CHAPTER 1
Changes in global trade shaping the Australian economy

Aerial photograph of Australian outback and dry road with roadtrain
Digging deeper into global supply chains

Gross trade vs value added trade

A value-added look at trade measures the individual country contributions at each stage of the global supply chain. This is different to the conventional measure of gross exports which measures the full price of a product every time it crosses an international border.

In the example below, Australia exports $100 of iron ore to China which is transformed into steel and exported to the United States for $110.

**Gross export statistics**

- **Australia’s iron ore exports to China**: $100
- **China’s steel exports to United States**: $110
  
  **Total**: $210

**Value-added trade statistics**

- **Value of Australia’s exports making it to the United States**: $100
- **Value of China’s exports making it to the United States**: $110
  
  **Value of trade**: $110 – $100 = $10
  
  **Total**: $110
It’s common knowledge that China is our largest export partner, but to what extent does Chinese demand drive Australian export growth? After all, a shipment of iron ore to China could become a car destined for the United States (US) or a refrigerator exported to Europe, the United Kingdom (UK) or any other global consumer. In this example, it is US demand for cars that determines whether that shipment of iron ore will be made or not, rather than Chinese domestic demand per se.

Similarly, the production process involves a plethora of intermediate goods and services that conventional trade statistics do not capture as exports. But they are, since these goods and services are embodied in the product. The suppliers of these intermediate goods and services could benefit from a more-nuanced understanding of how global supply chains affect their business.

Following on from work done by the Reserve Bank of Australia (RBA), this chapter updates their work and explores these issues further, identifying the key sources of export growth for Australian industries and how the sectors that supply them have changed over time. The chapter begins by explaining the concept of ‘value added’, followed by a modern analysis of the Australian export market. Here the true sources of export demand are revealed, as are the silent contributions made by industries that are typically only thought of in a domestic context. The chapter then presents a detailed analysis of recent changes to Mining production and the Manufacturing and Services industries before concluding with a brief summary of the lessons learned.

Traditional measures only capture half the story

Nearly every conceivable product or service embodies the production and inputs of other businesses. While consumers pay the product’s final value to the last business involved in the production process, businesses at every other stage have also contributed their capital and labour as intermediate inputs. Every stage of the production process adds value until the final product reaches the consumer. Figure 2.1 shows a hypothetical production process for tyres. The final price is the total value added by capital and labour at each stage of the production process.

At stage one of this hypothetical production process for a tyre, the value of capital and labour required to produce the iron ore and coal inputs are $0.50 each, while the value to produce the chemicals is $9 (a total capital and labour price of $10 for stage one). At stage two of the production process, four components are required to produce a tyre (of which iron ore, coal and chemicals from stage one of the production process are inputs). The value of capital and labour required to produce the steel component is $2, to produce the required energy is $3, to produce the rubber component is $20 and the design/assembly of the finished tyre is $5. This is a total capital and labour component price of $20 for stage one. At stage 3, an additional $45 of capital and labour is required for the tyre to reach the consumer.

‘Value added’ is the measure of these individual contributions and can be thought of as the last price of a product sold, less the price that business paid to other businesses for its inputs (i.e. $75 minus $30). In the context of international trade, it is the country’s firms participating in the global supply chain that add value. Similarly, it is the last country in the global supply chain that becomes the end consumer where the product or service is then absorbed as final demand.

Conventional trade statistics overstate the total value of worldwide trade because they treat all products and services as final. In the case of gross export statistics, they record the full price of a product every time it crosses an international border. The entire product’s value is then attributed to the exporting country without accounting for the value already added by other countries. This treatment effectively double-counts the intermediate inputs used at every stage of the global supply chain. Box 2.1 demonstrates the difference between the conventional treatment of gross exports and the value-added approach.

Although they are closely related, gross trade statistics and the value-added approach measure two quite different aspects of international trade, but both methods have their place. A useful method for comparing between industries or the various bilateral trade relationships Australia has with other regions is to find the ratio of value-added exports to gross exports. This is known as the Value-Added Exports (VAX) ratio. By definition, a VAX ratio of less than one occurs when value-added exports are less than gross exports. This can occur when some of the value of a country’s exports is imported from another country and not sourced from domestic value-added. A VAX ratio greater than one (when value-added exports are greater than gross exports) can occur when some of a country’s domestic value-added reaches a trading partner indirectly through being embedded in an

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Source: Department of Industry, Innovation and Science (2018), author calculations

Box 2.1: Comparison of gross trade and value-added trade

Suppose Red Ores Limited — a hypothetical Australian exporter — sells AUD$100 of iron ore to China, where it is then processed into steel. The steel is then sold to a manufacturer in the US for AUD$110, where it is consumed domestically. Red Ores has exported AUD$100 of value from Australia to the US, albeit indirectly and in a transformed state. China’s value-added trade with the US is then AUD$10, which represents the value added during the production process (AUD$110 minus AUD$100). The value-added approach draws a line directly from the original source of a product’s inputs to its final destination where the end product is eventually consumed.

Figure 2.2 illustrates how this example would be treated using conventional trade statistics compared with the value-added approach. Conventional measures record the full price of the product every time it crosses an international border. In this example, the Australian shipment of iron ore has been counted twice, while the value added approach only records the net contribution made by each country to the final product. Conventional trade statistics overstate the value of international trade, particularly as products move further down the global supply chain.

Figure 2.2: Comparison of gross trade and value-added trade

intermediate country’s exports. For example, iron ore from Australia is exported to China and transformed into an earth moving component for a machine built in the United States which is then exported to Australia.\textsuperscript{24}

Each VAX ratio relates to one particular trade relationship, such as exports flowing from the Australian Resources industry (which includes the mining and agricultural sectors) to China. Here the VAX ratio describes the amount of value created by the Resources industry per dollar of resources exported to China.

**Identifying the true sources of export demand**

In the earlier stylised example of a global supply chain (Figure 2.2), iron ore was exported from Australia to the US through China, where it was first transformed into steel. If this particular example was indicative of the entire Australia–China–US supply chain, then the resulting VAX ratio between China and the US would be less than one. This is in fact what the data shows. This implies that Chinese production for the US is relatively downstream, meaning that a large proportion of China’s exports are sent directly to the US for consumption. In contrast, a VAX ratio greater than one would imply a more indirect trading relationship. The majority of goods and services would first pass through a third country before arriving at their final destination.

Table 2.1 compares some of Australia’s key trade partners using data obtained from the World Input-Output Database (WIOD) for 2014.\textsuperscript{25} The first row shows that while only 4.3 per cent of Australian gross exports were exported directly to North America (the US, Canada and Mexico), 9 per cent of Australia’s value-added exports are consumed there. Australia produced 1.69 times more of the value consumed in North America than the amount of goods and services it exported there directly.

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\textsuperscript{24} Kelly, G and La Cava, G (2014) *International Trade Costs, Global Supply Chains and Value-Added Trade in Australia*, Reserve Bank of Australia

Table 2.1: Regional shares of Australian exports, 2014

<table>
<thead>
<tr>
<th>Region</th>
<th>Gross exports (per cent)</th>
<th>Value-added exports (per cent)</th>
<th>Difference (p.p.)</th>
<th>VAX ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>North America</td>
<td>4.3</td>
<td>9.0</td>
<td>4.7</td>
<td>1.69</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>1.3</td>
<td>1.8</td>
<td>0.5</td>
<td>1.14</td>
</tr>
<tr>
<td>European Union (EU)</td>
<td>2.1</td>
<td>4.6</td>
<td>2.5</td>
<td>1.75</td>
</tr>
<tr>
<td>Non-Euro EU</td>
<td>0.9</td>
<td>1.4</td>
<td>0.5</td>
<td>1.23</td>
</tr>
<tr>
<td>South Korea &amp; Taiwan</td>
<td>9.6</td>
<td>5.9</td>
<td>-3.7</td>
<td>0.49</td>
</tr>
<tr>
<td>Japan</td>
<td>16.2</td>
<td>14.5</td>
<td>-1.7</td>
<td>0.72</td>
</tr>
<tr>
<td>China</td>
<td>26.9</td>
<td>25.3</td>
<td>-1.6</td>
<td>0.75</td>
</tr>
<tr>
<td>Rest of World</td>
<td>38.8</td>
<td>37.5</td>
<td>-1.3</td>
<td>0.77</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>100.0</strong></td>
<td><strong>100.0</strong></td>
<td><strong>0.0</strong></td>
<td><strong>0.80</strong></td>
</tr>
</tbody>
</table>


The results are based on new sources of data that attempt to harmonise across 44 countries, making a number of necessary assumptions in the process.

According to these statistics, it follows that demand from North America is 1.69 times more important to the Australian economy than conventional trade statistics imply. The results are similar for other advanced Western economies but the opposite is true for the manufacturing hubs of North-East Asia. These countries often act as assembly points where intermediate goods and services — Australian resources in particular — are transformed into new products to satisfy demand elsewhere in the world.

These results have important implications for how global opportunities and risks are assessed. North American demand shocks, for example, have a much larger direct effect on Australian exports than traditional trade statistics suggest. They also highlight the importance for Australia of other countries’ steps to reduce their trade costs. Improvements made anywhere along the global supply chain can potentially benefit Australia. Figure 2.3 shows how the VAX ratio between Australia and its trading partners has developed over time. It shows that Australia’s VAX ratio with North America and the Euro-zone has been increasing over time, suggesting that demand from these regions has been increasing in importance for the Australian economy.
Figure 2.3: Ratio of Australian value added to gross exports (VAX) by destination region, 2000 to 2014

Industries’ silent contributions to exports

The same type of analysis can be applied to Australian industries. Just as gross trade flows mask the true destination of many Australian goods and services, they also tend to understate the contribution made by some sectors of the domestic economy. Underrepresented industries may be more exposed to the global economy than they themselves realise.

Table 2.2 shows industry contributions to Australian exports. For example, the value added to Australian exports by the Manufacturing industry is just 37 per cent of its gross exports (VAX ratio is 0.37). In contrast, the Services industry contributes 44.5 per cent of the value-added content that Australia exports around the world, despite representing just a quarter of gross exports.

<table>
<thead>
<tr>
<th>Industry</th>
<th>Gross exports (per cent)</th>
<th>Value-added exports (per cent)</th>
<th>Difference (p.p.)</th>
<th>VAX ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resources</td>
<td>48.3</td>
<td>39.1</td>
<td>-9.1</td>
<td>0.65</td>
</tr>
<tr>
<td>Agriculture</td>
<td>4.3</td>
<td>5.2</td>
<td>0.9</td>
<td>0.96</td>
</tr>
<tr>
<td>Mining</td>
<td>43.9</td>
<td>33.9</td>
<td>-10.0</td>
<td>0.62</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>24.9</td>
<td>11.6</td>
<td>-13.3</td>
<td>0.37</td>
</tr>
<tr>
<td>Construction/Utilities</td>
<td>0.5</td>
<td>4.8</td>
<td>4.3</td>
<td>8.23</td>
</tr>
<tr>
<td>Services</td>
<td>26.4</td>
<td>44.5</td>
<td>18.1</td>
<td>1.35</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>100.0</strong></td>
<td><strong>100.0</strong></td>
<td><strong>0.0</strong></td>
<td><strong>0.80</strong></td>
</tr>
</tbody>
</table>


The interdependencies are clear — industries rely on each other to produce exported goods and services. When a goods producer exports a product, they are effectively producing a container to ship the production of other domestic industries all around the world. Even the construction of factories and the energy that supplies them becomes an export using this model.

The industry-averaged results presented so far tend to smooth out the considerable variation that occurs within industries. For example, while the share of Resources exported directly to North America is only 0.4 per cent, the VAX ratio is around 12 (see Appendix A). This means that approximately five per cent of Australian Resources exports are destined for North America, despite purchasing only a fraction of this amount directly.26 Going back to Box 2.1, these commodities are first being shipped to a third country where they are transformed into steel, a car, a refrigerator, or even breakfast cereal before they reach North America. Similarly, while Resources only comprise 4.4 per cent of all Australian exports to North America, they are 31 per cent in value-added terms. Again, whilst this is the average for all Resources exports, higher concentrations exist for certain commodities (see Appendix A).

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26 Value-added exports are equal to the VAX ratio multiplied by the amount of gross exports.
Australia and the world — an international perspective

Research by the RBA (2014) has found that, by international standards, Australian production is highly fragmented (number of stages in the production process) and relatively upstream (stages away from the finished product), partly because of the importance of resource exports. This work showed that during the late 1990s, Australian production became more fragmented and further upstream. These changes coincided with a period of significant structural change in Australia and resulted from both the changing composition of Australian industry and adaptation within industries.27

Increasingly fragmented production can often signify a country’s growing integration into the global supply chain, as trade costs decline and the production process is increasingly outsourced to regions with comparative advantage. However, the domestic value-added content of Australian exports remains the second-highest in the world. Figure 2.4 shows the average country’s proportion of domestic value-added content was 61.5 per cent in 2014, while it was 80 per cent for Australia. This is mostly due to Australia’s geographic isolation and its industry composition. Indeed, the top ten countries either have large internal economies or are commodity exporters. As of 2014, Resources comprised 48 per cent of Australian gross exports, the second-highest after Norway, while Manufacturing was responsible for just 25 per cent of exports compared to the global average of 57 per cent. Because the more upstream Resources industry inherently has a higher proportion of value-added content, higher concentrations of resource exports in place of manufactured goods tend to increase a country’s overall VAX ratio.

Figure 2.4: International proportions of domestic value-added content to gross exports, 2010 and 2014

Notes: World average is the unweighted mean rate for 43 countries and the Rest of the World
Australian industry VAX ratios also tend to differ from global averages. The ratio for Resources, for example, is less than half the global average (Table 2.3).

This at least partially reflects Australia’s status as a major net exporter of commodities.\(^{28}\)

<table>
<thead>
<tr>
<th>Industry sector</th>
<th>VAX ratio</th>
<th>Industry weight</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Australia</td>
<td>World avg.</td>
</tr>
<tr>
<td>Resources</td>
<td>0.65</td>
<td>1.46</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>0.37</td>
<td>0.36</td>
</tr>
<tr>
<td>Construction/Utilities</td>
<td>8.23</td>
<td>4.82</td>
</tr>
<tr>
<td>Services</td>
<td>1.35</td>
<td>1.22</td>
</tr>
<tr>
<td>All industries</td>
<td>0.80</td>
<td>0.62</td>
</tr>
</tbody>
</table>


The increased dominance of goods exporters in Australia relative to other countries also plays a role in increasing the VAX ratio for other industries, since goods exporters rely on them for their own production. Services, in particular, account for around 20 per cent of the total value embodied in resources and manufactured goods. Legal and Accounting, Head Offices and Management Consultancy Activities; Wholesale Trade, except Motor Vehicles and Motorcycles; and the Land Transport and Transport via Pipelines sectors make the largest contributions.

Overall, Australia’s VAX ratio is 0.185 higher than the world average. This result can be broken down into the effects caused by Australian industry VAX ratios differing from those found elsewhere in the world, and the effect caused by industry composition. The former is called the ‘within effect’ because it represents the overall change due to differences between two countries within the same industry, while the latter is known as the ‘between effect’ because it captures the overall change due to different allocations of gross exports between industries — that is, their industry weights.

As a rule, the closer a nation is to the centre of a global trading block, the more diverse its exports and the lower its VAX. Table 2.4 shows that, in 2014, if Australia had a more typical industry composition, its overall VAX ratio would have been lower than the world average by 0.047 (‘within effect’). But Australia’s industry composition was not typical. As already discussed, high concentrations of Resources exports in place of Manufacturing tends to increase the overall domestic value-added content of a country’s exports. Had industry composition been the only factor, then the Australian VAX ratio would have been 0.231 higher than the world average (‘between effect’). The combination of these two effects explains why the Australian VAX ratio was 0.185 higher than the world average. Table 2.4 shows how each industry contributed to the difference.

\(^{28}\) Commodities can be consumed domestically, embodied in other industries’ exports or exported directly. A relative increase in the latter reduces the VAX ratio.
CHAPTER 2
Digging deeper into global supply chains

INDUSTRY INSIGHTS
Globalising Australia

Table 2.4: Difference in the Australian vs other countries’ value-added exports ratio by industry contribution, 2014

<table>
<thead>
<tr>
<th>Industry</th>
<th>VAX ratio differences</th>
<th>Industry composition</th>
<th>Industry total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resources</td>
<td>–0.205</td>
<td>0.206</td>
<td>0.001</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>0.006</td>
<td>0.083</td>
<td>0.089</td>
</tr>
<tr>
<td>Construction/Utilities</td>
<td>0.073</td>
<td>–0.053</td>
<td>0.020</td>
</tr>
<tr>
<td>Services</td>
<td>0.079</td>
<td>–0.004</td>
<td>0.075</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>–0.047</strong></td>
<td><strong>0.231</strong></td>
<td><strong>0.185</strong></td>
</tr>
</tbody>
</table>


Changing structures in the Australian export market

Australia has increasingly become a net exporter of intermediate products and a net importer of final products over the past two decades. This reflects the growing fragmentation of production across borders, as the emerging economies in Asia become major importers of Australian resource commodities that are used as intermediate goods for processing and export.30

At the turn of the millennium, Manufacturing was Australia’s largest export industry (40 per cent in 2000), but that mantle has since been handed to Resources. Measured as a proportion of GDP, manufactured exports have almost halved since 2000, while Resources exports have more than doubled. But as already discussed, these conventional measures tend to undervalue the silent contribution made by other sectors to the Australian export market. Table 2.5 shows the extent of the discrepancy. Services, for example, have consistently contributed around 45 per cent of the domestic value-added content in Australian exports since the beginning of the 2000s. The Services industry was and is Australia’s largest exporter in terms of the export value it creates for the country. Again, it’s worth noting that even though the goods-producing sectors appear to contribute less to the country than conventional statistics imply, they produce the products that allow other sectors to export through them.

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For industry i the difference between Australia and country j, averaged over 43 countries and the rest of the world is:

$$\Delta VAX_{\text{Australia}} = \frac{1}{n} \sum_i \sum_j (\Delta W_{ij} (\bar{v}_{ij} - v_j) + \Delta v_{ij} \bar{w}_{ij})$$

Where $\Delta W_{ij}, \bar{v}_{ij}, \Delta v_{ij}, \bar{w}_{ij}$ are for industry i in Australia and country j.

Kelly, G and La Cava, G (2014) International Trade Costs, Global Supply Chains and Value-Added Trade in Australia, Reserve Bank of Australia
Table 2.5: Gross and value-added Australian exports as a proportion of gross domestic product (GDP) by industry, 2000 and 2014

<table>
<thead>
<tr>
<th>Industry</th>
<th>Gross exports (per cent of GDP)</th>
<th>Value-added exports (per cent of GDP)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resources</td>
<td>3.3</td>
<td>5.0</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>4.8</td>
<td>2.6</td>
</tr>
<tr>
<td>Construction/Utilities</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Services</td>
<td>3.0</td>
<td>2.8</td>
</tr>
<tr>
<td><strong>Total exports</strong></td>
<td><strong>11.2</strong></td>
<td><strong>10.4</strong></td>
</tr>
</tbody>
</table>


Given the magnitude of changes that have occurred in recent years, it may come as a surprise that the VAX ratio for Australia was at the same level in 2014 as it was in 2000. But underneath the surface, almost every industry has reduced its VAX ratio since then. Services is the exception, in part due to the growth in goods exports that rely on its contribution. Had these effects been all that was in play, then Australia’s VAX ratio would have been 0.74 in 2014 rather than its actual value of 0.80. But these effects have been fully offset as the economy moves away from exporting manufactured goods to resources.

Degrees of fragmentation are the outcome of complex interactions between trade costs (like tariffs and compliance requirements), transportation costs and coordination costs associated with offshoring, as well as the possibilities for substitution between the goods and services used in production.31 Because the VAX ratio is related to fragmentation, it’s similarly affected. But where fragmentation measures the number of stages in production, the VAX ratio is calculated using export values in US dollars. Consequently, it is also affected by relative price movements, like the dramatic increase in commodity export prices that occurred over the period. With so many interactions, each industry has its own story.

Broadening the analysis from exports to all domestic production, the following sections delve deeper into some of the recent trends in key industries.

Mining sector production

The Resources industry includes both agricultural and mining sectors, but since the Mining and Quarrying sector (mining sector) accounts for around 90 per cent of exports, it makes sense to focus on developments in this sector. Figure 2.5 shows the share of each industry’s contribution to Mining output in terms of value added.

Figure 2.5: Industry value added to Australian Mining production, 2000 and 2014

Imports and Australian Services in 2014 were responsible for a greater share of the value created within the Mining sector than they were in 2000. Financial Services Activities; Legal and Accounting; Head Offices and Management Consultancy Activities; and Administrative and Support Services were the standout sectors. Their contributions all peaked in 2012, coinciding with the peak of the mining investment boom. These are essential services for businesses wishing to raise capital and expand their operations.

Whereas the increased contribution from Services can be related to structural change in the Mining sector, rising imports are more closely related to price competition from overseas. Around 83 per cent of the overall change in imported value added was due to the changing composition in the industry (the ‘within effect’). In the absence of any changes to their input requirements, the foreign contribution to Australia’s mining output still would have increased by 83 per cent of the amount it did. The remaining 17 per cent of the increase is due to the industry sourcing different goods and services from industries that are inherently more reliant on imports (the ‘between effect’).
There are significant links between the ‘within effect’ and Australia’s increasing terms of trade between 2000 and 2014. This suggests that international price competition may be responsible for the increase. Analysis shows that the link is strongest with currency movements occurring one year earlier.\textsuperscript{32}

**Manufacturing industry production**

A similar analysis for the Manufacturing industry is a more-complicated story because it is a broad industry that describes the production from 19 separate industry sectors. Over time, the final demand for each of these 19 sectors changes, as well as the sectors that supply them and their proportion of foreign value added.

As was the case for the Mining sector, the domestic Manufacturing industry now produces a smaller proportion of the value embodied in its own products than it did in 2000 (Figure 2.6). To be clear, this says nothing about the health of the Manufacturing industry by itself; it simply means that Manufacturing has become more integrated with other sectors domestically and abroad. It is a reflection of increased trade in intermediaries as the production process becomes more specialised. Increasing trade between sectors has the potential to increase the productivity of Australian businesses. Prices fall and production rises, increasing both efficiency and the size of the economy. Businesses decide to outsource their production when they expect that the productivity gains will outweigh the additional supply costs.

**Figure 2.6: Industry value added to Australian Manufacturing production, 2000 and 2014**


\textsuperscript{32} Regression analysis on the ‘within effect’ (holding industry composition constant) suggests that a one per cent change in the Trade Weighted Index leads to a 0.665 per cent increase in the overall level of foreign value added (p=0.012).
Around the time of the Global Financial Crisis (GFC), there was a significant shift in demand for different types of manufactured products, away from durable goods to non-durables. Taking one example, from 2007 onwards, the share of non-durable Food, Beverages and Tobacco Products increased from 37.5 to 42.0 per cent of final demand. In contrast, the share of Motor Vehicles, Trailers and Semi-Trailers (an example of durable goods) fell from 13.5 to 9.5 per cent of Manufacturing output.

Variations in final demand for the goods produced by different Manufacturing sectors (‘between effect’) do not explain the industry’s declining contribution to its own products. Figure 2.7 shows the contributing factors. Primarily responsible was the trend of increased outsourcing within most of the Manufacturing sectors (‘within effect’).

**Figure 2.7: Decomposition of the effects resulting in a reduction in the value-added content of Australian Manufacturing, 2000 to 2014**

While the individual contributions from almost every Manufacturing sector declined, the largest changes were declines in the manufacture of Motor Vehicles, Trailers and Semi-Trailers; and Machinery and Equipment and increases in Other Transport Equipment.33

Declining industry shares, coupled with increased outsourcing, are signs that a sector is struggling to remain competitive relative to its peers. More-competitive sectors, on the other hand, are likely to maintain or increase their industry shares, as they grow faster than the industry as a whole. In either case, the outsourcing of less-productive processes to more-productive specialists improves the sector’s competitiveness compared to what it otherwise would have been.

33 Other Transport Equipment includes shipbuilding, boatbuilding, aircraft manufacturing, railway rolling stock manufacturing, related repair services and other.
Manufacturing is increasingly sourcing a greater proportion of its inputs from overseas. However, unlike Mining, regression analysis does not find any relationship between the level of imports and short-term currency movements, although they do follow a similar long-term trend. China’s accession to the World Trade Organization (WTO) in 2001 is a likely source driving both these trends, but it does not explain why the proportion of imported content seems relatively unaffected by short-term currency fluctuations.

One possible explanation is that the intermediate goods and services embodied in manufactured products are not easily substituted. Manufactured products are often designed around existing ‘off the shelf’ components made by other businesses, or suppliers are contracted to custom-make the components. The costs associated with changing a design, finding new suppliers, and subsequent retooling can be prohibitive. It can also take years to build a trusted customer supplier relationship. Where this is the case, it is reasonable to expect that Manufacturing businesses are relatively unresponsive to short-to-medium-term currency fluctuations. However, a substantial and sustained currency appreciation could make switching to a foreign supplier worthwhile.

**Services industry production**

The Australian Services industry, unlike other industries, increasingly produces the majority of the value embodied in its own products, increasing from 85.4 per cent to 87.6 per cent between 2000 and 2014 (Figure 2.8).

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**Figure 2.8: Industry value added to Australian Services production, 2000 and 2014**

![Diagram showing industry value added to Australian Services production from 2000 to 2014.](source: 2016 World Input-Output Database (2016) Input-Output Tables; Department of Industry, Innovation and Science (2017))
At the industry level it appears that not much has changed, just a slight decline in the share of manufactured and imported content. But there have been changes at the sectoral level. Demand for Real Estate services increased, while Accommodation and Food services became responsible for a greater share of its own production from 2008, as did the Retail Trade sector in 2009. Relative price increases within these sectors no doubt play some role, since the WIOD measures production by value in US dollars. Rising property prices, for example, increase the value of each sale, and this shows up in the data as an increase in final demand. While some of these changes were significant, their effects were mostly offset by changes in other sectors.

Insurance, Reinsurance and Pension Funding, in particular, was affected heavily by the GFC and the European debt crisis. As monetary authorities around the world attempted to reinflate their economies, the return on financial assets declined. A large part of these companies’ earnings are generated from financial investments.

Figure 2.9 shows the aggregate change in Services’ own value added since 2000. Because the Real Estate sector outsources less of its production relative to other sectors, rising demand for this sector resulted in an overall increase of 0.7 percentage points to Services’ own value added (‘between effect’).

The ‘within effect’ added a further 1.5 percentage points due to the increasing contribution from the Retail Trade; Accommodation and Food Services; and Public Administration, Defence and Compulsory Social Security sectors in particular.

Figure 2.9: Decomposition of the effects leading to an increase in the value-added content of Australian Services, 2000 to 2014

There was another change evident in Figure 2.9 — Services reduced its level of imported intermediate inputs by 0.8 per cent from 2000 to 2014. On first inspection this seems counterintuitive, given the terms of trade boom and what has occurred in the Mining and Manufacturing industries. However, this was the result of final demand shifting between service sectors (demand effect) and individual sectors’ changing supply patterns (‘between effect’). Because some sectors rely more heavily on imports than others, the effect was to reduce the overall proportion of imported content by 0.3 and 0.9 percentage points respectively. Within sectors, the change was more consistent with that experienced by other industries. In the absence of any sectoral changes in demand or supply patterns, the proportion of imported value added would have increased by 0.4 percentage points.

Conclusion

The world is now seeing the results of falling trade, transport and other coordination costs through the increased trade in intermediate goods and services. As a result, trade has become more fragmented across borders, as each stage of the global supply chain now produces a smaller share of the final product’s value.

In 2014, the RBA showed that Australian production is still highly fragmented and relatively upstream, partly because of the dominance of the resources industry. Australia’s competitive advantage in resource extraction has led to growth in the share of commodity exports in place of manufactured goods. Industry composition was one of the main reasons why, in 2014, Australian exports had the second highest level of domestic value-added content in the world.

The recent introduction of global input/output tables has allowed for a closer look into the workings of global supply chains. Analysis of the WIOD shows that the advanced economies of North America and the EU are significantly more important sources of Australian export demand than conventional trade statistics suggest. Global trade is also far more complex than many people realise. The Services industry, for example, is responsible for almost half of Australia’s total export value, despite representing just a quarter of gross exports. And it has been this way since at least the turn of the century. Services was, and remains, Australia’s largest exporter in terms of the export value it creates for the country.

The value-added approach allows a peek behind the curtain, exposing the drivers of change and their flow-through effects on industry supply patterns. Investment in buildings and structures, for example, coincided with the Mining sector becoming more reliant on financial and legal services. The associated terms of trade boom was probably behind the growing tendency for mining companies to source more of their inputs from overseas. Manufacturing also tended to increase its international outsourcing, particularly from China. Services, on the other hand, decreased its foreign reliance and increased its own value added. Within service sectors, however, there was a tendency to increase imported value added. But this was more than offset by demand shifts between sectors to those that are less reliant on imports.

The purpose of this chapter has been to highlight the complexity of global supply chains and to provide nuance to future trade debates. And there are some clear implications. Whether it be between countries or sectors of the domestic economy, policies designed to increase trade could benefit from understanding where value is created and where it is consumed as this could improve how businesses respond to global opportunities and risk.
Appendix A
Value-added to gross exports

Table A1 shows the VAX ratio and proportion of Australian gross exports by destination and industry. Reading down the columns shows the VAX ratio between Australian industries and destination regions on the left, and the regional proportions (weight w) of the relevant industry’s gross exports. Similarly, reading across the table gives the VAX ratio at the top of each row and the industry’s proportion of all gross exports going to that region below. The intersection of weights (in bold) is the proportion of all Australian exports going to a region from each industry. Industry and regional totals are the VAX ratios and proportion of all gross exports for that industry or region.

For example, the first entry in Table A1 shows the VAX ratio for Australian Resources destined for North America is 12.03. Resources comprise 4.4 per cent of gross exports to North America and 0.4 per cent of Resources exports are destined for there, while resources exported to North America represent just 0.2 per cent of Australia’s total exports.

The end of the first row shows that the VAX ratio for all Australian exports to North America is 1.69, and 4.3 per cent of Australian exports are destined for the region. Similarly, the totals in the first column show that the VAX ratio for Australian resources exported to the world is 0.65 and that resources comprise 48.3 per cent of all exports. At the intersection of industry and regional totals is the 2014 Australian VAX ratio for all exports to the world. That figure is 0.80, which shows that Australian value-added exports is four-fifths of gross exports.
Table A1: Ratio of Australian value added to gross exports and sector weighting, from industry to export region, 2014

<table>
<thead>
<tr>
<th>Region total</th>
<th>Resources</th>
<th>Manufacturing</th>
<th>Construction/Utilities</th>
<th>Services</th>
<th>Industry Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Region total</td>
<td>VAX</td>
<td>w VAX</td>
<td>VAX VAX w</td>
<td>VAX VAX w</td>
<td>VAX VAX w</td>
</tr>
<tr>
<td>North America</td>
<td>VAX</td>
<td>0.120 0.004</td>
<td>0.050 0.100</td>
<td>0.086 2.19</td>
<td>0.058 1.69</td>
</tr>
<tr>
<td></td>
<td>w</td>
<td>0.044 0.002</td>
<td>0.058 0.025</td>
<td>0.009 0.362</td>
<td>0.000 1.000</td>
</tr>
<tr>
<td>UK</td>
<td>VAX</td>
<td>0.439 0.002</td>
<td>0.044 0.019</td>
<td>0.018 0.118</td>
<td>0.026 1.14</td>
</tr>
<tr>
<td></td>
<td>w</td>
<td>0.061 0.001</td>
<td>0.381 0.005</td>
<td>0.009 0.549</td>
<td>0.000 1.000</td>
</tr>
<tr>
<td>EU</td>
<td>VAX</td>
<td>0.228 0.012</td>
<td>0.072 0.024</td>
<td>0.047 1.94</td>
<td>0.035 1.75</td>
</tr>
<tr>
<td></td>
<td>w</td>
<td>0.027 0.006</td>
<td>0.283 0.006</td>
<td>0.010 0.434</td>
<td>0.000 1.000</td>
</tr>
<tr>
<td>Non-euro EU</td>
<td>VAX</td>
<td>0.142 0.005</td>
<td>0.065 0.006</td>
<td>0.018 0.130</td>
<td>0.016 1.23</td>
</tr>
<tr>
<td></td>
<td>w</td>
<td>0.026 0.002</td>
<td>0.208 0.001</td>
<td>0.009 0.479</td>
<td>0.000 1.000</td>
</tr>
<tr>
<td>Japan</td>
<td>VAX</td>
<td>0.053 0.237</td>
<td>0.039 0.117</td>
<td>0.035 2.09</td>
<td>0.071 0.72</td>
</tr>
<tr>
<td></td>
<td>w</td>
<td>0.070 0.114</td>
<td>0.179 0.029</td>
<td>0.001 0.115</td>
<td>0.019 1.000</td>
</tr>
<tr>
<td>China</td>
<td>VAX</td>
<td>0.056 0.365</td>
<td>0.037 0.190</td>
<td>0.154 1.71</td>
<td>0.170 0.75</td>
</tr>
<tr>
<td></td>
<td>w</td>
<td>0.655 0.176</td>
<td>0.176 0.047</td>
<td>0.003 0.167</td>
<td>0.045 1.000</td>
</tr>
<tr>
<td>S. Korea &amp; Taiwan</td>
<td>VAX</td>
<td>0.035 0.130</td>
<td>0.029 0.082</td>
<td>0.019 1.40</td>
<td>0.047 0.49</td>
</tr>
<tr>
<td></td>
<td>w</td>
<td>0.657 0.063</td>
<td>0.213 0.020</td>
<td>0.001 0.129</td>
<td>0.012 1.000</td>
</tr>
<tr>
<td>Rest of World</td>
<td>VAX</td>
<td>0.076 0.246</td>
<td>0.033 0.462</td>
<td>0.447 1.04</td>
<td>0.577 0.77</td>
</tr>
<tr>
<td></td>
<td>w</td>
<td>0.305 0.118</td>
<td>0.297 0.115</td>
<td>0.005 0.393</td>
<td>0.152 1.000</td>
</tr>
</tbody>
</table>

Looking ahead — observations from METS

*Ric Gros CEO, METS Ignited*

Australia is blessed with mineral wealth and, despite being a young nation, has built a world-leading, competitive mining industry and Mining Equipment, Technologies and Services (METS) and research sector. Australia today is a world-leading exporter of commodities, including iron ore, coal, lithium, gold, zinc and copper.

The commoditised nature of mining has meant that mining companies have a heavy reliance on METS companies for innovation across all aspects of their value chain and on Public Funded Research Organisations for research into new technologies and applications. This relationship has become a source of competitive advantage. This has then been leveraged to produce unique, diverse, customer-focused solutions for mineral exploration, extraction and processing equipment, and engineering services, as well as contract mining, mine software products and other related equipment.

Australian METS firms are competitive across the entire mining supply chain, with notable areas of global excellence; for example, 60 per cent of the world’s mining computer software is developed in Australia.

The METS sector is a success story. In 2015, its overall Gross Value Added (GVA) contribution to Australia totalled $86.2 billion, and it employed 503,000 Australians.

The specialised METS segment, or those products and services that are specific to the mining industry, represented a GVA of $43.3 billion. It also provided 314,000 jobs, and has grown at a rate of 6.5 per cent year-on-year since 2005, delivering over 150,000 new jobs during this period.

GVA from exports to over 200 mining jurisdictions, totalling $3.6 billion, form an important element of the specialised sector exports.

These are impressive numbers, but some sub-segments within the specialised METS Sector are growing at even faster rates. As shown in Figure 2.3, these are averaging 13.5 per cent year-on-year, or 261 per cent over a 10-year window.
Table 2.6: Growth and employment by sub-segment

<table>
<thead>
<tr>
<th>Specialised METS segments</th>
<th>GVA by segment</th>
<th>Jobs</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>GVA 2006</td>
<td>GVA 2015</td>
<td>Growth $ of each</td>
<td>GVA growth %</td>
<td>Jobs 2015</td>
<td>Total new jobs</td>
</tr>
<tr>
<td>Developing segments</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Professional and Tech Services</td>
<td>4.8</td>
<td>2.6</td>
<td>−2.2</td>
<td>2.0</td>
<td>1.0</td>
<td>−1.1</td>
</tr>
<tr>
<td>Tech Equip Manufacturing</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.3</td>
<td>0.4</td>
<td>0.1</td>
</tr>
<tr>
<td>ICT</td>
<td>3.0</td>
<td>2.8</td>
<td>−0.3</td>
<td>3.9</td>
<td>3.7</td>
<td>−0.1</td>
</tr>
<tr>
<td>Other</td>
<td>11.2</td>
<td>10.4</td>
<td>−0.7</td>
<td>8.9</td>
<td>8.4</td>
<td>−0.6</td>
</tr>
<tr>
<td>Total</td>
<td>6.9</td>
<td>18.0</td>
<td>11.1</td>
<td>260.9</td>
<td>152,000</td>
<td>94,304</td>
</tr>
<tr>
<td>Other segments</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Construction</td>
<td>5.2</td>
<td>8.1</td>
<td>2.9</td>
<td>155.8</td>
<td>44,000</td>
<td>15,753</td>
</tr>
<tr>
<td>Contract Mining</td>
<td>3.4</td>
<td>5.5</td>
<td>2.1</td>
<td>161.8</td>
<td>36,000</td>
<td>13,745</td>
</tr>
<tr>
<td>Wholesale Trade</td>
<td>2.1</td>
<td>3.6</td>
<td>1.5</td>
<td>171.4</td>
<td>23,000</td>
<td>9,583</td>
</tr>
<tr>
<td>Transport Services</td>
<td>3.0</td>
<td>4.4</td>
<td>1.4</td>
<td>146.7</td>
<td>28,000</td>
<td>8,909</td>
</tr>
<tr>
<td>Basic Equip Man</td>
<td>2.6</td>
<td>3.6</td>
<td>1.0</td>
<td>138.5</td>
<td>31,000</td>
<td>8,611</td>
</tr>
<tr>
<td>Total</td>
<td>16.3</td>
<td>25.2</td>
<td>8.9</td>
<td>154.6</td>
<td>162,000</td>
<td>56,602</td>
</tr>
<tr>
<td>Total Specialised METS</td>
<td>23.2</td>
<td>43.2</td>
<td>20.0</td>
<td>186.2</td>
<td>314,000</td>
<td>150,906</td>
</tr>
</tbody>
</table>

Source: METS Ignited

These ‘faster-developing’ segments have increased GVA by some $11.1 billion and have added an additional 94,000 jobs to the economy. These segments and are represented by the following areas:

- **Professional & Technical Services**
  - surveying and mapping
  - engineering design and consulting
  - scientific testing and analysis
  - scientific research
  - technical and vocational education and training
  - other specialised design

- **Technical Equipment and Technical Services**
  - scientific equipment
  - sophisticated mineral processing capabilities
  - other specialised machine tools

- **ICT (Information and Communication Technologies)**

- **Other Services**
  - advanced water purifications
  - desalination
  - precision electronic equipment.
As the mining industry evolved, the demand for research grew. Australia today has a world-class mining research capability represented by: CSIRO, Data 61, Mining3, CRC Optimising Resource Extraction, Deep Exploration Technologies CRC and universities with mining-related faculties — University of Queensland, Queensland University of Technology, University of New South Wales, University of Technology Sydney, RMIT, University of Western Australia, Curtin, Newcastle University, Federation University, University of South Australia, and University of Wollongong. These are complemented by facilitative institutions like Australian Mineral Industries Research Association Limited, Australian Coal Association Research Program, Australian Research Council and Minerals Research Institute of Western Australia, while accounting for only 3.7 per cent of the world’s publications, delivers 6.9 per cent of the world’s one per cent most-highly cited publications. Australia’s research capability is world-class across all sectors, not just the resources industry.

Despite the success of the Australian METS industry to date and the strength of its research capability, a range of key challenges and ecosystem trends are threatening its ability to compete.

- In 2015, Australia ranked 10th for innovation input but 24th for innovation output, and 72nd (out of 141 countries) for innovation efficiency, or the ability to translate inputs into outputs.
- Australia is ranked poorly (33rd and declining) on collaboration — a critical innovation measure.
- This poor track record for commercialising its innovations seems to be correlated with a comparatively low level of collaboration through the innovation process. This results in a lack of alignment between problems and solutions, reflecting the relationships between METS, the mining and research sectors, which are often characterised as transactional rather than strategic. Consequently, it leaves much value “on the table”.
- The Australian capital markets lack depth — especially in early-stage and long-term capital — which, combined with weak management skills with the sector, limits growth in business scale.
- Despite the number of major Australian mining houses and world-class R&D infrastructure, few Australian METS have emerged as major global Original Equipment Manufacturers, inhibiting access to global supply chains of the T1 miners.
- There is competition from new and emerging markets such as China and India.

The emerging opportunities and megatrends

VCI, a specialist consulting company, recently postulated:

“In 2036, all mining equipment will be autonomous and controlled as part of an integrated value chain system, which will be optimised using artificial intelligence on a market pull basis, creating highly responsive production systems. Integration with preferred customers and suppliers will become seamless. Maintenance that isn’t automated will be undertaken by staff assisted by augmented reality technology. Robots and drones will be cheap and ubiquitous and will carry out ad hoc physical tasks with zero risk to people.”
VCI also identified the following megatrends impacting the world of mining over the next 20 years:

- The global demand for minerals will be driven by rising middle class in India and China.
- There will be fewer high-quality near-surface ore bodies, requiring deeper underground and underwater mines.
- Business models will be challenged by globalisation and technological advances.
- There will be increasing societal expectations focusing on sustainable practices and information transparency.
- The Internet of Things and increasing computing power will facilitate automation and data analytics, driving productivity, increasing safety, shifting employment profiles and demanding integrated systems and interoperability.
- Technology advances will change extraction methods and economics and will impact on demand for specialty industrial minerals and rare earths.
- Global green energy, including battery storage and smart distribution grids, will impact demand on traditional fossil fuels like coal.

**A successful transition**

The face of mining in 2026 will be significantly different to 2016, transforming the world of METS, the role of research and how they interact with one another and the global mining industry.

Success will depend on:

- METS, mining and research industries collaborating more effectively and earlier in the innovation process, with access to Living Labs to able to accelerate ideation, design, prototyping and testing.
- METS, and specifically SMEs, clustering to achieve scale, accelerate innovation and to optimise value-chain opportunities.
- METS aligning their focus to the strategies and roadmaps of mining companies.
- Increasing the capital market’s level of investment in the METS sector.
- Well-aligned industry development initiatives across government, research, METS and miners.

Industry 4.0 will facilitate a revolution of innovation across the globe. Australian METS companies are well-placed to play a dominant role in the mining industry of the future and potentially growing a significant share of a world market. However, it will require innovation in its business models and technologies and, more importantly, in behaviours and relationships and the way in which we collaborate and align across the whole ecosystem, from government to research, METS, capital markets, and miners.