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Should Australia be concerned by Beijing's trade threats: modelling the economic costs of a restriction on imports of Australian coal

James A. Giesecke, Nhi H. Tran and Robert Waschik†

A country's economic dependence on its trade with various other countries is often expressed in terms of trade values and shares. A country's vulnerability to economic coercion by the countries with which it trades is similarly expressed in such terms. Using the recent issues relating to Australia's coal trade with China as an example, we propose a better framework for assessing vulnerability to coercive trade instruments. We argue that the capacity for a given export trade to fund real consumption is a superior indicator of economic vulnerability than the simple value of the underlying trade flow. Our framework takes account of trade diversion, foreign capital ownership, the terms of trade, resource mobility, and capital and production tax rates. Using this framework, we demonstrate that the damage from trade sanction is far less than might be expected from a simple focus on the value of the affected trade flow alone.

Key words: coal embargo, multi-region CGE model, trade policy.

1. Introduction and relation to literature

> Economic power can be thought of as … the ability of individual countries, groups of countries, or even groups within countries to either compel or persuade other countries to act (or at least contemplate acting) as they otherwise would not by the threat or actual use of penalties or inducements of various forms. Examples include a threatened denial of market access via a threat of an increased trade barrier, a harsher policy towards inward foreign investment already located in the territory, or other such actions often grouped under the heading of retaliatory power. Whalley (2009:4–5)

Economists have long understood the potential for the discriminatory use of international trade policy. Scores of papers before and since Johnson's 1954 'Optimum Tariffs and Retaliation' have shown how larger countries with more economic power can use trade distortions to improve their welfare at the expense of a smaller trading partner. A number of studies have used computable general equilibrium (CGE) models to show how a nation's

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optimal tariff depends upon relative market size, among other factors (see Markusen and Wigle 1989; Fisher and Waschik 2006; Dixon and Rimmer 2010).

The rules-based international trading system under the World Trade Organization (WTO) has served to constrain the use of discriminatory trade policy, by requiring that member nations bind their tariffs under GATT Article II. The WTO's dispute settlement mechanism has also served as a tool against the capricious application of economic power. One telling example is the 2003–2005 dispute where Antigua and Barbuda successfully challenged the United States ban on the Cross-Border Supply of Gambling and Betting Services.[1] But recent developments in the functioning of the international trading system have renewed concern regarding the discriminatory application of trade policy by large countries. Since the United States has blocked the appointment of new WTO judges as the term of sitting judges has expired, the WTO's Appellate body has lost the ability to rule on new dispute cases. Over the past few years, there have been many examples of the unilateral application of tariffs by large countries like the United States and China. Section 201 U.S. tariffs on washing machines and solar panels imposed in January 2018 were followed by tariffs on steel and aluminium imports into the United States, and a full-blown trade war between the United States and China. While the U.S. tariffs have been imposed in response to economic concerns (distortions in China's markets, intellectual property issues, market access), an additional element was Washington's concerns over China's state-led push for rapid development in high-technology sectors in which the United States has traditionally led.[2] The Trump Administration's willingness to use trade instruments for non-economic ends was most recently displayed with the threat of tariffs on Mexico over border control issues. Beijing has also made use of trade restriction measures to advance non-economic aims.[3] While some restrictions have been applied against the United States in retaliation for U.S. trade restrictions, Beijing has also imposed trade restrictions in response to decisions made by governments and institutions within small target countries across such areas as: security (passage of foreign interference laws, the limiting of access by Chinese firms to critical infrastructure provision, emplacement of missile defence assets); diplomacy (honouring established extradition protocols, maintaining diplomatic relations with Taiwan); and recognition of individual achievement advancing fundamental human rights (award of the 2010 Nobel Peace Prize). As Hamilton (2019) notes, 'in Taiwan, long familiar with Beijing's tactics, this ploy has a name, *yi shang bi zheng*, use business to pressure government'. When Beijing applies such economic pressure, its aims are to limit or

[1] See Jackson (2012) for more detail on this and other WTO disputes where 'small states have gained bargaining leverage despite having less resources than large states'.

[2] See Laskai (2018).

[3] For a comprehensive recent summary, see Hanson, Currey and Beattie (2020).

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influence debate on subjects that are either sensitive to the Chinese Communist Party or are concerned with China's strategic interests, and to mobilise local economic interest groups to pressure the target country's government to adjust its policies more to Beijing's liking.

So, how worried should a small country be about the use of discriminatory trade policy by a large trading partner? In this paper, we propose a framework for analysing this question that looks beyond the simple metric of the value of the affected trade flows. In particular, we argue that the net impact on national real consumption, a traditional macroeconomic measure of the welfare impact of a change in the economic environment, is a superior measure of economic vulnerability. Motivated by recent reports of processing delays for Australian coal through Chinese ports, we investigate this question by examining a policy of Chinese restriction of imports of Australian coal as a case study exemplar.

The remainder of the paper is structured as follows. Section 2 describes the Australia–China trade relationship, providing context for the frequently made claim that Australia is economically dependent on China. Section 3 describes the economic model used in the paper. We discuss the modelling results in Section 4. Section 5 concludes the paper.

2. Background

As Table 1 demonstrates, China is a large economy: Over 2017–2019, it was the destination for 9.5 per cent of global commodity exports (row 5/row 1) and 15.2 per cent of global coal exports (row 7/row 3). Australia is a small economy, the source of 1.5 per cent of global exports of all HS commodities[4] over 2017–2019 (row 2/row 1). China is the destination for a large share of Australia's exports: Over 2017–2019, China was the destination for 35.6 per cent of all Australian commodity exports (row 6/row 2) and 21.1 per cent of Australian coal exports (row 8/row 4). Over 2017–2019, Australia was the source of 55.4 per cent of Chinese coal imports (row 8/row 7). Given the large share of Australia's exports that are destined for China, it is perhaps not surprising that the popular and media narrative on Australia's economic exposure focuses on risks to the value of exports. Hence, it is perhaps understandable that some Australians express sentiments like those demonstrated in the following statement:

However, our contention in this paper is that statements like this risk confusing simple measures of trade value for more sophisticated measures of net economic impact. Unchallenged, they risk allowing the national narrative about our trade with China to unduly influence our national security debate. In this paper, we shift the focus away from headline trade values and explore

[4] HS is the Harmonized Commodity Description and Coding System or 'Harmonized System' of tariff nomenclature, an internationally standardized system of names and numbers to classify traded products, developed and maintained by the World Customs Organization.

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instead by how much Australian economic welfare is impacted in a hypothetical trade restriction scenario. To do this, we undertake a model-based exploration of the effects of a permanent policy-mandated 25 per cent reduction in imports of Australian coal by China. This example is motivated by reports in 2019 of a policy of delays in the processing of Australian coal through Chinese ports, possibly in retaliation to a number of national security policy actions taken by Canberra. Unlike other studies, we do not focus on the impact in Australia of the distortions applied by the United States and China in the 'trade war' that has been ongoing between these two countries since 2018 (Balistreri *et al.* 2018; Li *et al.* 2018; Amiti *et al.* 2019; Bellora and Fontaigne 2019; Bown 2019; Mao and Görg 2020). While a number of studies have illustrated the indirect impacts of the US/China trade war on their smaller trading partners, we are concerned with the direct impact of recent trade distortions applied by these large countries against their smaller trading partners, to understand the scope to which these large countries can exercise economic power. In the example that we simulate, the large country (China) does not apply an optimal tariff against its smaller trading partner (Australia). The objective of the large country's distortion is not to improve its own welfare, but to exercise economic power to affect the behaviour of its smaller trading partner.

The simulations are undertaken with a variant of the Global Trade Analysis Project (GTAP) model (Hertel 1997). This variant embodies dynamic mechanisms covering regional industry-specific capital accumulation, lagged regional employment adjustment, national income accounting and an explicit baseline forecast for how the global economy will evolve in the absence of the trade policy shocks (see Section 2). The focus of our study is different from that in other papers that typically decompose the effects of changes in trade distortions into terms of trade and allocative efficiency effects (Gilbert and Wahl 2002 and the references therein). As a result, our modelling takes account of: (i) the capacity of the sector to find alternative markets for coal; (ii) the capacity of mobile resources within the sector to find alternative employment; (iii) the degree of foreign ownership of the sector;

Table 1 Exports of coal (HS 2701) and all commodities (US$b)

			2019	2018	2017
1 World exports	of all commodities	to All	$14,517.82	$18,859.62	$17,342.47
2 Australian exports	of all commodities	to All	$266.38	$252.76	$230.17
3 World exports	of coal	to All	$107.05	$126.32	$109.71
4 Australian exports	of coal	to All	$44.24	$49.68	$43.30
5 World exports	of all commodities	to China	$1,523.39	$1,735.24	$1,571.39
6 Australian exports	of all commodities	to China	$103.00	$87.72	$76.40
7 World exports	of coal	to China	$16.05	$19.10	$16.95
8 Australian exports	of coal	to China	$9.44	$10.58	$8.87

Source: UN Comtrade Database https://comtrade.un.org/data.

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(iv) royalty revenue; and (v) taxation of capital and resource revenue within the sector. As we shall see, with these factors taken into account, we find that the average annual reduction in Australian real consumption (private and public) over 2020–25 due to a permanent policy-mandated 25 per cent reduction in imports of Australian coal by China is 0.04 per cent, approximately $AUD 24 per person per year. In addition to clarifying the distinction between the headline and net impacts of an instrument of trade coercion, a particular contribution of our paper is the presentation of a back-of-the-envelope (BOTE) model that identifies the main economic mechanisms mediating headline and net impacts. The BOTE model serves two purposes. First, it equips readers to identify and understand how multiple economic channels contribute to the effect on Australian welfare of a trade restriction imposed by a major trading partner. Second, the BOTE model is potentially generalisable to other commodities and countries, allowing readers to estimate the potential welfare effects of restrictions on other bilateral trade flows.

3. The model: Overview of GTAP-MVH

We use the GTAP-MVH model documented in Dixon *et al.* (2020). GTAP-MVH is a dynamic implementation of the GTAP (Global Trade Analysis Project) model documented in Hertel (1997) and Corong *et al.* (2017). GTAP is a comparative static multi-country, multi-commodity computable general equilibrium (CGE) model with particular emphasis on the modelling of commodity-specific trade flows between countries and trade taxation instruments. The full GTAP database contains 57 sectors and 141 countries/regions (Aguiar *et al.* 2016). For this paper, we aggregate the standard database to 34 sectors and 18 regions. The 18 regions are as follows: the U.S.A., Canada, Mexico, Australia, Japan, South Korea, China, India, Indonesia, the Philippines, Thailand, the rest of ASEAN, France, Germany, the U.K., the rest of the E.U., Russia and the rest of the world. The mapping between the full list of 57 sectors in the original GTAP database and the 34 sector aggregation used in this paper is available in Giesecke *et al.* (2019:48–51). Our sectoral aggregation was guided by a desire to preserve the identification of the top export and import commodities of China and Australia. Similarly, our country aggregation was guided by a desire to preserve identification of countries that are as follows: (i) among the top export destinations and import sources for China and Australia; (ii) important coal producers or markets for Australian coal.

As discussed in Dixon *et al.* (2020), standard GTAP has a number of attributes that limit its usefulness for investigation of the policy issues examined in this paper. In particular, standard GTAP assumes that capital is fully mobile between sectors in each region in both the short-run and long-run, and real wages are either inflexible within each region (in the short-run) or fully flexible within each region to maintain full employment (in the long-

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run). This treatment of factor markets can obscure aspects of the transition from the short-run impacts of trade restriction (which might be characterised by employment losses) to the long-run outcome. As discussed in Dixon *et al.* (2019), GTAP-MVH carries innovations that overcome these and a number of other limitations of standard GTAP. We summarise these below and refer the reader to Dixon *et al.* (2020) or the Appendix S1 at the end of this paper for further details.

GTAP-MVH contains the Dixon and Rimmer (2002) treatment of the labour market within a dynamic CGE model. Within GTAP-MVH, this allows region- and occupation-specific labour markets to transition from a short-run environment in which real wages are sticky to a long-run environment in which real wages are fully flexible. This allows the labour market effects of a negative economic shock (like trade restriction) to be manifested over the short-run as falls in both employment and real wages, with a gradual transition to a long-run characterised by lower real wages as the economy returns to full employment.

In standard GTAP, capital within each region has no industry specificity. That is, the aggregate regional capital stock in year t is free to flow between industries in year t. This is unsatisfactory for generating insights into both the short-run adjustment costs of economic shocks and the transition paths to long-run outcomes. For example, if trade restrictions are particularly damaging to prospects for a specific industry, we want this manifested in the short-run as steep drops in rates of return and investment in the affected industry, not as an implausible instantaneous outflow of the industry's physical capital to other unrelated sectors. As described in Dixon *et al.* (2020), GTAP-MVH models regional capital stocks as specific to each industry. Units of new industry-specific capital are assumed to be constructed with a technology that is common to all industries (consistent with the single capital-creator assumption of standard GTAP), but are allocated to specific industries on the basis of movements in relative rates of return across industries. This allows industry-specific capital stocks within each region to gradually adjust through time in response to movements in their rates of return.

As described in Dixon *et al.* (2020), standard GTAP handles the accounting for country-specific savings/investment imbalances via a device called the Global Bank. Countries with a surplus of savings over investment are modelled as contributing funds to the Global Bank, while countries with a deficit of savings over investment are modelled as borrowing funds from the Global Bank. Aggregate borrowing from the Global Bank is constrained to equal aggregate lending to the Global Bank, ensuring enforcement of equality between global savings and global investment in each year.

However, there is no accounting between years of each region's claim upon, or liability to, the Global Bank. This limits the capacity of the model to inform the welfare consequences of policy change, because it impairs the model's capacity to track the future consequences for national income of

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current changes in the balance of savings and investment. Ianchovichina And Mcdougall (2012) address this limitation of standard GTAP by introducing the concept of the Global Trust. The Global Trust facilitates a distinction between the capital assets located within a country and the country's wealth. The former depends on investment within the country, while the latter depends on the country's accumulated net savings. Dixon *et al.* (2020) adapt the Ianchovichina and McDougall (2012) code for the Global Trust and include it in GTAP-MVH. This allows year-on-year tracking of the accumulation by each region of foreign assets (claims on the Global Trust) and foreign liabilities (claims by the Global Trust). With this in place, GTAP-MVH can be used to calculate each region's net national product as GDP at market prices, less depreciation, plus the region's claims on income of the Global Trust, less the region's payments of income to the Global Trust.

The specification of net national product in GTAP-MVH facilitates establishment of a straightforward rule for determining national consumption. First, we assume that the ratio of nominal consumption (private and public) to nominal net national product in each region is exogenous. That is, the average propensity to consume out of net national product is exogenous in each region. Second, the ratio of real public consumption to real private consumption in each region is exogenous. That is, we assume that each region maintains constant region-specific proportions in the manner in which national consumption is split between privately purchased commodities and publicly provided commodities.

In our baseline forecast, we exogenously determine growth in each of the model's 18 regions in real GDP at market prices, population and the working age population, using information from the IMF's World Economic Outlook database (IMF 2019) and population estimates and projections by the World Bank (2018). For more detail on the baseline forecast see Giesecke, Waschik and Tran (2019:15). Results from this baseline forecast are compared to results from a policy simulation described in the present paper where China restricts imports from Australia. Using a dynamic model allows us to illustrate both the immediate impacts of China's import restriction as well as the longer-term adjustments to international trade patterns.

4. Restriction on imports of Australian coal by China

To identify the economic factors that contribute to the welfare effects of a trade restriction, we use an example in which the Chinese government permanently reduces imports of Australian thermal and metallurgical coal by 25 per cent. Our choice of this example was first motivated by reports in 2019 that processing of Australian coal through Chinese ports was being purposefully delayed, probably in response to a range of national security decisions taken by Canberra (Walker 2019). Subsequently, the list of commodities targeted by Beijing has expanded, to include wine, barley, beef, lobsters and timber. As outlined in a list of 14 grievances provided by an

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anonymous Chinese official to the Australian media in November 2020, Beijing's motivation for this action has also expanded, beyond Canberra's earlier national security decisions, to now include such things as the free reporting of China matters by Australia's media, Canberra's funding of the Australian Strategic Policy Institute, Canberra's position on the South China Sea and Canberra's call for an independent international inquiry into the origins of the COVID-19 pandemic.

We argue that there are five main elements to understanding the impact on the Australian economy of a restriction on imports of Australian products into China:

i The capacity of mobile resources within the sectors adversely affected by the trade restriction to move to other sectors;
ii The inability of immobile natural resource assets in the directly affected sectors to move to other sectors;
iii The capacity of the target sector to divert export sales to markets other than China;
iv The degree of foreign ownership of the target sector's physical capital and natural resource endowment; and
v The effective rate of taxation of the foreign-owned returns to capital and natural resources in the target sector.

GTAP-MVH is based on familiar general equilibrium theory that underpins the elements (i), (ii) and (iii). Elements (iv) and (v) relate to accurately measuring the impact of the trade restriction on net national product. As discussed in Section 3.1, GTAP-MVH's accounting for net national product recognises foreign claims on Australian capital income, and Australian claims on global capital incomes. However, a limitation of this theory for the application in this section is that these claims do not include an industry dimension. To remedy this, we adjust GTAP-MVH's calculation of income accruing to foreigners from each region to take account of industry-specific capital ownership, and effective rates of taxation of industry-specific foreign-owned capital. We discuss below the values of the parameters needed to do this.

To our knowledge, precise estimates for foreign ownership and capital tax parameters for the coal industry in particular are not readily available, and an independent estimation was beyond the scope of the present study. However, plausible estimates can be obtained from a number of sources.

For capital ownership, three studies point to a foreign share of around 80 per cent as a plausible estimate. Connolly and Orsmond (2011) state 'overall, based on published data by the iron ore, coal and LNG producers, effective foreign ownership of the current mining operations in Australia could be around four-fifths, with the share for iron ore producers a little lower and coal and LNG producers a little higher'. Edwards (2011) estimates the foreign ownership share for the Australian mining sector in general at 83 per cent.

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Campbell (2014) estimates the foreign ownership share for Hunter Valley coal at approximately 90 per cent. In this paper, we assume that 80 per cent of the Australian coal sector is foreign owned. On the basis of the above studies, we think this is a plausible conservative estimate.

Dixon and Nassios (2018) estimate the effective rate of corporate taxation of foreign-owned capital in Australia at 17 per cent. On this basis, we set the tax rate on foreign capital and natural resource income in the Australian coal sector at 17 per cent. Using ABS (2019), we estimate that the average royalty rate on coal production between 2015/16 and 2017/18 was 8 per cent, and as such, we set the value for the production tax rate on Australian coal in the model's database at this value. These assumptions are an approximation of a more complex system in which, for example, mining royalties can be based on step functions of price (as in Queensland), and in which they are tax-deductible against corporate income tax expense. These matters could be modelled in a more detailed study, along with more precise estimates of foreign capital ownership and effective corporate tax rates specific to the coal sector. Readers interested in the sensitivity of our results to the values of these parameters can use the back-of-the-envelope equations presented later in the paper to examine the effects of alternative values.

With these details on the ownership and taxation of productive assets in the Australian coal sector in place, we turn our attention to the modelling results of a permanent policy-mandated 25 per cent reduction in Chinese imports of Australian coal. Table 2 summarises key results. To explain the results, we begin by examining the impact on Australian coal exports. Figure 1 reports a decomposition of the deviation in the Laspeyres index for Australia's coal exports into the individual contributions made by changes in Australian coal exports to destination countries. In the baseline forecast, 81 per cent of Australian coal is exported, and of this, 22 per cent is destined for China. This accounts for the −6 percentage point contribution made by China to the coal export deviation reported in the year the import restriction is imposed (Figure 1). However, when China reduces its demand for Australian coal, it must meet its coal requirements by raising its demand for coal from other suppliers. For countries that are net coal importers, the fall in the price of Australian coal relative to the price of coal from countries that are now expanding export sales to China induces substitution towards Australian coal. This offsets much of the lost export sales to China (Figure 1).

In Figure 2, we see that, relative to baseline, Australia's terms of trade fall by approximately 0.75 per cent by 2025, and that this is due almost entirely to the negative deviation in Australia's export price index (the import price deviation is close to zero). Figure 3, which decomposes the deviation in Australia's f.o.b. export price index into the contributions made by sector-specific export price changes, makes clear that the main contributor to this is coal, the Australian f.o.b. price of which falls by approximately 2.7 per cent (Figure 2).

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Figure 4 reports deviations in the capital stock, employment and real GDP at market prices and at factor cost. The coal import restriction generates a negative deviation in employment in 2019 of −0.013 per cent, but the employment deviation attenuates over the remainder of the simulation as real wages adjust to return employment to baseline. The decline in the terms of trade reduces long-run capital formation by approximately 0.015 per cent. The short-run deviation in employment together with the long-run deviation in capital generates an average deviation in real GDP at market prices over the period of approximately −0.008 per cent.

Our main interest is the real consumption deviation (Figure 5), since it provides insight into the welfare impact of the coal import restriction. As we shall see, this is not the same as the value of coal exports directly affected by the import restriction, which we suspect is what business commentators are focusing on when they make alarming statements like that by Gottliebsen cited earlier. How far wrong can our estimate of the consumption impact of a trade restraint go if we focus on crude headline export values alone? As reported earlier, approximately 22 per cent of Australian coal exports in the GTAP database are destined for China, and as reported in Table 3, in our forecast coal exports as a share of GDP in 2025 are projected to be 4.5 per cent. Since the share of (private and public) consumption in GDP is 0.74 (see Table 3), if we base our calculations on headline export values alone, we might mistakenly expect that the long-run real consumption deviation would be approximately equal to −0.34 per cent (=100 * −0.25 * 0.22 * 0.045/0.74). This is a big number in economic terms. However, in Figure 5 we see that the year 2025 deviation in real consumption is less than 1/6 this figure, at −0.056 per cent.

Part of the problem with the above calculation is that it ignores the possibility that, by lowering export prices, alternative markets can be found for the product blocked by the trade partner. This is why typical back-of-the-envelope estimates of the cost of trade restrictions rest on estimates of the

Table 2 25% restriction on imports of Australian coal by China (% deviation from baseline)

	2018	2019	2020	2021	2022	2023	2024	2025
Australia real GDP	0.0000	−0.0133	−0.0072	−0.0062	−0.0080	−0.0086	−0.0085	−0.0079
Australia employment	0.0000	−0.0133	0.0016	0.0056	0.0028	0.0015	0.0007	0.0004
Australia real consumption	0.0000	−0.0449	−0.0358	−0.0354	−0.0397	−0.0449	−0.0506	−0.0570
China real GDP	0.0000	−0.0195	−0.0197	−0.0196	−0.0166	−0.0163	−0.0177	−0.0199
China employment	0.0000	−0.0326	−0.0281	−0.0231	−0.0115	−0.0058	−0.0029	−0.0016
China real consumption	0.0000	−0.0161	−0.0141	−0.0119	−0.0061	−0.0031	−0.0015	−0.0006

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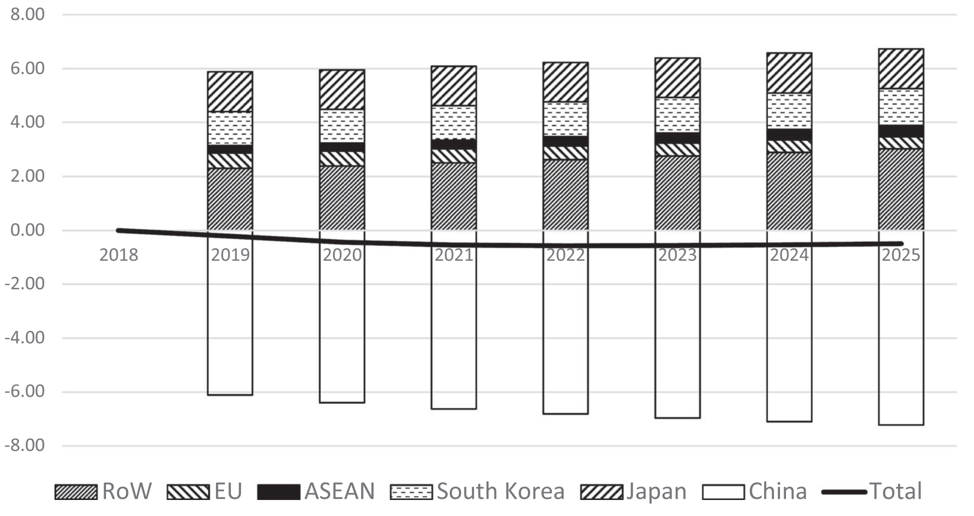

Figure 1 Trade diversion: decomposition of deviation in Australia's coal exports, by destination (% deviation from baseline).

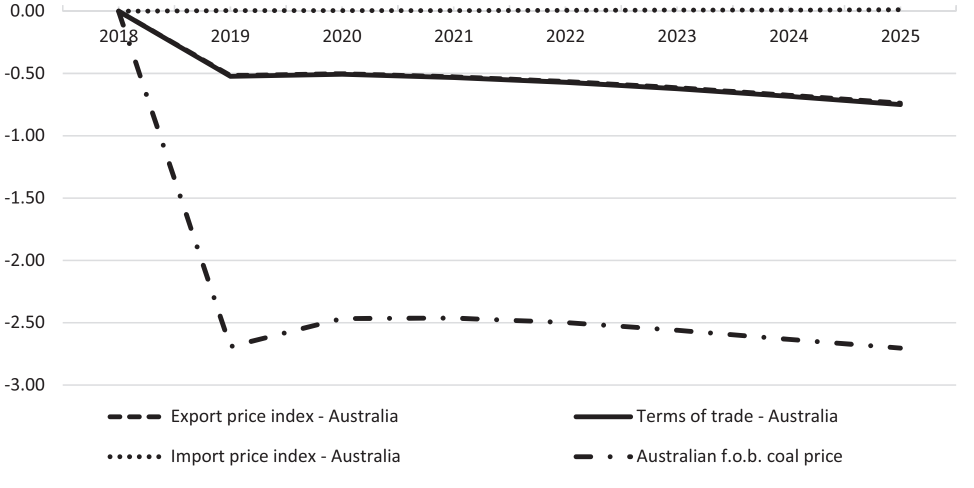

Figure 2 Australia's terms of trade, f.o.b. export price index, c.i.f. import price index and f.o.b. coal export price index (% deviation from baseline).

terms of trade loss.[5] However, an estimate of the consumption loss can also go wrong if we focus only on the terms of trade loss. If we ignore foreign ownership and taxation of capital, then a back-of-the-envelope approximation for the impact of a decline in the terms of trade on domestic consumption is $(S^X_{GDP}/S^{C+G}_{GDP})\cdot tot$, where S^X_{GDP} and S^{C+G}_{GDP} are the shares of exports and consumption (private and public) in GDP, and *tot* is the percentage change in the terms of trade. As reported in Table 3, the 2025

[5] See for example Dixon and Rimmer 1999.

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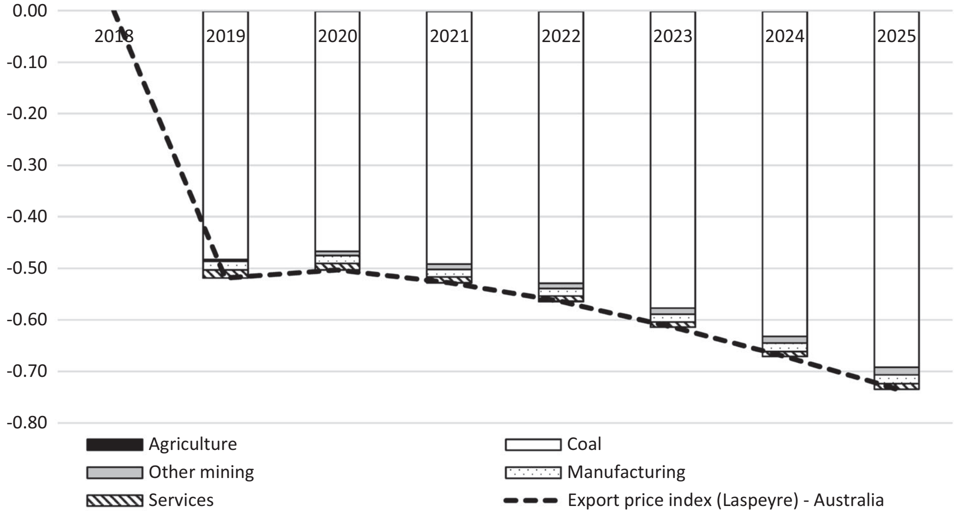

Figure 3 Decomposition (by commodity) of deviation in Australia's f.o.b. export price index (% deviation from baseline).

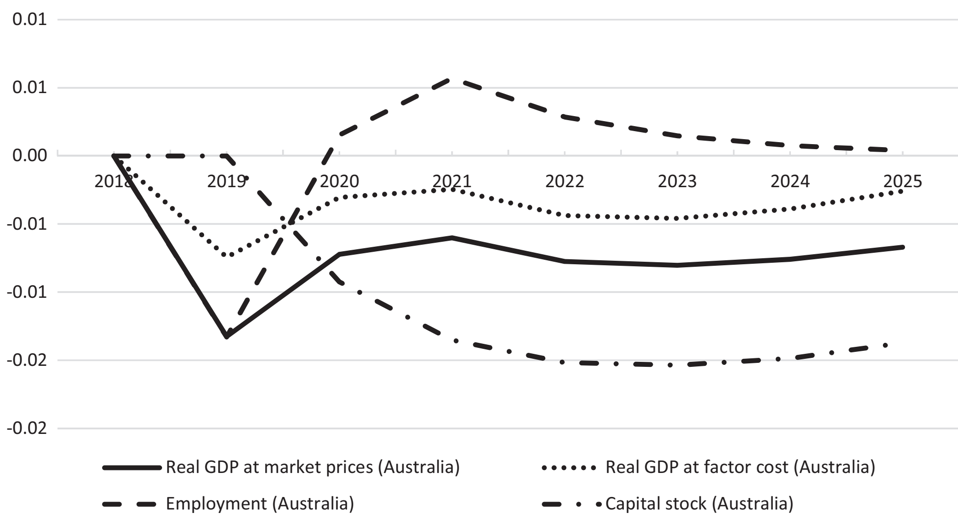

Figure 4 Australia's employment, capital stock and real GDP (% deviation from baseline).

values for S^{X}_{GDP} and S^{C+G}_{GDP} are approximately 0.18 and 0.74, respectively. Hence, a back-of-the-envelope estimate for the consumption impact of a 0.75 per cent fall in Australia's terms of trade is approximately −0.18 per cent (= 100 * −0.75 * 0.18/0.74). However, in Figure 5 we see that the year 2025 deviation in real consumption is less than 1/3 this figure, at −0.056 per cent.

To explain why the model's estimate of the welfare impact of the Chinese restriction on imports of Australian coal is so much smaller than is suggested

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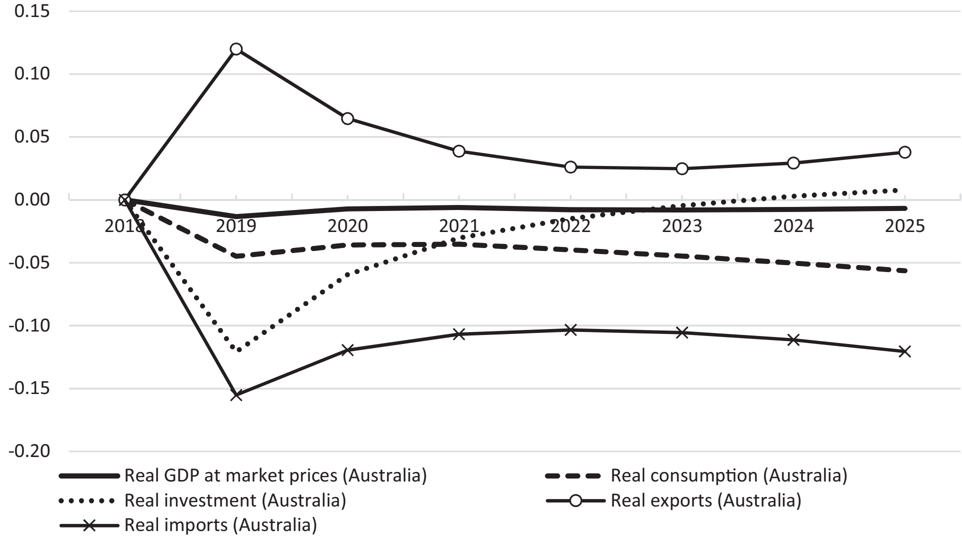

Figure 5 Australia's expenditure-side components of real GDP (% deviation from baseline).

Table 3 Key parameters and results related to 2025 back-of-the-envelope consumption calculation

Key parameters from 2025 economy		
(1) Foreign ownership of coal sector	S^{For}_{coal}	0.8
(2) Local ownership of coal sector	$1\text{-}S^{For}_{coal}$	0.2
(3) Production tax rate	T^{Q}_{coal}	8%
(4) Effective capital tax rate	T^{K}_{coal}	17%
(5) Coal output as a share of GDP	$S^{Output}_{coal,GDP}$	0.055
(6) Coal exports as a share of GDP	$S^{ExpUse}_{coal,GDP}$	0.045
(7) Local use of coal as a share of GDP	$S^{LocUse}_{coal,GDP}$	0.010
(8) Coal fixed factor returns as share of coal costs	S^{K}_{coal}	0.57
(9) Consumption (private and public) as share of GDP	S^{C+G}_{GDP}	0.74
(10) Exports as share of GDP	S^{X}_{GDP}	0.18
Key 2025 simulation results (% deviation from baseline)		
(11) Coal price	p_{coal}	−2.7
(12) Coal output	q_{coal}	−0.36
(13) Coal sales (row 11 + row 12)		−3.05
(14) Export price index		−0.734
(15) Coal contribution to export price index		−0.69
(16) Terms of trade loss outside coal sector (row 14 – row 15)	tot^{*}	−0.044

by these simple back-of-the-envelope calculations, we develop the more detailed back-of-the-envelope calculation given by equations 1–6 which, in addition to terms of trade effects, also takes account of foreign ownership,

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taxation and domestic use of the commodity targeted by trade sanction.

$$c_i = c_i^{(1)} + c_i^{(2)} + c_i^{(3)} + c_i^{(4)} + c_i^{(5)} \tag{1}$$

where: c_i is the percentage change in real consumption attributable to the trade sanction on target commodity i; $c_i^{(1)}$ is the contribution to the percentage change in real consumption attributable to savings on domestic use of the foreign-owned component of local supply of the target commodity; $c_i^{(2)}$ is the contribution to the percentage change in real consumption attributable to the export revenue loss suffered by local owners of the industry producing the target commodity; $c_i^{(3)}$ is the contribution to the percentage change in real consumption attributable to the royalty revenue loss on the output of the foreign-owned component of the industry producing the target commodity; $c_i^{(4)}$ is the contribution to the percentage change in real consumption attributable to the corporate tax loss on the foreign-owned share of the industry producing the target commodity; and $c_i^{(5)}$ is the contribution to the percentage change in real consumption attributable to the fall in the terms of trade arising from price falls on export commodities other than the target commodity.

The consumption contributions $c_i^{(1)}$ through $c_i^{(5)}$ are determined as follows:

$$c_i^{(1)} = -p_i \cdot S_{i,GDP}^{LocUse} \cdot S_i^{For} / S_{GDP}^{C+G} \tag{2}$$

$$c_i^{(2)} = p_i \cdot (1 - S_i^{For}) \cdot S_{i,GDP}^{ExpUse} / S_{GDP}^{C+G} \tag{3}$$

$$c_i^{(3)} = (p_i + q_i) \cdot S_i^{For} \cdot T_i^{Q} \cdot S_{i,GDP}^{Output} / S_{GDP}^{C+G} \tag{4}$$

$$c_i^{(4)} = (p_i / S_i^K) \cdot S_i^K \cdot S_{i,GDP}^{Output} \cdot T_i^K \cdot S_i^{For} / S_{GDP}^{C+G} \tag{5}$$

$$c_i^{(5)} = tot^* \cdot (S_{GDP}^{X} - S_{i,GDP}^{ExpUse}) / S_{GDP}^{C+G} \tag{6}$$

where: p_i is the percentage change in the price of the targeted commodity; $S_{i,GDP}^{LocUse}$ is the value of local use of the targeted commodity expressed as a share of GDP; S_i^{For} is the proportion of the fixed factors in the sector producing the targeted commodity that is foreign owned; S_{GDP}^{C+G} is the share of private and public consumption in GDP; $S_{i,GDP}^{ExpUse}$ is the value of exports of commodity i expressed as a proportion of GDP; q_i is the percentage change in the output of commodity i; T_i^Q is the production tax rate on commodity i; T_i^K is the effective capital income tax rate applied to the sector producing the target commodity; $S_{i,GDP}^{Output}$ is the output of the target commodity expressed as a proportion of GDP; S_i^K is the share of payments to fixed factors in the total costs of sector i; tot^* is the terms of trade loss outside of that attributable to

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falls in the export price of the targeted commodity; and S^X_{GDP} is the share of aggregate exports in GDP.

Using these equations and the parameters and results from Tables 3 and 4, we can explain the 2025 real consumption outcome generated by our GTAP-MVH simulation in terms of the five effects summarised below:

1. Savings on domestic use of the foreign-owned component of supply of coal ($c^{(1)}_{coal}$):	0.028%
2. Export revenue loss attributable to local coal ownership ($c^{(2)}_{coal}$):	−0.033%
3. Royalty revenue loss on foreign-owned component of coal production ($c^{(3)}_{coal}$):	−0.015%
4. Corporate tax loss on foreign-owned share of coal sector profits ($c^{(4)}_{coal}$):	−0.027%
5. Loss from fall in terms of trade outside the coal sector ($c^{(5)}_{coal}$):	−0.008%
Total effect (2025 loss in real consumption relative to baseline) (c_{coal}):	−0.056%

We explain each of these effects in detail below.

1. *Savings on domestic use of the foreign-owned component of supply of local coal*. The restriction on Chinese imports of Australian coal lowers the price of Australian coal by approximately 2.7 per cent. To the extent that Australian coal production is foreign owned, this price reduction represents a benefit to local users of domestic coal. As reported in Table 3 row 7, local use of domestic coal as a share of GDP is 0.01. With 80 per cent of this supplied by foreign-owned firms, the −2.7 per cent price reduction represents a gain to domestic agents of 0.00021 of GDP (= (−2.7/100) * 0.01 * 0.8). When expressed as a proportion of consumption (private and public), this represents a gain of 0.028 per cent (= 100 * 0.00021/0.74) (see Table 4).
2. *Export revenue loss attributable to local coal owners*. Australian agents own 20 per cent of the Australian coal sector. These agents must absorb the loss associated with reduced export revenue on their share (20 per cent) of coal exports. As reported in Table 3 row 6, coal exports as a share of GDP are 0.045. Noting the 2.7 per cent price fall and the 20 per cent domestic ownership share, the loss to domestic agents expressed as a share of GDP is −0.00025 (= 0.045 * (−2.7/100) * 0.2). Expressed as a proportion of consumption (private and public), this represents a loss of −0.033 per cent (= 100 * −0.00025/0.74) (see Table 4).
3. *Royalty revenue loss on foreign-owned component of coal production*. As discussed above, we set the royalty rate on coal production at 8 per cent. The Chinese restriction on coal imports from Australia lowers coal prices and coal output volumes, and thus lowers coal royalty payments. Australia must absorb the loss associated with the lost royalty revenues collected on the foreign-owned share of coal production. The deviation in 2025 coal output is −0.36 per cent (Table 3 row 12), and thus, together with the 2.7 per cent fall in the coal price, the 2025 deviation in the value of coal sales is −3.05 per cent (Table 3 row 13). Noting that coal output as

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Table 4 Back-of-the-envelope calculation of real consumption loss

1. Savings on domestic use of foreign-owned supply of local coal	
(A) Local use of domestic coal as share of GDP	0.010
(B) Foreign ownership of coal sector	0.8
(C) Coal purchase from foreign owner as share of GDP (A × B)	0.008
(D) Price saving (%)	−2.7
(E) Saving by domestic coal users, as share of GDP (C × D/100)	0.00021
(F) Consumption as share of GDP	0.74
(1) Saving by domestic coal users, expressed as % of consumption (E/F × 100)	0.028
2. Export revenue loss attributable to local coal owners	
(A) Coal exports as share of GDP	0.045
(B) Local ownership share	0.2
(C) Export sales attributable to local owners as share of GDP (A × B)	0.0091
(D) Price loss (%)	−2.7
(E) Export sale loss attributable to local owners as share of GDP (C × D/100)	−0.00025
(F) Consumption as share of GDP	0.74
(2) Export sale loss attributable to domestic owners, expressed as % of consumption (E/F × 100)	−0.033
3. Royalty revenue loss on foreign-owned component of coal production	
(A) Coal output as share of GDP	0.055
(B) Foreign ownership of coal sector	0.8
(C) Revenue loss (%)	−3.05
(D) Production tax rate (%)	8.0
(E) Royalty loss on foreign-owned share as % GDP (A × B/100 × C/100 × D)	−0.00011
(F) Consumption as share of GDP	0.74
(3) Royalty loss on foreign-owned share expressed as % of consumption (E/F × 100)	−0.015
4. Income tax loss on foreign-owned share of coal sector profits	
(A) Coal output as share of GDP	0.055
(B) Coal sector fixed factor income as share of coal costs	0.57
(C) Coal fixed factor income as share of GDP (A × B)	0.031
(D) Foreign ownership of coal sector	0.8
(E) Coal price (%)	−2.7
(E) Return on fixed factors (E/B) (%)	−4.8
(F) Loss to foreign owners expressed as share of GDP (E/100 × D × C)	−0.0012
(G) Tax rate	0.17
(H) Tax revenue loss as share of GDP (F × G)	−0.0002
(I) Consumption as share of GDP	0.74
(4) Lost income tax on foreign-owned capital as % of consumption (H/I × 100)	−0.027
5. Generalised terms of trade loss effect	
(A) Terms of trade loss attributable to export price movements outside coal	−0.044
(B) Non-coal exports as share of GDP	0.14
(C) Consumption as share of GDP	0.74
(5) Consumption loss via generalised terms of trade loss	−0.008
Real consumption loss (%) via back-of-the-envelope calculation (1 + 2+3 + 4+5)	**−0.0550**
Real consumption loss (%) via GTAP-MVH	**−0.0563**

a share of GDP is 0.055, and that 80 per cent of this is foreign owned, the royalty rate of 8 per cent implies that the loss as a share of GDP is −0.00011 (= (−3.05/100) * 0.055 * 0.8 * 0.08). Expressed as a proportion of consumption (private and public), this represents a loss of −0.015 per cent (= 100 * −0.00011/0.74) (see Table 4).

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4. *Corporate tax loss on foreign-owned share of coal sector profits*. Australian taxpayers must bear the loss associated with reduced capital income tax receipts on the foreign-owned share of the coal sector. Fixed factors represent approximately 57 per cent of the costs of the coal sector (Table 3 row 8). Hence, the 2.7 per cent price reduction translates to a fall in fixed factor returns in the coal sector of approximately 4.8 per cent (= 2.7/0.57). Noting that the coal sector is projected to be approximately 5.5 per cent of the 2025 economy (Table 3 row 5), with the foreign ownership share at 80 per cent and the effective tax rate on fixed factors at 17 per cent, the loss to domestic agents associated with reduced income tax receipts from the foreign-owned proportion of coal capital is estimated to be −0.0002 as a share of GDP. Expressed as a proportion of consumption (private and public), this represents a loss of −0.027 per cent (= 100 * −0.0002/0.74) (see Table 4).
5. *Loss from fall in terms of trade outside the coal sector*. As discussed with reference to Figure 3, the fall in the coal price is the chief contributor to the terms of trade fall. However, it is also clear from Figure 3 that price falls in other export sectors make a small contribution to the terms of trade decline (−0.044 percentage point contribution, see Table 3 row 16). This terms of trade loss outside of coal arises because of the need to expand exports of other commodities when coal export revenue falls. Expansion of non-coal exports is necessary both to finance imports, and to assist with the absorption of mobile resources released from the coal sector. With non-coal exports and consumption as a share of GDP at approximately 0.14 and 0.74, respectively, the fall in non-coal export prices translates to a real consumption loss of −0.0081 per cent (see Table 4).

Taken together, the above five effects anticipate a 2025 real consumption loss of −0.055 per cent (Table 4). Because our back-of-the-envelope model is designed to capture the main GTAP-MVH economic mechanisms relevant to this simulation, and because it is calibrated using GTAP-MVH data, this result is very close to the GTAP-MVH model outcome of −0.0563 (Figure 5). To put this loss in context, we note that in 2018 consumption per capita in Australia was approximately $55,200. A −0.0563 per cent consumption loss is thus equivalent to approximately $31 per person. The back-of-the-envelope model demonstrates that this result is dependent on characteristics of the targeted sector and the output and factor markets in which it operates. In general terms, the sectoral characteristics that help insulate consumption from the effects of trade restriction are as follows: high rates of foreign capital ownership (S_i^{For}) (particularly if capital and output taxation rates, T_i^K and T_i^Q, are low), high rates of local use of the commodity ($S_{i,GDP}^{LocUse}$), small sectoral scale (i.e. low values for $S_{i,GDP}^{Output}$ and $S_{i,GDP}^{ExpUse}$) and muted impacts on the output price of the targeted commodity and prices of other exports (i.e. low values for p_i and tot^*, respectively). The latter price effects depend on export and

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factor markets. A ready capacity to find alternative markets for the targeted commodity will imply lower impacts on p_i. Similarly, a ready capacity to shift resources out of the target sector, and find new markets for other export commodities, will imply lower impacts on tot^*. While not explored further in this paper, this suggests a role for government policy in: aiding targeted sectors to find new markets, assisting affected workers to rapidly find alternative employment, and facilitating firms in other export sectors to expand into new markets.

Before concluding, we consider the macroeconomic impacts of Beijing's restriction on imports of Australian coal on China. Restricting imports of Australian coal produces an allocative efficiency loss in China because coal users in the country are forced to switch to more costly coal sources. This allocative efficiency loss is expressed in Figure 6 by the real GDP (at market prices) deviation lying below the real GDP (at factor cost) deviation. The introduction of the allocative efficiency distortion creates a transitory negative deviation in employment and a permanent negative deviation in the capital stock. The negative deviations in employment and capital, together with the costs of the allocative efficiency distortion, lower real GDP relative to baseline by an average of approximately 0.02 per cent over the simulation period (Figure 6). Figure 6 also reports China's terms of trade and real consumption deviations. The coal import restriction improves China's terms of trade slightly (up by 0.03 per cent by 2025). This reflects the reduction in the price of Australian coal and the general contracting effects on Chinese trade of the coal import restriction. The rise in the terms of trade offsets much of the national income loss created by the allocative efficiency distortion from restricting imports of Australian coal, leaving little change from baseline in China's real consumption by 2025.

5. Concluding remarks

Reports emerged during 2019 that imports of Australian coal through Chinese ports were being targeted by Beijing for delayed processing as a political response to a number of national security decisions made by Canberra. This generated considerable media and political commentary on Australia's economic reliance on China and the risks of punitive retaliatory trade policy. In 2020, these risks began to be realised, with Australian barley, wine, timber, beef and lobsters added to Beijing's list of restricted imports. No doubt, if required to do so, the Australian public would be willing to shoulder considerable economic costs if such proved to be the price of pursuing the nation's security interests. Nevertheless, we think that in such a debate, it is important that policymakers be informed by plausible estimates of the possible magnitude of economic damage caused by Beijing targeting our exports. We conjecture that the debate so far has not been informed by plausible estimates of potential economic damage, but rather, has been dominated by loose references to trade values and trade shares. As we have

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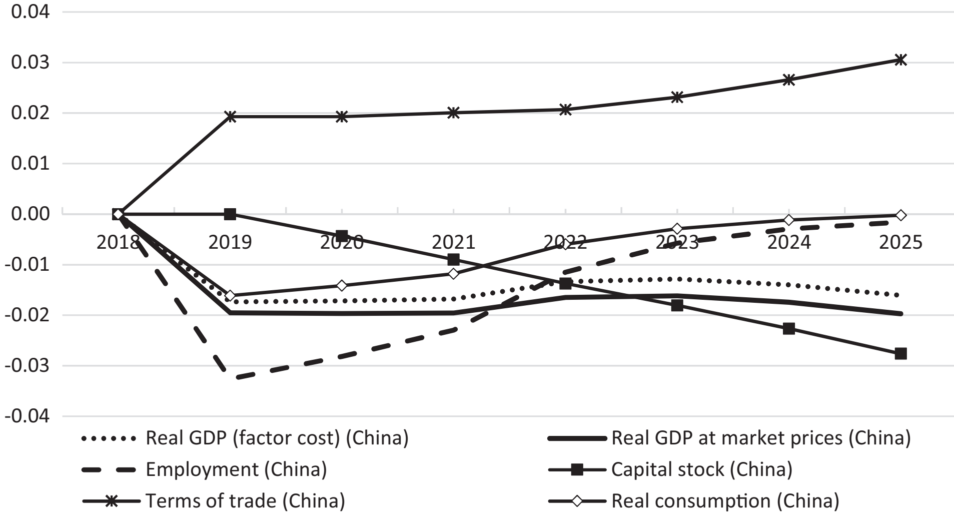

Figure 6 China's employment, capital, real GDP, real consumption and terms of trade (% deviation from baseline).

shown in this paper, using a coal embargo scenario as an example, a naïve focus on trade values and trade shares risks greatly overstating potential economic damage. This is a problem if it impairs the capacity of policymakers to make good national security decisions.

In the coal embargo scenario examined in this paper, we found that a simplistic focus on the value of our China export trade risks overstating Australia's vulnerability to economic sanction, because it misses four factors that mediate the connection between trade sanction and economic damage, namely: (i) the capacity to divert trade to other markets; (ii) the ability to redeploy resources from the sector targeted by trade sanction to other sectors of the economy; (iii) foreign ownership of the capital and natural resources employed in the target sector; and (iv) taxation of the target sector.

An important question for future research is the extent to which our findings are generalisable to other sectors of the Australian economy. We suspect that the findings are generalisable to a significant proportion of our trade with China. Together with coal, about 70 per cent of Australia's exports to China are primary products, many of which are largely undifferentiated by country of origin. Cuts by Beijing of imports of these products from Australia would need to be replaced by other international suppliers redirecting their exports to China, thus opening new markets for Australian exporters. About 60 per cent of Australia's exports to China are ores and coal products. The Australian mining sector has high foreign ownership in general, insulating the impact on domestic incomes of trade sanction.

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The Australian travel sector is also an important source of export revenue that has been the subject of attempts at trade disruption by the Chinese government.[6] In 2018, exports of education-related travel and personal travel accounted for $37.6b and $22.5b, respectively, accounting for the majority of the $97.1b in total services exports over this period.[7] Just over 30 per cent of these were exports to China (i.e. Chinese students and tourists coming to Australia). In future work, the trade sanction damage estimation approach outlined in this paper could also be applied to these sectors. We would expect the factors outlined in this paper to be just as relevant to this sector. Unlike the mining sector, these service sectors (i) have lower foreign capital ownership (meaning more of the economic cost would be borne by domestic agents); (ii) are products that are more differentiated by country of supply (requiring steeper price reductions to replace lost exports to China); and (iii) have lower shares of fixed factors in production (facilitating resource mobility to other sectors). An evaluation of the welfare impact of recent threats by China to the Australian education and tourism sectors would need to take account of these features of the travel sector.

Data availability statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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[7] See ABS 5368.0.55.003 – International Trade: Supplementary Information, Financial Year, 2018-19, Table 3.9.

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Supporting Information

Additional Supporting Information may be found in the online version of this article:

Appendix S1. Technical Appendix.

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