect exports to increase, especially given the emissions associated with

[6] This chart and all those presented in this section show the implied percentage deviation in the level of a variable in the policy scenario relative to the baseline.
[7] The Australian results presented here will focus on the Bowen and Hunter basins as this where the vast majority of Australia's coal is produced and these are the regions most likely to be directly affected by shifts in demand.

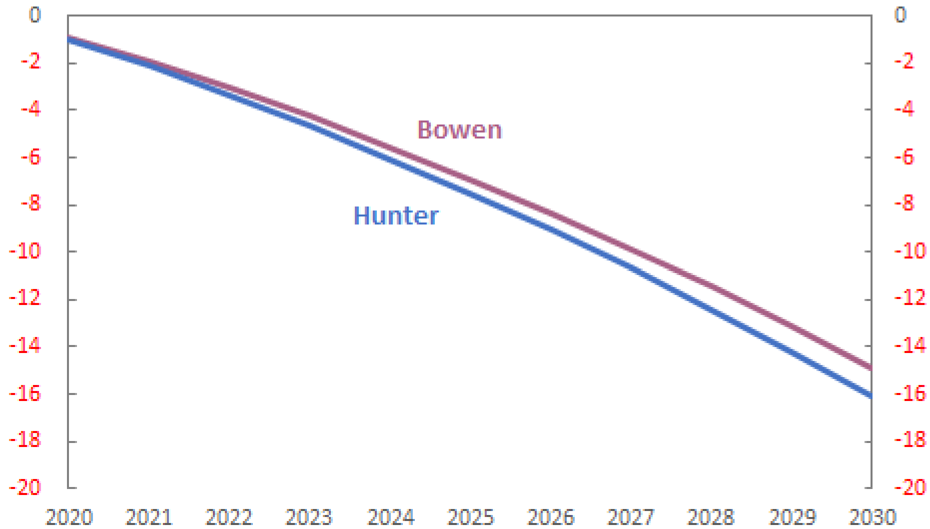
transporting the coal, but rather just that efforts to reduce emissions overseas are better focussed initially on reducing the consumption of their domestic coal.

Chart 2 - Deviations in Australian exports of thermal coal



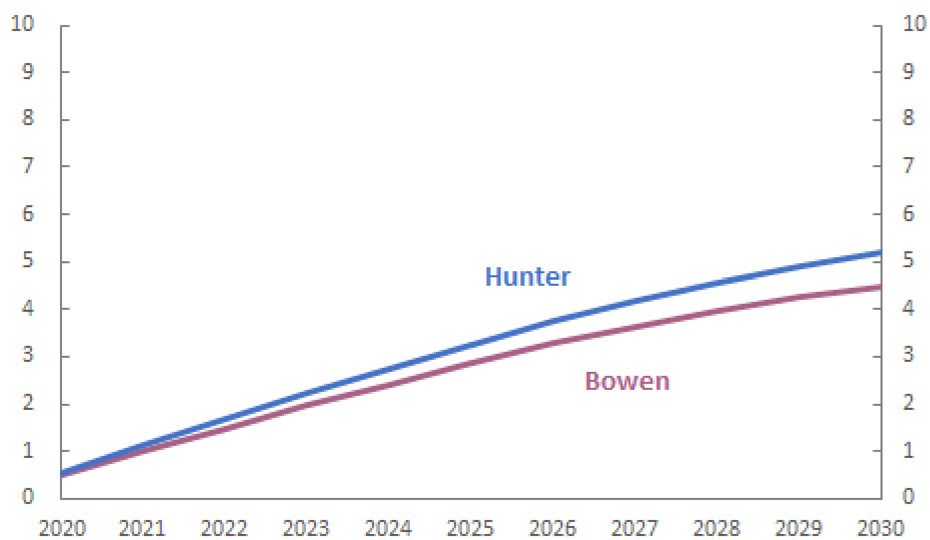
The projected decline in Australian thermal coal production is marginally more significant than that projected in exports, as shown in chart 3 (over the page). Although exports account for the majority of coal produced in Australia, there is still a significant component which is used domestically and Australia has a relatively high share of fossil fuel-based electricity generation for a developed country. Added to this, the coal which is exported from Australia is usually of a higher energy content than that used domestically, and so Australia goes through something of a similar process to that projected for the rest of the world in focussing initial efforts on reducing consumption of domestically produced coal in the generation of electricity.

Chart 3 - Deviations in Australian thermal coal production



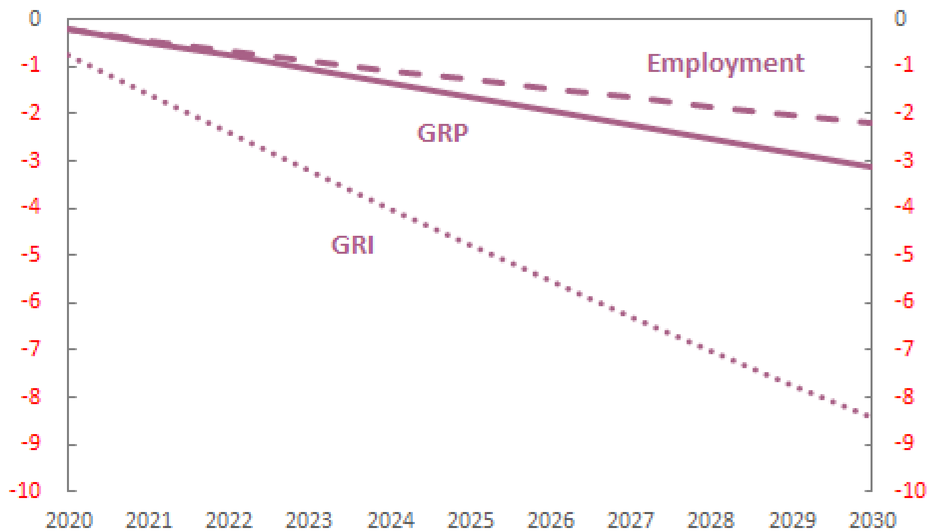
A notable sectoral result from this analysis is the projected change in the demand for Australia's metallurgical coal as shown in chart 4 (below). In contrast to what is expected in terms of global and Australian demand for thermal coal, the demand for metallurgical coal is projected to *increase*, providing an opportunity mines supplying both markets. The reason for this is that metallurgical coal is mainly used in steel production, which is projected to increase in the low-carbon scenario modelled – the transition to decarbonisation requires a turning over of the capital stock. There is currently no feasible, large-scale alternative feedstock to metallurgical coal in the production of steel, and Australia actually plays a more important role in global trade of metallurgical than thermal coal.

Chart 4 - Deviations in Australian metallurgical coal production



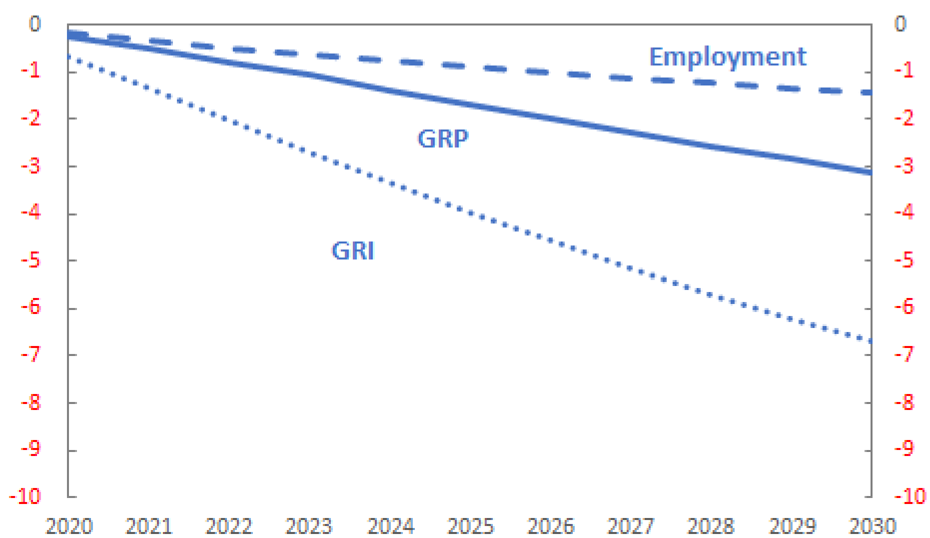
Despite the projected increased production in some sectors, both the Bowen and Hunter are projected to face considerable challenges in terms of macroeconomic adjustment (charts 4 and 5). The broad story is the same in both cases: a protracted decline in demand for a key commodity detracts from the local economy, incomes and employment. The impact on incomes is largest (in percentage terms) as the regions' terms of trade suffer. Consistent with the fact that thermal coal mining is not very labour intensive, the employment impacts are the most modest out of the three indicators.

Chart 4 - Macroeconomic impacts in the Bowen basin



The primary driver of the difference in the impacts projected for the Bown and Hunter is the significance of the thermal coal sector which is larger in the former. Added to this, the Hunter has a slightly more diverse economy with a bigger role played by services and manufacturing.

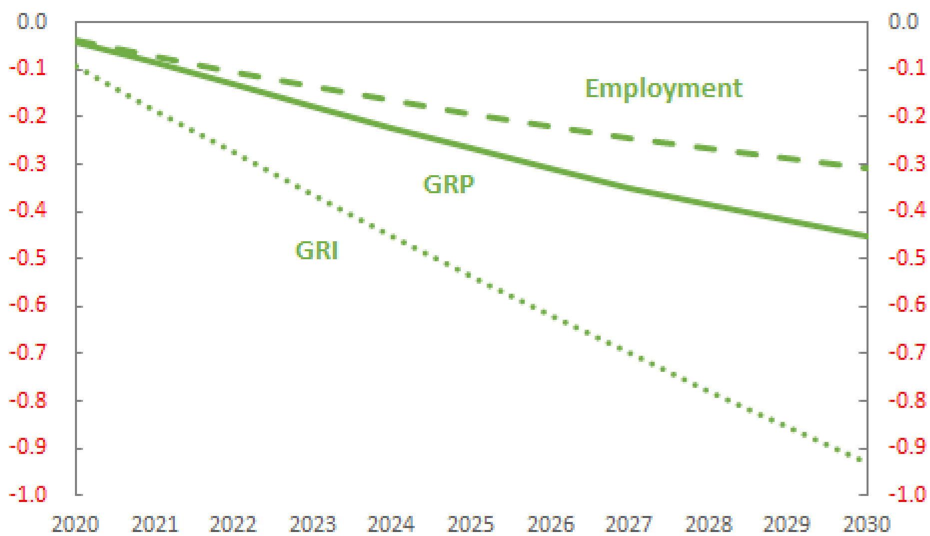
Chart 5 - Macroeconomic impacts in the Hunter basin



Impacts on the Australian economy as a whole are minimal. GNI, GDP and employment will all continue to grow in the low-carbon scenario modelled, at slightly lower rates than under the baseline. Impacts will become more pronounced beyond 2030 if countries' reduce emissions in line with what is necessary to keep global warming below 2C. This is a topic for future work.

It is important to keep in mind that period shown involves slower reductions in emissions than will be needed in later periods, and so, one might expect more significant effects to be felt later. However, the assumed behaviour of firms and households is also relatively more rigid.

Chart 6 - Australian macroeconomic impacts



The results presented in this section show a considerable challenge ahead for Australia's thermal coal industry and those regions in which it is prominent. These sectoral and regional challenges stand in contrast to what appears a manageable transition for the Australian economy as a whole and the majority of its sectors. This underscores the importance of planning and understanding by policy makers.

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