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EXECUTIVE SUMMARY

Diversifying Australia's export trade with China - increasing the share of our goods exports going to other countries and/or broadening the range of commodities supplied to China - has been an Australian policy goal for several years. This paper uses the Global Trade Analysis Project model (GTAP) to examine whether productivity increases in Australia can contribute to this objective.

Contrary to prior expectations, GTAP simulations suggest that increases in Australian productivity, whether across the economy or in specific sectors, would have a very limited impact on geographical and product diversification of our China trade. A uniform one percent productivity increase in Australia would slightly increase the percentage of exports to China, although it would marginally reduce the percentage of our exports of 'other minerals' (mostly iron ore) to that country. A one percent productivity increase in the processed food and beverages sectors would slightly reduce the share of exports to China, while a similar productivity increase in our heavy manufacturing sector would marginally increase it. The finding of no major impact on geographical and product diversification holds when an extension of GTAP is used allowing for firm heterogeneity in productivity.

The explanation for limited changes in territorial and product concentration of trade varies. For a uniform shock, the impact is largely to reinforce the existing pattern of trade because the shock is insufficient to alter appreciably the pattern characterised by strong complementarities between Australia and China. In relation to shocks to specific sectors, their modest size in trade terms is relevant. For a somewhat similar reason, tariff liberalisation with the European Union (with or without an accompanying productivity shock) delivers strong export growth to that region but does not alter greatly the share of exports to China.

Limited changes in territorial and product concentration of trade notwithstanding, GTAP simulations suggest that productivity-enhancing Australian trade policy contributes to welfare gains to Australia from tariff elimination under free trade agreements. It also helps to offset productivity increases in competitor economies; boost welfare gains from increases in the capital stock; and reduce Australian welfare losses from forced diversification arising from policy interventions of trading partners and competitors. As such, harnessing the benefits from productivity-enhancing trade policy is a vital national interest.

1. Introduction

In both the public and private sectors in Australia, interest in diversifying Australia's trade with China has increased over recent years. This extends to both exports and imports, though only exports are addressed here. For exports, Chinese trade sanctions against Australia from mid-2020 were a useful wakeup call against over-reliance on the Chinese market. But the economic risks from over-reliance go much deeper. While China is a vital market for Australia, and is likely to remain so, it has entered a phase of slower economic growth as its economy matures. Its imports of iron ore may have plateaued and could fall over time. Tensions in the US-China relationship could result in China making significant concessions to the United States that damage Australia (as was the case in the US-China Economic and Trade Agreement of 2020) or importing much more from politically aligned countries or pursuing both options simultaneously. Emerging new suppliers of products of export interest to Australia — Guinean iron ore for example — add to the challenges facing Australia by potentially reducing international commodity prices and taking share in the Chinese market.

Attempts to broaden Australia's trade profile by relying less on China have taken different forms.

Acronyms and abbreviations

Acronym	Full term	Acronym	Full term
ABARES	Australian Bureau of Agricultural and Resource Economics and Sciences	**EU**	27 The 27 members of the European Union
ABS	Australian Bureau of Statistics	**f.o.b.**	free on board
afe	primary factor reducing technical change	**FTA**	free trade agreement
ao	output-augmenting technical change	**PF&B**	processed food and beverages
applic.	applicable	**GDP**	gross domestic product
ava	value-added augmenting technical change	**GTAP**	Global Trade Analysis Project model
BLADE	Business Longitudinal Data Environment	**HH**	Index Hirschman-Herfindahl Index
c-firms	Firms producing commodity c	**HM**	heavy manufacturing
CIE	Centre for International Economics	**nec**	not elsewhere classified
CGE	computable general equilibrium	**perc.**	percentage
CoPS	Centre of Policy Studies	**ROK**	Republic of Korea
DFAT	Department of Foreign Affairs and Trade	**s,**	d source, destination

New free trade agreements (FTAs) have been negotiated with the United Kingdom and the United Arab Emirates. Considerable effort has been invested in negotiating an FTA with the European Union (EU). And elaborate strategies are being devised to develop trade and build wider economic relations with rapidly growing economies like India and Southeast Asia. But none of them, individually or collectively, come close to substantially diversifying our export trade in the foreseeable future, never mind replacing the leading role China has played, and continues to play, in Australia's trade.

Australia has, in practice, diversified slightly away from China in the past few years, the share of our goods and services exports to China falling from about 38 per cent in 2020 to 35 per cent in 2024. But this has little to do directly with Australian policy. A key cause was declining iron ore prices given the weighting of iron ore in our exports to China compared with the rest of the world. Chinese sanctions also spurred diversification — barley is a good example — though Australia's scramble for alternative markets often came at a cost to producer returns that was only partially masked by more general rises in commodity prices.

What can be ruled out is any contribution from increasing productivity in Australia, whether for the whole economy or for specific sectors. As is well known, our productivity performance has been lacklustre at best over recent years.

So, what might have happened to export diversification if Australian productivity had been rising? Specifically, would increases in Australian productivity have helped in diversifying Australian exports to China?

The Global Trade Analysis Project (GTAP) computable general equilibrium model can examine the impact of a rich set of policy interventions, and we use it for this purpose. The paper also uses an extension of the GTAP model developed by Dixon, Jerie and Rimmer (2018, 2019) that incorporates firm heterogeneity, particularly in relation to productivity. The latter model has been used mainly to examine the sensitivity of results using the standard GTAP model to variations in some of its underlying assumptions.

The paper examines several scenarios. The first three consider impacts where increased productivity is the only shock:

A. a one per cent shock to economy-wide productivity in Australia.
B. a one per cent shock to productivity for processed food and beverages in Australia.
C. a one per cent shock to productivity for heavy manufacturing in Australia.

These scenarios are a selection of those that could be considered. They are strategies that might, at first sight, be thought to have an important impact. But on the evidence from simulations with the standard GTAP model, none show much prospect of diversifying the export trade with China given the strength of complementarities in Australia-China trade. In other words, increased productivity is not a 'silver bullet' that would serve this objective. This conclusion is supported by the extended GTAP model.

A question which follows from this — and the second major issue addressed in this paper — is whether productivity increases should remain an important objective for trade policy despite their limited effectiveness as a tool in promoting diversification. The unambiguous answer is yes.

GTAP is again used to tackle this issue. The following cases are examined:

D. the impact of a one per cent increase in economy-wide productivity in Australia on gains from tariff elimination under a free trade agreement with the European Union.

E. the effect of a one per cent increase in the supply of capital in Australia, with and without a one per cent increase in economy-wide productivity.
F. the impact of an increase in productivity in a competitor economy - the EU's processed food and beverages sectors - with and without a one per cent increase in productivity in the same sectors in Australia.
G. the impact, with and without a one per cent shock to economy-wide productivity, of Chinese interventions to severely restrict imports from Australia.

In each of these cases, productivity growth in Australia is effective in promoting better export performance (compared to the alternative of no productivity increase), as well as contributing to welfare gains for Australia.

The remainder of this paper is organised as follows. Part one briefly reviews the literature on productivity and diversification, how the GTAP model is used in the paper and its limitations. The second part addresses the concept of productivity and how it might be promoted in Australia. Part three looks at the relationship between productivity and diversification. Parts four to six turn to the empirical part of the paper, examining the implications for diversification of a uniform one per cent increase in productivity in Australia, and productivity increases of one per cent in the processed food and beverages sectors, and the heavy manufacturing sector. Part seven uses the extended version of GTAP, providing for firm heterogeneity for productivity, to obtain results for the same sectors. Part eight examines ways in which productivity can be highly useful in international trade despite its limitations in promoting diversification. Finally part nine offers some concluding remarks and suggestions for further research.

2. Preliminaries

2.1. Literature Review

To the authors' knowledge, no attempt has been made to use an economic model to evaluate strategies for reducing the share of Australia's exports directed to China and broadening the composition of our trade with China. There is, of course, a general literature on this topic, including a report by the Parliamentary Joint Standing Committee on Trade and Investment Growth (2021) and several useful submissions arising from its inquiry on Australia's trade and investment profile and strategies for diversification. Work by the Productivity Commission (2021) examined supply chain vulnerabilities with the potential to affect Australian imports and exports, concluding that they were manageable for the most part, but noting diversification as one strategy that might be adopted.

Among specialised literature, the Australian Bureau of Statistics has released detailed work on the measurement of productivity in Australian statistics (ABS 2021; 2025). The GTAP model is thoroughly documented in the original study edited by Hertel (1997) and updates are covered by Corong et al. (2017). Using GTAP to model productivity in specific sectors is addressed in Tsigas, Frisvold and Kuhn (1997). The GTAP Version 11 database is discussed in Aguiar et al. (2022). Methods for updating the GTAP database and developing a baseline are discussed briefly below: key contributions include Dixon and Rimmer (2023; 2025).

There is a huge academic, mostly micro econometric, literature on the relationship between productivity and exports. Surveys of some of this literature can be found in Wagner (2007; 2012). More recent literature is discussed in Alka (2024). The emphasis in this literature shifted in the mid-1990s toward work using detailed datasets for individual firms. Much of this literature starts from the observation that the productivity of exporting firms is a good deal higher than that of firms focusing on a domestic market. The literature typically looks at two explanations. One is that higher productivity firms self-select into export activity, so that higher productivity precedes exports. The other is that firms become more efficient as they learn from exporting. In this case, the direction of causation runs from exports to productivity.[1]

Most studies appear to favour the self-selection hypothesis, but a number argue for the learning from exporting explanation. The division continues in recent studies. Thus, Alka in a study of manufacturing firms in Ghana, Kenya, Nigeria and Tanzania, finds 'strong and robust evidence for the learning-by-exporting effect', while finding no evidence either that more productive firms self-select into exporting or that firms deliberately invest so that they can move onto the export market (Alka 2024, pp.1,13). On the other hand, Ciarli, Coad and Moneta (2023), in a study of Chilean exporters, find no evidence that export growth influenced total factor productivity growth in subsequent years, and argue that the chain of causation runs from higher productivity to exporting.

Some studies look at the relationship between firm productivity and the number of export markets they serve. For example, MuÛls and Pisu (2007) argue that for Belgian manufacturing firms there is a statistically significant positive correlation between firm productivity and the number of markets they serve. Wagner (2012) goes so far as to say that it is a stylized fact that the number of export markets increases with firm productivity. As before, this can be explained by firms self-selecting into several export markets based on their higher productivity, or by firms 'learning by doing' to export into multiple markets.

There are some studies of this kind that consider Australia. Bodman (1996) finds time series for exports and labour productivity to be cointegrated and, using vector error correction modelling, concludes that exports are a cause of productivity growth, albeit with a relatively small impact. He finds no evidence of causation running from productivity to exports. Palangakaraya and Yong (2007) find evidence of both self-selection and learning by exporting, based on a dataset for Australian manufacturing firms covering 1994 to 2000. Tuhin and Swanepoel (2016) use the Business Longitudinal Data Environment (BLADE) to examine business performance indicators, including labour productivity, before and after exporting. They document superior business performance by firms for several years before exporting commences, although some 'born global' firms start exporting immediately. Their analysis also shows that continuing exporters far outpaced non-exporters and intermittent exporters in labour productivity and other business performance indicators.

There is a growing body of literature that uses general equilibrium models that differ from the standard version of GTAP and seek to build on the work of Melitz (2003). This work incorporates firm heterogeneity and accords firm productivity a key role in determining exports. Some of this work modifies the standard version of GTAP to consider the new trade theories.[2] Important contributions in this area include Akgui, Villoria and Hertel (2016); Bekkers and Francois (2018); and Dixon, Jerie and Rimmer (2018; 2019).

The impact of an FTA with the European Union, which is used as a case study on the impact of FTAs in the present study, is modelled using GTAP and AP G-Cubed by Centre for International Economics (CIE) economists (Pearce, Tulloh and Jiang 2014), though this does not address the impact on diversifying trade with China. Two edited collections (Drake-Brockman and Messerlin 2018; Bungenberg and Mitchell 2022) look at the economic impact of an Australia EU FTA, but do not model it.

2.2. Use of the GTAP Model in this Paper: limitations and model baselines

For work with the standard version of GTAP, the present paper employs Version 11c of the GTAP database, which was the latest version at the time of writing. Version 11 was released in April 2023 and has, as its latest reference year, 2017 (meaning that the latest full set of data in the model is for 2017), though it also has data for 2004, 2007, 2011 and 2014. The unlimited Executable-Image version of GEMPACK was used. This allows modelling for all 65 sectors and 160 regions/countries in the latest version of the GTAP model, restricted only by the time, computer memory and processing speed available to the user.

To implement shocks to the GTAP model, a 17 sector and 20 region version of the database was used, identifying five factors of production. The aggregation used is given in Box 1.

Despite their complexity, models like GTAP involve highly simplified assumptions of how the world economy operates. Their primary value is in casting light on relationships among economic variables that are not evident at first glance. GTAP includes a wide range of policy variables — that is its strength — potentially leading to a better and richer understanding of how changes in tariffs, subsidies, taxes and other interventions impact on trade and the wider economy. But modelling results come with important qualifications:

- As discussed in further detail below, there are significant limitations due to the reliance on 2017 data.
- There are some qualifications to the macroeconomic results given the treatment of investment in the model. With appropriate parameter settings (rordelta =1) additions to the capital goods sector adjust to equalise expected rates of return. But the new investment does not 'come online' during a simulation (Hertel & Tsigas 1997; Malcolm 1998). A dynamic model would be needed to address this issue. There is also no distinction between FDI and foreign capital flows more generally.
- Results may be affected by key elasticities of substitution that are not known with any precision.
- The standard version of GTAP, used in Parts four to six, assumes perfect competition and constant returns to scale. It also does not allow for firms having differing levels of productivity, with important consequences for their involvement in international trade.

Box 1
GTAP Database Aggregation Used in this Paper
Sectors: Grains and crops; livestock and meat products; wool; fish and forestry; coal; oil; gas; other minerals[3]; processed food; beverages and tobacco; textiles and clothing; light manufacturing; electrical and electronics manufacturing; heavy manufacturing; utilities and construction; transport and communications services; other services.
Countries and Regions: Australia; China; Japan; Republic of Korea (ROK); India; Taiwan and Hong Kong; United States; New Zealand and other Oceania; Indonesia; Viet Nam; Other Southeast Asia; Other South Asia; United Kingdom; Other North America; European Union (27); Other Europe; Latin America; Middle East and North Africa; Sub-Saharan Africa; Rest of the World.
Factors of Production: Land; skilled labour; unskilled labour; capital; natural resources.

- Standard GTAP also assumes that markets clear in long-run closures with full employment and full utilisation of capital.

At first sight using 2017 data is a serious problem. China's real GDP has increased by more than 40 per cent since then, and the volume of imports of goods and services has risen by over 20 per cent. China's trade with Australia has also changed, with imports of mineral ores rising appreciably faster than China's total merchandise imports. Still, GTAP's 2017 database remains a good one. Input output data underpinning the model tends to change relatively slowly. And developing a consistent and unified statistical approach to organising data for 160 economies/regions (representing 99 per cent of world GDP and 96 per cent of world population) and for 65 commodities is an achievement of the first order (Aguiar et al. 2022).

One way of addressing dated data is to construct a baseline scenario and carry out simulations with reference to it. Pearce, Tulloh and Jiang (2014) offer an example of this, with the baseline typically running out to 2030, and with modelling results (for example for an Australia-EU FTA) compared to the world envisaged under the baseline in 2030. Although the authors do not provide details on how the baseline was constructed, it would normally involve a simulation with GTAP with inputs including the growth of world GDP and population among other variables. Developing a baseline of this kind clearly involves a great deal of uncertainty.

Dixon and Rimmer (2023) look at a baseline prepared with GTAP data for 2004, 2007, 2011 and 2014 and examine how well it matches actual 2017 data. Their baseline thus runs over the years 2014-2017. In constructing it, they experiment with ways to model technological change based on the historical record over 2004-14. They find a very poor fit between baseline and observed 2017 data. In a subsequent (2025) paper, they develop a GTAP baseline for the period to 2050, with the initial part extending from 2014 to 2019, 2019 being chosen because it was the last year before distortions introduced by the COVID pandemic. The method adopted for 2014 to 2019 is complex, involving 19 steps, often with several model simulations at each step. The authors find a much greater measure of agreement between baseline and actual data for 2014-19.

For the extended GTAP model used in Part seven of this paper, it was necessary to use a different version of the GTAP database. Details are given there.

3. Measuring Productivity

Productivity, the focus of all the scenarios examined here, can be addressed in several ways. Within Australia, the Australian Bureau of Statistics (ABS) and the Productivity Commission provide data on both the productivity of individual factors of production (like labour productivity) and multifactor productivity, but with a preference for the latter. It should be noted, however, that the ABS uses different measures of multifactor productivity depending on the context (Box 2). With GTAP, we model productivity in the Australian economy as the primary factor reducing technical change, denoted in the model as 'afe'. An increase in afe with value added unchanged leads to a fall in demand for the main primary factors of production - land, labour, capital and natural resources: that is, it leads to their more efficient use. This measure is broadly similar to multifactor productivity as defined by the ABS and Productivity Commission (see Box 2 and Appendix A) and follows usage in Dixon and Rimmer (2025). In the following, we simply refer to a uniform increase in afe as an increase in Australia's productivity.

At the level of specific GTAP sectors in Australia, we adopt a different measure, again with an eye to maintaining broad consistency with the approach favoured by the ABS. Productivity is here defined as output-augmenting technical change or 'ao'. An increase in ao with gross output for the sector unchanged leads to a fall in demand for both the value added by primary factors of production and the intermediate goods and services used in the production process. Partly because it uses gross output for a sector rather than value added in producing the goods and services involved, it is not directly comparable with the nation-wide productivity measure afe. Note that a rise in ao also leads to a fall in

Box 2

ABS, the Productivity Commission, ABARES and GTAP: Approaches to Multifactor Productivity

Several Australian Government agencies provide data on multifactor productivity. The ABS uses two definitions. First, in the national accounts, productivity is measured as chain volume estimates of GDP for the market sector per combined input of labour and capital. Second, in many of its estimates of productivity for individual industry sectors, the ABS typically defines multifactor productivity as gross (rather than value added) output in market sectors for a combined input of labour, capital and intermediate products (rather than just labour and capital only). Note that in both cases, the ABS only measures productivity for the market sector (ABS 2021, 2025). The sector is defined in terms of the Australian and New Zealand Industry Classification, but broadly 'consists of industries which predominantly produce goods and services which are sold at market prices' (ABS 2025, pp.1-2).

The ABS expresses a preference for using gross output in measuring productivity and for including intermediate goods and services in the definition (see ABS 2021, para. 19.41). For the economy-wide measure, however, it is not appropriate to use gross output since this could effectively mean counting the output of sectors more than once because of inter-industry transfers (ABS 2021, para.19.43). It is also not practicable to include intermediate inputs in the definition.

The Productivity Commission adds its own estimates and provides other analytical data in its quarterly and annual productivity reports. It estimates labour productivity for the non-market sector but does not do this for multifactor productivity.[4] ABARES provides data on total factor productivity for Australian broadacre and dairy farms based on farm surveys. Interestingly, it produces data on climate-adjusted productivity as a way of reducing the volatility rising from changing climatic conditions.

The word 'productivity' does not appear in the GTAP model. But as the main text has noted, GTAP has several variables covering technical change that affect productivity. Appendix A provides formal definitions of several types of technical change. All GTAP measures apply to firms but are not limited to specified market sectors.

demand for intermediate goods and services. Usage here follows Tsigas, Frisvold and Kuhn (1997).

One possible objection to modelling the impact of changes in productivity is that it is not a single policy instrument that can be, like taxes and subsidies, altered by the government. Achieving a small gain in productivity could, however, be realised by addressing several different impediments. Detailed discussion of the measures needed can be found in various reports by the Productivity Commission and in Banks (2010, 2012). Box 3 sets out some of the main instruments that have been identified.

Based on measures such as these — ranging from upskilling the labour force and competition policy reform, to removing excessive business regulation and labour market reform — there would appear to be considerable scope to lift Australia's productivity performance. A one per cent productivity improvement of the kind examined here is a realistic objective. Considerably higher increases, taking Australia back to rates achieved in the 1990s, would be possible given political will.

4. Measuring and Modelling Diversification

Interest in diversification is not new. There has been a long-standing view in Australia that the composition of our exports – with a clear emphasis on minerals and agricultural commodities that are either unprocessed or at an early stage in processing – is unfavourable. In this regard, Australia's pattern of trade is rather like that of many developing economies and, like them, Australia has been keen to encourage a higher proportion of manufactures in its exports. Work by the former Bureau of Industry Economics and by the economic areas of the former Department of Trade provided an analytical basis for this view. Diversification from slow-growing and volatile commodity markets became one of the objectives of Government policy from the mid-1980s (McKinsey and Company and the Australian Manufacturing Council 1993, vii). The Albanese Government's Future Made in Australia programme is a recent manifestation of this kind of thinking. Diversification of this type is not examined here except insofar as it concerns the composition or direction of Australia's trade with China.

4.1. Measuring Diversification

As used here, diversification can be measured in several ways. In the case of territorial diversification, the focus is on what might be called relative diversification with respect to China, which is reflected in the change, in percentage points, in the share of Australia's goods exports to China. Diversification in the composition of exports to China is also examined. In this case, the focus is on relative diversification with respect to the GTAP commodity 'other minerals' (which includes iron ore) and on other key sectors captured by the breakdown by industry used here. Results are also given for a more general diversification measure: the Hirschman-Herfindahl index (see Wickes, Adams and Brown 2022).

4.2. Modelling Diversification

The authors' prior expectation was that a positive shock to productivity, whether for the whole Australian economy or for specific sectors, would result in significant increases in exports and trade diversification. But results from initial simulations suggested a need to revisit this expectation and think more carefully about GTAP output under different circumstances.

Box 3
Achieving Productivity Gains in Australia

A widely cited speech by Gary Banks (2012), then Chair of the Productivity Commission, identified a long 'to do' list where action could improve Australia's productivity performance. The speech, which is still relevant, saw market incentives (especially through greater competition) as the key driver of private sector productivity improvements. Under this heading, Banks proposed abolishing remaining tariffs, limiting scope for anti-dumping actions, ending a variety of subsidies to industry, reforming drought support policy, phasing out preferences in public sector procurement, and further competition policy reviews (addressing as priorities issues such as pharmacy ownership and taxi licence quotas among others).

A second group of recommendations were intended to improve the capability of firms to make changes: policies here included those intended to develop human capital, accelerate innovation, promote efficient infrastructure, and improve the efficiency of public administration. A third group was designed to increase flexibility to improve productivity. Regulatory reforms, including to workplace relations, were proposed. See also Banks 2010.

A recent Productivity Commission report (2023) on measures to promote productivity across the whole economy also contained a long list of recommendations –some 71 in all. In a report running to nine volumes, it examined education, migration, workplace reform, data technology, lifting productivity in the non-market sector, and securing environmental objectives at least cost. A CGE model was developed to assist in identifying priority areas for reform, though reliance on its findings was markedly less than in many previous Commission reports. More recently still, the Commission was asked to conduct five inquiries to assist Australian governments to make productivity-enhancing reforms. These inquiries covered 'the creation of a more dynamic and resilient economy, building a skilled and adaptable workforce, harnessing data and digital technology, delivering quality care more efficiently and investing in cheaper, cleaner energy and the net zero transformation' (Chalmers 2024). Final reports on these 'five pillars' were submitted to the Government in December 2025. The reports included some 47 recommendations built around three core drivers of productivity growth: new ideas are the most significant driver; investment in human and physical capital is critical; and regulation needs to be designed with growth in mind (Productivity Commission 2025)

4.3. A Productivity Shock for a Single Sector

Given that GTAP assumes perfect competition with zero economic profits, the initial impact of a productivity increase in a specific sector would be to lower export prices for Australian exports of that commodity. Representative firms in importing economies would then increase demand for the Australian commodity, both because of substitution of the Australian product for supplies from other countries or regions, and because aggregate demand for the final product in importing economies would increase. Something similar would occur for imports by the household and government sectors. Depending on the magnitude of the productivity shock and the elasticities of substitution involved, the result could be a very substantial increase in the quantity of exports for that sector. The model does not automatically account for any responses by the government of the importing country (which might be a potent factor in some cases), though it is possible to model these separately.

Increased demand for the sector would have implications for other sectors of the Australian economy. Sectors providing inputs for the sector shocked might see their gross output rise. But gross output and exports in other sectors might decline as the expanding sector bids away capital and labour from them. Demand for the output of some sectors might also fall because productivity in a sector, as defined here, involves increased efficiency in the use of intermediate products. Under the closure (that is, the split between exogenous and endogenous variables) adopted here, changes in the supply of skilled and unskilled labour and land are exogenous and changes in them are normally set to zero. Changes in the initial endowment of capital are also exogenous and normally assumed to be zero. Although the capital stock does change over the review period to reflect new investment and depreciation, the end of period capital stock does not, as already noted, come online as it might in a dynamic model.

The impact of a productivity shock on territorial diversification might vary considerably, with the initial direction of output and trade an important variable. Thus:

- Where gross output is mainly sold on the domestic market and expansion reinforces this, the output may be consistent with either increased diversification or concentration.
- Where exports of the shocked sector are mainly directed to China and expansion proceeds in this direction, the result may be increased concentration.
- Where exports are directed mainly to countries other than China, the result may be increased territorial diversification.

The impact on concentration or diversification is likely to be quite small. To see this, suppose that Australia's exports to the world in 2017 were US$330 billion, and to China were US$100 billion.[5] Suppose further that there is a sector with exports of USD$10 billion which were sold entirely to countries other than China. Assume that this sector's exports expand by 10 per cent under a productivity shock, again entirely to the rest of the world, that there are no domestic sales, and that the impact of expansion on other sectors is negligible. Then Australia's new total exports are US$331 billion of which US$100 billion continues to be directed to China. The difference before and after the shock in the share of Australian exports going to China – the measure of territorial diversification used here – is a mere 0.2 percentage points.

4.4. A Uniform Productivity Shock for the Australian Economy

The results of an economy-wide productivity shock might be thought of as giving successive shocks by sector to the economy. The results in this case are likely to be highly complex. Even a small productivity shock would also have a significant impact on Australia's GDP, which would have implications for domestic demand, and through this for exports.

4.5. Using Different Models

Different models can, of course, lead to different results. The Melitz (2003) model, which assumes firm heterogeneity and is set in the context of monopolistic competition (rather than perfect competition like the standard version of GTAP), assigns firm productivity the key role in determining whether firms enter and sustain a position in the export market. An increase in productivity allows firms to cross a productivity threshold that divides firms competing solely on the domestic market and those more productive (and often more profitable) firms operating internationally.

It seems to follow from this that an increase in productivity either generally or in a particular sector would lead to a strong export response. But its impact on the share of exports going to particular destinations is not clear. There would presumably be some impact if there were marked differences between China and the rest of the world in the fixed costs associated with exporting, which the Melitz model accounts for (such as learning about the new market or organising initial documentation and product labelling). As noted earlier, there is a body of work that suggests ways to modify the standard GTAP model to account for new theories.

5. The Impact of a Uniform Productivity Increase for Australia

Table 1 provides an overview of key results for the productivity scenarios. Although the GTAP model is not linear, the results can be very approximately scaled up or down to give estimates for other levels of shocks such as a half or five percent (Appendix B). In the case of a uniform one per cent productivity shock for Australia (Scenario A), the GDP outcome is, at about one per cent, consistent with our expectations, as is the strong positive result for economic welfare.

But the low result on the volume of exports is puzzling at first sight: it is at odds with both the widely held view that increasing productivity assists firms to penetrate world markets by lowering costs, and the 'new trade theory' developed by Melitz (2003) and others (see below). It occurs mainly because of changes to the economy arising from the one per cent shock. The quantity of output for the services sectors expands appreciably, drawing resources away from most other sectors. The utilities and construction sector expands fastest by 1.45 per cent. 'Other services' is the second most strongly expanding, growing by 1.05 per cent. More intense use of resources in more domestically focused sectors then has a negative impact on export volumes.

A uniform productivity shock of the kind modelled in Scenario A generates only small changes in the geographical direction of Australian exports. This is shown in the last two columns of Table 2 which give changes in these shares under the experiment in percentage points. At the margin, the modelling shows an increased concentration on China relative to other destinations, though the change is extremely small. Similarly, Table 3 shows that the industry composition of Australian exports to China undergoes little change. There are small declines in the share of minerals not elsewhere classified (nec) - which in this context is mainly iron ore - and small increases in the shares of coal and gas. The Hirschman-Herfindahl (HH) index shows only marginal change toward greater diversification, although it needs to be interpreted with caution given the limited number of sectors involved. The basic reason for limited change in composition and territorial direction of exports is that the shock is uniform: it therefore largely reinforces the existing pattern of trade that reflects the strong complementarities between Australia and China.

6. A One Percent Increase in Productivity for the Processed Food and Beverages (PF&B) Sectors

Processed food (as used here covering vegetable oils and fats, dairy products, sugar and food products nec) and beverages are significant Australian exports to China and more broadly. The base data in the GTAP model gives their combined export value to China at over two billion US dollars in 2017 and over US$10 billion to the world (Table 4).

Table 1
Changes in Selected Indicators for Australia under the Productivity Simulations

Scenario	Economic Welfare (US$ million)	GDP Quantity Index, %	Volume of Exports to the World, %	Volume of Exports to China, %
A	13,197	1.019	0.174	0.214
B	532	0.041	-0.007	-0.230
C	1,874	0.110	-0.070	0.166

Source: GTAP simulations and author calculations. As noted already, Scenarios B and C use a different definition of multifactor productivity to Scenario A. Comparisons should therefore be made with caution.

Table 2
Changes in the Geographical Direction of Australian Exports from a One Per Cent Uniform Productivity Increase

	2017	After Shock	After Shock	Change Value	Change Volume
	Value, %	**Value, %**	**Volume, %**	**perc. points**	**perc. points**
China	33.179	33.185	33.192	0.007	0.013
Japan	14.946	14.963	14.979	0.018	0.033
ROK	7.075	7.085	7.090	0.011	0.016
Rest of SE Asia	6.673	6.669	6.663	-0.004	-0.010
India	5.514	5.523	5.528	0.009	0.014
USA	5.043	5.030	5.023	-0.013	-0.021
Hong Kong and Taiwan	4.664	4.662	4.663	-0.002	-0.001
EU (27)	4.492	4.491	4.489	-0.001	-0.003
NZ, Other Oceania	3.959	3.954	3.948	-0.006	-0.011
Middle East, North Africa	3.450	3.445	3.442	-0.004	-0.008
UK	2.736	2.731	2.727	-0.005	-0.009
Indonesia	1.877	1.876	1.875	0.000	-0.002
Viet Nam	1.441	1.441	1.441	0.000	0.000
Latin America	1.231	1.230	1.229	-0.002	-0.002
Sub-Saharan Africa	1.149	1.147	1.146	-0.002	-0.004
Rest of Europe	0.950	0.949	0.948	-0.002	-0.003
Rest of North America	0.747	0.746	0.745	-0.002	-0.003
Rest of South Asia	0.683	0.683	0.683	0.000	0.000
Rest of World	0.179	0.178	0.178	-0.001	-0.001
Australia	0.012	0.012	0.012	0.000	0.000
Total	100.000	100.000	100.000	0.000	0.000

Source: GTAP simulations and author calculations. The original data are in basic prices (that is, prices received by the producer, including export subsidies, but excluding export taxes and other charges).

The impact of a one per cent productivity increase for these two sectors is obviously much less than the uniform one per cent increase examined in Scenario A. However, the effect on welfare and GDP is still positive, with economic welfare in particular rising by more than half a billion US dollars (Table 1). Australia's total exports to the world and to China fall slightly. This occurs despite a significant expansion of exports of both processed food and beverages in volume terms. In the competitive market assumed in the model, higher productivity leads to lower export prices. In volume terms, processed food exports rise by 4.9 per cent (with a 5.1 per cent increase in exports to China) and beverages by 2.1 per cent both to the world and China (Table 4).

The volumes of total Australian goods exports to the world and China contract because the exports of all but three sectors - processed food, beverages and oil - fall This occurs, first, because in the model closure adopted here, changes in the supply of land, skilled and unskilled labour are exogenous and are set to zero. And second. although the capital stock expands, the increased stock does not, as we have seen, come online. Gross output does rise for three sectors other than processed food and beverages – meat and livestock, utilities and construction, and transport and communications. Output in the grains and crops and fish and forestry sectors falls even though they provide inputs to processed food and beverages. This occurs presumably because expansion in processed food and beverages is offset by

Table 3
Changes in the Industry Composition of Australian Exports to China from a Uniform One Per Cent Productivity Increase

	2017	After Shock	After Shock	Change Value	Change Vol.
	Value, %	**Value, %**	**Volume, %**	**perc. points**	**perc. points**
Grains and Crops	2.854	2.861	2.861	0.007	0.007
Meat, Livestock	1.705	1.703	1.701	-0.002	-0.005
Wool	1.940	1.943	1.942	0.003	0.002
Fishing and Forestry	0.848	0.850	0.850	0.002	0.002
Other Minerals	43.326	43.297	43.318	-0.029	-0.008
Coal	11.102	11.156	11.189	0.054	0.087
Oil	0.324	0.327	0.327	0.003	0.002
Gas	4.258	4.286	4.288	0.029	0.030
Processed Food	1.282	1.279	1.277	-0.003	-0.005
Beverages	0.807	0.805	0.804	-0.001	-0.003
Textiles and Clothing	0.040	0.040	0.040	0.000	0.000
Light Manufacturing	1.255	1.250	1.248	-0.005	-0.007
Electrical and Electronics	0.540	0.536	0.535	-0.003	-0.004
Heavy Manufacturing	17.882	17.866	17.845	-0.016	-0.037
Utilities and Construction	0.033	0.033	0.033	0.000	0.000
Transport and Communic.	3.553	3.542	3.535	-0.010	-0.017
Other Services	8.251	8.225	8.208	-0.026	-0.043
Total	100.000	100.000	100.000	0.000	0.000
HH Index	0.197	0.196			

Source: GTAP simulations and author calculations. The HH Index is a measure of diversification and ranges from zero to one. A decrease, as shown in the Table, represents greater diversification.

more efficient use of intermediate inputs from those other sectors.

As Table 1 shows, Australian exports to China fall by more than exports to the world in volume terms under the shock. This is also true for the value of exports. There is therefore a measure of territorial diversification, albeit relatively small (Table 4). There is also some impact on the composition of exports both to China and the world. Shares of the processed food and beverages sectors in Australian exports to China and the world rise, but by a modest amount. This is because processed food and beverages, while significant, were a relatively small proportion of Australian exports in 2017. At the same time, the share of other minerals nec in exports to China rises very slightly in value. There is thus a measure of increased export concentration to China in one sense used in this paper. But the change is tiny. The HH index shows no change in export concentration.

Source: GTAP simulations and author calculations

7. A One Percent Increase in Productivity in the Heavy Manufacturing (HM) Sector

As used here, the heavy manufacturing sector covers petroleum and coal products; chemical products; basic pharmaceutical products; rubber and plastic products; mineral products nec; ferrous metals; and metals nec. According to the GTAP database, Australian exports of these items to the world and China in 2017 were around US$51 billion and US$19 billion, respectively.

A one per cent productivity increase for heavy manufacturing accordingly produces a bigger impact on welfare and GDP than for processed food and beverages. Table 1 shows an increase in welfare of around US$1,870 million and a rise in GDP of 0.11 per cent. As with processed food and beverages, exports of heavy manufacturing expand strongly in volume terms, rising by 4.6 per cent to China and by a slightly smaller percentage to the world (Table 5). But aggregate exports of all commodities to the world fall slightly and rise only slightly to China because exports of commodities other than heavy manufacturing all fall as the expansion of heavy manufacturing draws away labour and capital from other sectors (Table 1). China's share of our total exports rises in both volume and value terms (Table

Table 4
Exports of Processed Food and Beverages under a One Per Cent Productivity Shock to Those Two Sectors

	China	Total
Australian Exports of PF&B, US$ million, 2017		
Processed Food	1,336.587	7,496.459
Beverages	840.747	2,905.140
Change in Share of Total Australian Exports to China, perc. points		
By Value	-0.006	0.000
By Volume	-0.011	0.000
Growth by Exports Volumes, %		
Processed Food	5.096	4.932
Beverages	2.097	2.133
Change in Share of PF&B in Exports to China and the World, perc. points		
Processed Food by Value	0.051	0.091
Processed Food by Volume	0.066	0.118
Beverages by Value	0.009	0.010
Beverages by Volume	0.017	0.020
Change in Share of Minerals nec in Exports to China and the World, perc. points		
By Value	0.009	0.000
By Volume	-0.001	-0.007
HH Index for Composition of Export Values to China		
Before Shock	0.197	
After Shock	0.197	

5). In other words, there is no evidence of territorial diversification away from China.

Source: GTAP simulations and author calculations

The composition of our exports to China and to the world changes slightly, with the share of heavy manufacturing rising in both cases. The share of minerals nec falls slightly (Table 5). There is thus a degree of diversification in the composition of our exports to China, but the change is small. The HH index shows no change in overall diversification.

8. An Alternative Model: Findings from the Dixon, Jerie and Rimmer Extension of GTAP

Lack of realism in some of the assumptions in the standard GTAP model (in particular that firms in a region are alike and can be modelled using a single representative firm) suggests benefits from examining findings from models that allow for firm heterogeneity, especially differences in productivity. This paper looks briefly at one of the extensions of the standard GTAP model developed by Dixon, Jerie and Rimmer to make GTAP more compatible with work by Melitz. Full details on their methodology are available in Dixon, Jerie and Rimmer (2018, 2019) and in online material they prepared for applied researchers using their techniques. We use their work to explore the implications of productivity increases for the three sectors examined here.

Dixon, Jerie and Rimmer assume that the marginal productivity of firms in any region is given by the density of a Pareto distribution, which is (Moral de la Rubia 2025; Wikipedia 2025):[6]

$f(x) = a * x_m^a * x^{-a-1}$ for $x \geq x_m$ and zero otherwise.

Here f(x) denotes the relative frequency of firms with marginal productivity x, x_m is the minimum value x can take (assumed to have a lower bound of one because of increasing returns to scale) and 'a' is a shape parameter (which as the name suggests determines the shape of the function). Figure 1 plots this function for the values of 'a' assumed to hold for the three sectors being considered, namely processed food (a=2.5), beverages (a=2.0) and heavy

Table 5
Exports of Heavy Manufactures from Australia under a One Per Cent Productivity Shock to that Sector

	China	Total
Australian Exports of Heavy Manufacturing, US$ million, 2017	18,638	51,063
Change in Share of Total Australian Exports to China, perc. points		
By Value	0.090	0.000
By Volume	0.078	0.000
Growth of Export Volumes, %	4.593	4.541
Change in Share of Exports of HM to China and the World, perc. points		
By Value	0.630	0.609
By Volume	0.790	0.750
Change in Share of Minerals nec in Exports to China and the World, perc. points		
By Value	-0.191	-0.035
By Volume	-0.322	-0.100
HH Index for Composition of Export Values to China		
Before Shock	0.197	
After Shock	0.197	

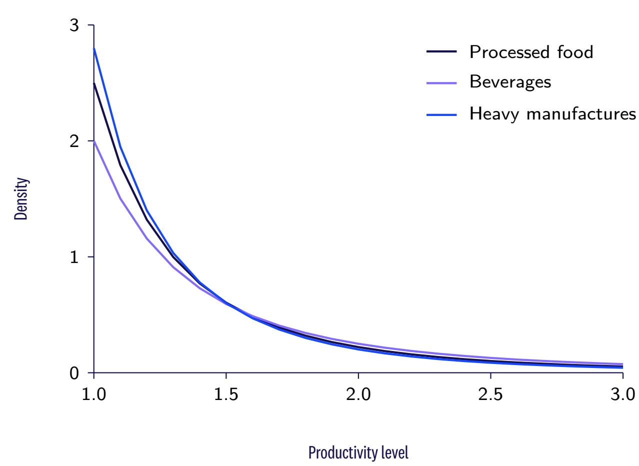

Figure 1: Assumed Marginal Productivity of Firms

Source: Author calculations based on shape parameters given in the main text. A similar graph of the density of a Pareto distribution, in a different context, occurs in Wikipedia (2025).

manufactures (a=2.8).[7] As the graph shows the highest frequency for marginal productivity occurs for low values of that variable: a relatively small proportion of firms have high marginal productivity (Dixon, Jerie and Rimmer 2019).

The Dixon, Jerie and Rimmer Model is based on an earlier version of the GTAP model (Version 6.2) than the version used elsewhere in the present paper (Version 7). Accordingly, it was necessary to use an earlier version of the database (Version 10.2) which has 2014 as its latest year of data. However, essentially the same 17 sector and 20 region aggregation was used (see Box 1).

Table 6 shows the results for several variables of a one per cent productivity shock for the three sectors. As might be expected, a productivity shock leads to an increased number of firms engaged in exporting: the percentage increase in the number of firms supplying the world market increases by between 6.5 and 6.9 per cent for processed food (depending on the destination) and by between 5.1 per

Table 6
Impact of One Per Cent Productivity Shocks, using the Dixon, Jerie and Rimmer GTAP Enhancement

Indicator	Processed Food	Beverages	Heavy Mnfcs
Economic welfare, US$ million, as equivalent variation.	1,466	501	5,098
GDP index, % change.	0.063	0.025	0.188
Change in share of total Australian exports to China, by volume, percentage points.	0.003	0.001	-0.022
Growth in volume of Australian exports by sector to world, % change	4.814	3.241	3.274
Growth in volume of Australian exports by sector to China, % change	4.848	3.213	3.281
Growth in number of Australian exporting firms by sector, % change	6.500 to 6.869	5.073 to 5.892	3.897 to 4.062
Productivity of typical exporting Australian firm by sector, % change	-1,733 to -1,869	-1.779 to -2.160	-0.627 to -0.684
Export prices, f.o.b., % change	0.624 to 0.763	0.714 to 1.106	0.172 to 0.229
Change in share by volume of sector in exports to China, percentage points	0.047	0.009	0.380
Change in share by volume of minerals nec in exports to China, percentage points	-0.003	0.000	-0.180
HH index for composition of export volumes to China Before shock After shock	0.337 0.337	0.337 0.337	0.337 0.336

Source: Dixon, Jerie and Rimmer Model output and author calculations. As noted in Table 3, the HH index runs from zero to one, with one representing the highest degree of concentration. The HH index given here is much higher than in Table 3. This occurs because the index is dominated, in the case of China, by the proportion of iron ore in total Australian exports to China. This fell sharply between 2014 and 2017 because of falling iron ore prices (down by more than 25 per cent) and a substantial rise in the value of other key exports by 2017, such as heavy manufactures and services.

cent and 5.9 per cent for beverages and about four per cent for heavy manufactures, respectively. The quantity of product exported expands, but it does so in a relatively uniform manner across markets, so that there is no strong impetus towards greater diversification. Somewhat paradoxically, the productivity increase brings firms with lower marginal productivity to the world market. The marginal productivity of the typical exporting firm falls by 1.7 to 1.9 per cent for processed food, by 1.8 to 2.2 per cent for beverages and 0.6 to 0.7 per cent for heavy manufactures.[8] With lower marginal productivity, export prices rise to cover higher marginal costs.

The productivity shocks result in an increase in economic welfare (measured as equivalent variation) for Australia.[9] Although the results are not strictly comparable with those for the standard GTAP simulations (for one thing, different years are being examined), they are noticeably larger. There is also an increase in Australia's GDP, again larger than in earlier simulations.

Within the Chinese market, the model shows a degree of diversification in Australia's export mix. The share of processed food in Australia's exports to China rises by 0.047 percentage points, while the share of minerals nec falls. However, the changes are minute and the HH index indicates no significant change in concentration. Similar conclusions hold for beverages and heavy manufactures (Table 6). Overall, the results confirm the conclusions from simulations with the standard GTAP model.

9. The Continuing Importance of Productivity in Australia's Trade Policy

Productivity increases make a very strong contribution to Australian welfare. But their impact can be stronger when they work in conjunction with other changes such as a major new FTA or an increase in the supply of capital or in the availability of skilled labour. In addition, improvements in productivity can position Australia to take advantage of new export opportunities (Brown 2025). They can also help to preserve Australia's market share in the event of significant improvements in the competitiveness of rival suppliers and the emergence of new suppliers. Even if they do not by themselves drive significant changes in the direction of exports, improving productivity needs to be a key part of Australia's export strategy (Brown 2025).

9.1. Adding to Gains from Tariff Elimination with the EU 27

An increase in productivity can complement gains from tariff elimination under a free trade

Table 7
GTAP Output for Scenarios Involving Tariff Elimination Between Australia and the EU

	D1	D2
Welfare, Australia, US$ million change	384	13,535
GDP, Australia, % change	0.032	1.051
Total Australian exports, volume % change	0.374	0.560
Australian exports to the EU, volume, % change	5.380	5.500
Change in share of Australian exports to the EU, volume, percentage points	0.220	0.217
Change in share of Australian exports to the EU, value, percentage points	0.220	0.219
Exports to China, volume, % change	0.131	0.353
Change in share of exports to China, volume, percentage points	-0.081	-0.069
Change in share of exports to China, value, percentage points	-0.083	-0.077

Source: GTAP simulations and author calculations. D1 covers the elimination of tariffs with the EU. D2 gives outcomes for a combination of tariff elimination with the EU and a uniform one per cent productivity increase in Australia. Elimination of tariffs includes elimination of the tariff equivalent of quotas.

agreement. The EU 27 and Australia are currently negotiating an FTA. The column of data in Table 7 under D1 report GTAP output on the impact of complete elimination of tariffs and quotas (measured as ad valorem tariff equivalents), hereafter referred to as just tariffs. This is not a realistic outcome of an FTA but serves as an example.[10]

Column D1 in Table 7 shows that tariff elimination with the EU has only a modest impact on welfare and GDP. It has much stronger impact on the volume of Australian exports to the EU. But there is little impact on the geographical concentration of exports because the EU is only a moderately large market for Australian goods: it took only 3.2 per cent of the total for goods in 2017, the reference year for the model. The share of Australian exports going to China falls by about 0.08 percentage points.

Column D2 reports on the impact of implementing tariff elimination along with a uniform productivity increase of one per cent. A combined shock of this kind might occur for different reasons. One is that the FTA might induce a productivity increase as competition sharpens in the domestic market, as firms learn and become more efficient from exporting more to the EU, and as other gains from exporting are realised such as economies of scale. The second is that the two shocks might be largely independent in their origin. As might be expected, the results for welfare and GDP in either case are not far different from adding those for a uniform productivity shock discussed previously to those in Column D1. With the combined shock, welfare rises substantially by over US$13 billion and the impact on Australia's GDP is about three times as great as in column D1. But because a uniform productivity shock does not have much impact on the territorial concentration of exports, as shown in Part 4, neither does the combined productivity/tariff elimination shock.

Tariffs between the US and other economies have undergone and are undergoing massive changes during the second Trump Administration. It is therefore important to consider whether these tariffs are likely to affect the results in columns D1 and D2. As an experiment, changes in tariffs were modelled for two bilateral relationships with the United States: The EU and Australia. The model database was updated to consider the impact of these tariffs, and the shocks for tariff elimination between the EU and Australia were then re-run with and without a one per cent uniform productivity shock. The results were not very different from those in columns D1 and D2.

This may suggest that the broad impact of an Australia-EU FTA is not sensitive to these tariffs. But this observation comes with a couple of important caveats: EU tariffs on US agricultural products were still under consideration at the time of writing (Box 4) and in any event are not easily modelled, and tariff changes involving other countries, for example between the United States and China, could impact trade flows under an Australia-EU FTA.

9.2. Working in Conjunction with an Increase in the Supply of Capital

A second set of simulations results are set out in the first column of Table 8. These examine outcomes when the supply of capital increases by one per cent. Table 8 presents two set of results, one where no productivity increase is assumed and one where productivity across the whole economy is increased by one per cent.

As Table 8 shows in Column E, an increase in productivity adds enormously to the impact of the rise in capital supply. The change in welfare increases

Box 4
Trump and Partner Countries' Tariffs
For experimental purposes, the following tariffs are assumed:

- US tariffs on goods from Australia: 10 per cent except for meat and livestock products since beef will now have free entry. No change in Australia's tariffs on US goods.
- US tariffs on goods from the EU: 15 per cent. EU tariffs on industrial products from the US go to zero. Changes in EU tariffs on agricultural products, including processed food, are modelled as unchanged.

These assumptions are vastly oversimplified. For example, US tariffs on the EU under their agreement are at the higher of 15 per cent and the most favoured nation rate. Those on Australia apply at higher levels for certain sectors like steel. The EU has undertaken to improve access in some areas of agriculture. A 21 August 2025 statement from the EU and the US says that the EU "will provide preferential market access for a wide range of US seafood and agricultural goods, including tree nuts, dairy products, fresh and processed fruits and vegetables, processed foods, planting seeds, soybean oil, and pork and bison meat' (European Commission 2025, p.1). At the time of writing, the International Trade Committee of the European Parliament was examining proposals to implement this agreement through adjusting customs duties or introducing and modifying tariff quotas, although the Committee noted that progress would be subject to the US honouring its part of the agreement and respecting 'the territorial integrity and sovereignty of the Union and its member states' (Lange 2026).
Key US tariffs made under the authority of the International Emergency Powers Act using the justification of a national emergency were ruled invalid by lower courts, but the matter has now gone to the US Supreme Court. As they are presently based, the US tariffs can, in any event, be changed abruptly because recent agreements are not legally binding.

fivefold to over US$16 billion and growth in GDP almost fourfold. There is also an appreciable increase in the volume of Australian exports to the world and to China. But under neither simulation is there an appreciable impact on Australian export concentration on China in volume or value terms.

In some ways a more interesting comparison is between the results of a uniform increase in productivity for Australia of one per cent (explored in Scenario A) and the increase in productivity combined with an increase in the supply of capital (Table 8). As might be expected, both welfare and GDP expand more strongly when the capital supply increases along with productivity. The growth in the volume of Australian exports increases almost sixfold in the latter case. Although exports to China grow more strongly with a combined productivity and capital shock, Table 8 shows a very slight diversification away from China, whereas under Scenario A there was a slight increase in concentration (Table 2).

9.3. Countering an Increase in Productivity in Competitor Economies

An increase in productivity in a specific sector in other countries/regions has a similar impact to that experienced by Australia: export volumes increase significantly. Where Australia competes with them in third country markets, the increase may come at the expense of Australian exports. In the cases of processed food and beverages, for example, Column F of Table 8 shows the impact of a one per cent increase in EU27 productivity in those sectors. With no accompanying productivity increase in Australia, our processed food exports fall by around 0.5 per cent and beverages by 0.6 per cent.

If, however, Australia's own productivity in the same sectors rises by one per cent, the adverse impacts on the sectors shown by GTAP are more than overcome. Australia's exports volumes of processed food rise by around 4.4 per cent, and beverages by around 1.5 per cent. With the productivity increase, Australia's welfare also rises by approximately US$550 million.

9.4. Offsetting the Costs of Forced Diversification

A fourth pair of simulations examine a hypothetical case where China becomes concerned by their import dependence on Australia for some commodities or, alternatively, sanctions Australia in the context of deteriorating international conditions. Within the GTAP model, these cases can be handled by assuming that China places a high tariff (in the case of goods) or other forms of import tax (in the case of services) on imports from Australia. For this experiment, we assume the tariff or import tax is applied at an ad valorem rate of 50 per cent except for gas, where a 20 per cent tariff is sufficient to reduce Australian exports to China by more than 99 per cent.

Column G of Table 8 gives results with and without a one per cent uniform increase in Australian productivity. Without a productivity increase, the outcomes for Australia are severe, with an almost US$23 billion welfare loss and a decline in GDP. Australia's exports to China fall by 60 per cent. There is a big shift of Australian exports away from China, with the share of exports directed to China falling by about 20 percentage points. Japan again becomes Australia's largest export market. With a productivity increase, the welfare loss is more than halved and GDP now increases, though exports to China still

Table 8
GTAP Output for the Remaining Scenarios

	E	F	G
Without Australian Productivity Increase			
Welfare, Australia, US$ million change	3032	22	-22,805
GDP, Australia, % change	0.382	0.001	-0.194
Total Australian Exports, volume % change	0.838	0.006	0.336
Exports to China, volume, % change	0.728	0.013	-60.263
Change in Share of Exports to China, volume, percentage points	-0.036	0.002	-20.038
Change in Share of Exports to China, value, percentage points	-0.042	0.002	-20.415
Increase in the Supply of Capital, %	1.000	0.000	0.000
Australian Exports of Processed Food, % change, volume	Not applic.	-0.499	Not applic.
Australian Exports of Beverages, % change, volume	Not applic.	-0.644	Not applic.
With Australian Productivity Increase			
Welfare, Australia, US$ million change	16,287	552	-9724
GDP, Australia, % change	1.405	0.041	0.825
Total Australian Exports, volume % change	1.000	-0.001	0.432
Exports to China, volume, % change	0.935	-0.027	-60.215
Change in Share of Exports to China, volume, percentage points	-0.021	-0.009	-20.035
Change in Share of Exports to China, value, percentage points	-0.035	-0.003	-20.411
Increase in the Supply of Capital, %	1.000	0.000	0.000
Australian Exports of Processed Food, % change, volume	Not applic.	4.409	Not applic.
Australian Exports of Beverages, % change, volume	Not applic.	1.475	Not applic.

Source: GTAP simulations and author calculations. As indicated in the main text, Scenario E covers an increase in the supply of capital of one per cent; Scenario F an increase in productivity in the EU processed food and beverages sectors of one per cent; and Scenario G action by China to severely restrict imports from Australia. The increase in the supply of capital refers to the capital endowment, which is equivalent to the change in the volume of capital services provided at the beginning of the period in question (in this case 2017). Data on changes in exports are volumes consistent with initial measurements at basic prices.

fall by about 60 per cent and the share of exports to China fall by about 20 percentage points.

10. Concluding Remarks and an Agenda for Further Research

This paper suggests that increased productivity is not, by itself, a 'silver bullet' for Australia in seeking to diversify export trade with China. In the GTAP simulations considered in Parts four to six, most productivity shocks lead to small changes in the percentage shares of Australia's export destinations. In all the simulations, impacts on aggregate exports are very small, even though increasing productivity in processed food and beverages and heavy manufacturing lead to strong export growth in those sectors. Part seven shows that the main conclusion – that productivity does not by itself drive substantial diversification – holds when an alternative model is used providing for firm heterogeneity with respect to productivity. And only one simulation, in part eight, shows substantial diversification where China hypothetically imposed severe restrictions on Australian exports. That outcome was negative for Australia, particularly in terms of welfare losses, even when accompanied by an increase in productivity. It underlines yet again Australia's strong interest in continuing to build trade and wider economic relations with China. Much the same could be observed for China.

Although it is not a silver bullet in promoting diversification, this paper, like many others, has shown that increasing productivity is a vital policy objective. It supports big welfare gains. It complements and strengthens the gains from new free trade agreements and from increases in the supply of capital. It protects Australia's trading position from productivity improvements in rival suppliers. In an extreme scenario where

Australia is forced to diversify because of the restrictive policies of a third country, it lowers what could be high costs of adjustment. And, reduced to essentials, it reinforces an old but important point: Australian trade policy has a vital role to play in lifting productivity not only through international engagement to keep the region and world economically more integrated and open at a difficult time in world history but through its contribution to building internationally competitive domestic economic frameworks.

Further research is needed on several issues:

- On GTAP, developing a simpler method for constructing a baseline than the one developed by Dixon and Rimmer (2025), and making it available to applied researchers, would be useful. The same goes for extending the work of Dixon, Jerie and Rimmer to build firm heterogeneity into the current (Version 7) of GTAP.
- When tariff data become available, it would be useful to gauge, however roughly, how gains from an Australia-EU FTA may be impacted by new tariffs between the United States and other economies and via impacts on productivity.
- How trade facilitation and export taxes and subsidies can affect diversification, including in the context of productivity changes, also would be helpful.

At a broader level, growth in regional economies and beyond will create new opportunities for Australian exports. India's resource consumption could triple within the next two decades with big implications for India's imports despite the Indian Government's reluctance to open its economy. India's relatively ambitious FTA agenda (at least by their standards) may be a sign that this reluctance may be weakening. Southeast Asia also presents big opportunities for Australia's resources and energy exports and for a range of services.

Fundamental redirection of our trade will not come quickly and, to the extent that it happens, will be occurring in a changed geopolitical environment where US support for the international trading system — critical to rapid growth in many Asian economies since the Second World War — is much weaker than even 15-20 years ago. This is unlikely to change in substance with the end of President Trump's second administration in January 2029, though the tone may change. China will continue to rise and extend its political and economic influence regionally and around the world. And the rise of rival suppliers of minerals and other commodities means that Australia must consider closely how to sustain Chinese imports demand. Amid our growing security concerns, open public debate on our international policy objectives must play a key role in developing future international trade and economic agendas.

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Endnotes

1. There are, of course, other ways in which increased exports can promote productivity, including greater specialisation, economies of scale, exposure to more competitive international markets, and linkages to other sectors of the economy (Kunst and Marin 1989).
2. By the new trade theories, we mean work of the kind developed by Melitz (2003) that considers firm heterogeneity.
3. We sometimes refer to other minerals as minerals not elsewhere classified (nec).
4. The non-market sector covers education and training, health care and social assistance, and public administration and safety (including defence).
5. We work in US dollars here because all GTAP monetary amounts are in that currency.
6. Moral de la Rubia (2025, p.88) refers to this as a Type 1 Pareto distribution. There are other more general forms.
7. Except for beverages, for which a single estimate is available, these values for the shape parameter are derived by taking arithmetic averages of much more disaggregated data from the online material accompanying Dixon, Jerie and Rimmer (2018).
8. The term 'typical firm' has a specialised meaning in Dixon, Jerie and Rimmer. It refers to the firm operating on the source - destination (s,d) link that 'employs the average number of input bundles in production (not fixed setup costs) over all of the c-firms [that is, firms producing commodity c] serving the c, s, d link' (Dixon, Jerie and Rimmer 2019, 103).
9. Dixon, Jerie and Rimmer prefer to use real private consumption as a welfare measure and to implement this, their closure for the model makes it possible to exogenize the balance of trade, investment and government consumption. The present paper has not followed this course.
10. For example, it does not account for the impact of other elements of an FTA such as services, investment and trade facilitation. It also assumes far more tariff liberalisation than seems likely: the EU has strong sensitivities in areas

like food and agriculture, which means that barriers for some commodities are likely to be subject to long phase out periods, while a limited number may be excluded altogether.

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A. Measuring Productivity with GTAP

As the main text has indicated, there are several technical change variables in GTAP that are relevant to the analysis of productivity. They include:

Output Augmenting Technical Change This is defined in the GTAP model equations as:

(i) ao(a,r) = aosec(a) + aoreg(r) + aoall(a,r)

where, in percentage change terms, aosec(a) is worldwide output technical change for activity a; aoreg(r) is output technical change in region r; and aoall(a,r) is output augmenting technical change in region r for activity a. In the closure used in this paper for the standard GTAP, all variables on the right-hand side of (i) are exogenous.

Further, again following the GTAP convention that lower-case names represent percentage changes and with bracketed terms such as (a,r) indicating that the variable applies to activities, a, and for region r, we have

(ii) qva(a,r) = -ava(a,r) +qo(a,r) – ao(a,r) – ESUBT(a,r) *[pva(a,r) -ava(ar) -po(a,r) -ao(a,r)]

and

(iii) qint(a,r) = -aint(a,r) + qo(a,r) – ao(a,r) - ESUBT(a,r) *[pint(a,r) -aint(ar) -po(a,r) -ao(a,r)]

where qva(a,r) is value added by activity a in region r; qo(a,r) is gross output; pva(a,r) is firms' price of value added; ava(a,r) is value-added augmenting technical change; po(a,r) is unit cost or revenue; qint((a,r) is composite intermediate inputs; aint(a,r) is composite intermediate input augmenting technical change; pint(a,r) is the price of intermediate input; and ESUBT is an elasticity of substitution between the value added variable qva and the quantity of composite intermediate inputs, qint.

Now the default setting for ESUBT is zero for all a and all r. In addition, if ava and aint are set to zero, then the above equations simplify to:

(iv) qva(a,r) = qint(a,r) = qo(a,r) – ao(a,r)

So, under the conditions described, (i) the percentage change in the quantity of value-added equals the percentage change in the quantity of intermediate inputs and (ii) a rise in output augmenting technical change for a given gross output leads to a fall in both demand for value-added inputs and intermediate inputs.

As the main text has indicated, ao(a,r) can reasonably be used as a measure of multifactor productivity for specific activities.

Value-Added Augmenting Technical Change

Following the GTAP equations, this can be decomposed as follows:

(v) ava(a,r) = avasec(a) + avareg(r) +avaall(a,r).

Here avasec(a) is world value-added technical change; avareg(r) is value-added technical change in region r; and avaall(a,r) is value-added technical change for activity a in region r. For the standard GTAP in this paper, the three right hand variables are exogenous and normally set to zero.

If other technical change variables that are exogenous are set to zero, then

(vi) qva(a,r) = qo(a,r) – ava(a,r)+ ESUBT(a,r) * [pva(a,r) – ava(a,r) -po(a,r)]

Now from the database of model parameters, ESUBT(a,r) is zero for all a and all r. Following this default position, equation (vi) simplifies to:

(vii) ava(a,r) = qo(a,r) – qva(a,r).

An increase in ava(a,r) reduces the quantity of labour, capital and land required to produce gross output, qo(a,r). To see this let qfe(e,a,r) be the percentage change in demand for primary factor e used in activity a in region r. Then again following the model equations closely,

(viii) qfe(e,a,r) = qva(a,r) – ESUBVA(a,r) * [pfe(e,a,r) – pva(a,r)]

where ESUBVA(a,r) is an inter-factor elasticity of substitution and pfe(e,a,r) is the percentage change in the price of factor e for activity a in region r (for example, growth in wages in the case of labour). Then it follows that:

(ix) qfe(e,a,r) = qo(a,r) – ava(a,r) – ESUBVA(a,r)*[pfe(e,a,r) – pva(a,r)]

So, an increase in ava(a,r) results in a reduction in the percentage change in the quantity of a factor (like labour) demanded for a given percentage change in gross output, adjusted however by substitution between factors of production (such as substitution of capital for unskilled labour). The default elasticities for ESUBVA for Australia range from 0.200 for coal, oil, gas and other minerals, to 1.599 for transport and communications.

Factor Input Technical Change

Factor input technical change is denoted afe(e,a,r), where e is a primary factor of production (or endowment commodity in the GTAP terminology), a is an activity and r is a country or region. Again, following the GTAP convention that percentage changes are in lower case, it is given as:

(x) afe(e,a,r) = afecom(e) + afesec(a) + afereg(r) + afeall(e,a,r)

Here afecom(e) is worldwide factor input technical change for input e, afesec(a) is worldwide factor input technical change for activity a, afereg(r) is factor input technical change in region r, and afeall(e,a,r) is factor input technical change for factor e, and activity a in region r.

In the closure adopted here for the standard GTAP, all the right-side variables are exogenous. For simulation A, afereg(r) is set to one and the other right-side variables to zero.

Looking again at the model equations, we have:

(xi) qfe(e,a,r) = -afe(e,a,r) + qva(a,r) – ESUBVA(a,r) * [pfe(e,a,r) -afe(e,a,r) -pva(a,r)]

where qfe(e,a,r) is the demand for primary factor e for activity a and region r. An increase in afe(e,a,r) for a given quantity of value-added thus leads to a fall in demand for primary factors of production, but with the outcome affected by of the relative prices of the primary factor in question and of the value-added component, as well as the elasticity of substitution ESUBVA(a,r).

For Scenario A in Table 1, a one per cent change in afe has an identical impact to a similar increase in ava.

B. How Linear is GTAP?

The question of whether the GTAP model is multiplicatively linear – hereafter just linear - in which case multiples of a shock give rise to the same multiple of change for the endogenous variables, is an important one. It is particularly relevant where attempts are made to generalise from, say, the one per cent shock used here, to those of a lower or higher value, for example, to a half or five per cent (Brown 2025).

Following material in Australian Transport Assessment and Planning Group (2021), a typical CGE model can be written in matrix form as Aw = 0, where A is an m by n matrix and w is an n by 1 vector of the variables in the model in percentage change form. Since n is generally greater than m (or in other words the number of variables exceeds the number of equations), some variables need to be made exogenous to solve the model. After doing this, the model can be written as $A_1y + A_2x = 0$ where A_1 is an m by m matrix, y is an m by 1 vector of endogenous variables, A_2 is m by n-m matrix and x is a n-m by 1 vector of exogenous variables. If A_1 is invertible, then the system can be written:

$$Y = - A_1^{-1} * A_2 * x$$

which gives the vector of endogenous variables, y, as a function of the two A matrices and the exogenous variables x (see, for example, Horridge et al. 2024, Australian Transport Assessment and Planning Group 2021, Lkhanaajav 2016).

In this form, the system looks linear for the simple case in which only one exogenous variable is shocked and other exogenous variables are zero. But the problem is that at least some parts of the A matrices can change with changes in the exogenous vector x. Where this is the case, as it is with GTAP, the system is in fact non-linear. In practice, however, for a variety of endogenous variables, GTAP appears to be approximately linear. Table 9 illustrates this by comparing key results for the shock to afereg(r) under Scenario A under one per cent and five per cent shocks. As the Table shows, the ratio of results for the five per cent shock are between about five and six times those of the one per cent shock.

Table 9. Changes in Selected Indicators under One and Five Per cent Shocks

Scenario	Economic Welfare (US$ billion)	GDP Quantity Index, %	Volume of Exports to the World, %	Volume of Exports to China, %
A, 1 per cent	13.197	1.019	0.174	0.214
A, 5 per cent	65,788	5.089	1.037	1.190
Ratio	4.985	4.994	5.960	5.561

Source: GTAP simulations and author calculations

This approximate relationship is likely to hold only if the endogenous variables are not further transformed, since departures from the simple multiple can be compounded where this is the case.

The fact that GTAP is strictly non-linear is recognised in methods used to solve the model, which typically split shocks up into smaller shocks and update shares and elasticities after each one. The method used here is normally Gragg with 3, 5 and 7 steps followed by extrapolation of the results to give greater accuracy. Gragg has greater precision than alternatives such as Euler, although it cannot be used when the exogenous variables are shocked to fall by -100 per cent. A 1 step Johansen method, historically the first of the major methods developed, is often used for exploratory analysis. For discussion of the different methods, see Horridge et al. (2024) and Lkhanaajav (2016).

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