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Access Economics

Mining and METS: engines of economic growth and prosperity for Australians

Report prepared for the Minerals Council of Australia, 2017

Contents

Glossary

ABS	Australian Bureau of Statistics
ANZSIC	Australian and New Zealand Standard Industrial Classification
DAE	Deloitte Access Economics
DIDO	Drive-in drive-out
FIFO	Fly-in fly-out
FIRB	Foreign Investment Review Board
FTE	Full-Time Equivalent
GDP	Gross Domestic Product
IO	Input-Output
IOIG	Input-Output Industry Group
MCA	Minerals Council of Australia
METS	Mining Equipment, Technology and Services
NEM	National Electricity Market
OECD	Organisation for Economic Co-operation and Development
PC	Productivity Commission
R&D	Research and Development
RBA	Reserve Bank of Australia
RCEP	Regional Comprehensive Economic Partnership
SOL	Skilled Occupations List

Executive summary

The mining sector has long made – and continues to make – a significant contribution to Australia's economic growth and development. The Australian mining industry uses sophisticated production techniques and highly skilled labour to make the most of Australia's comparative advantage in mineral endowments. The supporting activities of the mining equipment, technology and services (METS) sector add further to Australia's national income and employment.

The Australian economy continues to enjoy the fruits of the latest mining boom that began in 2003. A sharp increase in commodity prices was followed by unprecedented investment in new mines, equipment and infrastructure – at its peak in 2012, resources investment accounted for 60% of total investment in Australia (including investment in both the mining and oil and gas sectors). This growth in mining capacity underpins the current production phase of the mining boom, in which rising export volumes support a range of manufacturing and service activities across Australia. Minerals and energy exports are the primary source of Australia's export earnings, accounting for 64% of merchandise exports by value in 2015-16 (DIIS, 2016).

This report estimates the total economic contribution of the mining and METS sector to Australia's gross domestic product (GDP) by using an input-output modelling framework in order to capture all mining and METS activities. This economic analysis applies a similar approach to the methodology used in the RBA's 2013 Research Discussion Paper *Industry Dimensions of the Resource Boom: An Input-Output Analysis*. Overall, Deloitte Access Economics estimates that the direct economic contribution of mining and METS activities was $133.2 billion in value added in 2015-16, with 484,114 full-time equivalent (FTE) jobs directly supported by the sector.[1] This figure represents the 'economic footprint' attributable directly to the mining and METS sector in the Australian economy.

In addition to this direct economic contribution, the mining and METS sector depends on outputs from other industries in the Australian economy, such as petroleum, electricity and manufacturing, as inputs to production. This indirectly generates economic activity by facilitating production and paying wages and profits in these other industries. This indirect economic contribution added a further $103.6 billion in 2015-16, supporting another 655,654 FTE jobs.

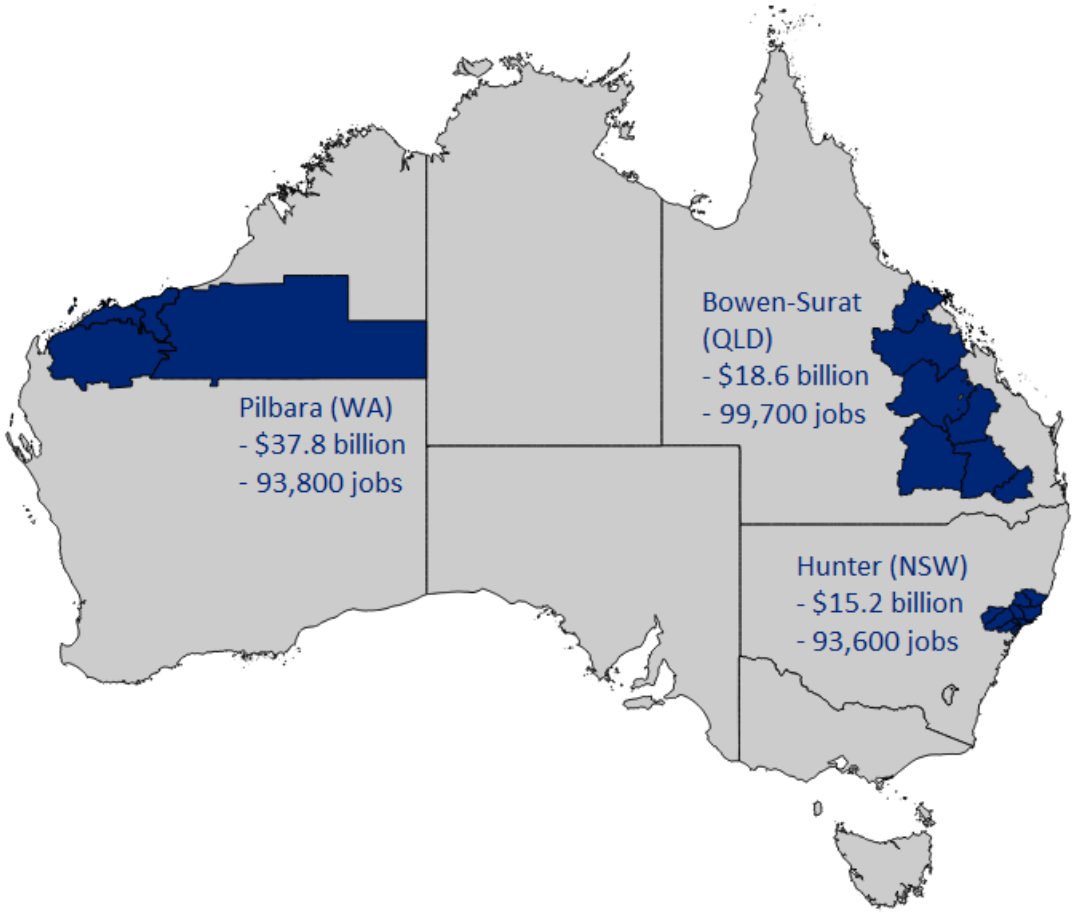
The total economic contribution of Australia's mining and METS sector in 2015-16 was $236.8 billion, representing around 15% of the Australian economy. This economic activity supported a total of 1,139,768 FTE jobs across Australia, which represents around 10% of total FTE employment.

While this economic activity is distributed across Australia, there are a number of regional areas where mining and METS activities make a particularly significant economic contribution (Figure i), much higher than the national average. In 2015-16, these included:

- The Pilbara region (WA), with a total economic contribution from mining and METS of $37.8 billion, which represented around 88% of total regional economic activity;
- The Bowen-Surat region (QLD), with a total economic contribution from mining and METS of $18.6 billion, which represented around 63% of total regional economic activity; and
- The Hunter region (NSW), with a total economic contribution from mining and METS of $15.2 billion, which represented around 34% of total regional economic activity.

[1] The value added by an industry is the value of its output, less the value of intermediate inputs used to produce this output (as these represent outputs of other industries). It is important to note that GDP adds up value added by industry, not the value of industry output or sales. Accordingly, the economic contribution of an industry must be distinguished from its total revenue and total exports, which do not discount inputs supplied by other industries or economies.

Figure i: Regional contribution – value added and full-time equivalent jobs, 2015-16*



* Some of the mining and METS jobs that have been created in these regions are fly-in fly-out (FIFO) or drive-in drive-out (DIDO) positions.
Source: Deloitte Access Economics (2017)

Australian mining and METS companies compete in fiercely contested international markets and cannot pass on higher domestic costs to offshore customers. Consequently, innovation and technological improvements play an important role in ensuring that mining and METS companies are able to operate productively and remain globally competitive. Innovative applications of new technologies have been a significant driver of growth in the Australian mining and METS sector over the most recent mining boom.

The benefits of innovation can range from broad strategic improvements through to enhancing individual worker's tasks. This report includes case studies of innovative applications of technology across 10 mining and METS companies in Australia. The productivity benefits of innovation highlighted in these case studies include:

- **Reduced operating costs** reflecting efficiency gains from using new technologies;
- **Extending the productive life of mines, such as by enabling the extraction of deposits** that are deeper or more remote;
- **Higher yields, such as increased metal recovery from ores;**
- **Safety improvements** flowing from simplified processes and earlier detection of hazards;
- **Higher workforce satisfaction and productivity** in translating innovative ideas suggested by employees into operational improvements;
- **Applying knowledge from research institutions** to implement new or improved processes and products; and
- **Brand development** and generating new opportunities by enabling access to new markets overseas.

Australia's comparative advantage in mining and METS not only hinges on innovation in driving productivity growth but also on policies that strengthen competition, support the accumulation of skills and capital, and enable firms to respond flexibly to changing market conditions. By increasing competition in markets for products, finance, energy, infrastructure and labour, previous governments facilitated the current mining boom and allowed its benefits to spread and endure. More recently, however, the pace of reform has slowed; and in some cases past reforms have been eroded by policies and regulations that impede national competitiveness and productivity.

In looking to sustain the economic contribution of Australia's mining and METS sector into the future, policymakers need to ensure that the economic environment remains open and flexible. Policy considerations likely to be relevant include:

- **Competitive and fair taxation system** – ensuring that Australia's corporate taxation rate and other mining-related taxes are stable and competitive relative to other economies, and upholding good economic principles in setting taxation policy, for example, in respect of taxing business inputs;
- **Flexible workplaces** – ensuring that Australia has an industrial relations framework that is both equitable and productive by addressing deficiencies in the *Fair Work Act 2009* and considering more flexible approaches to workplace relations, as well as ensuring that appropriate skilled migration settings are maintained;
- **Openness to foreign investment** – greater clarity and consistency in Foreign Investment Review Board decisions, and ensuring that Australia continues to engage with the broader region through bilateral and multilateral agreements;
- **Affordable and reliable energy** – as the mining and METS sector is a significant energy user, it is essential that firms in this sector have access to reliable and affordable power;
- **Efficient approaches to regulation** – simplifying or streamlining government regulations such as environmental approvals in order to improve certainty and consistency; and
- **Support for collaboration and entrepreneurship** – continued support for bodies that enhance collaboration between the mining and METS sector and research organisations.

The risks of inaction in these areas are significant. Supportive and flexible policy settings helped to establish the most recent mining boom; yet there is now the potential for adverse policy settings to compromise a major source of Australia's national prosperity and future economic growth. It is critical that governments pay heed to these key policy areas and initiate reforms where improvement is required, so that mining and METS continue to innovate and grow, helping to secure Australia's future prosperity.

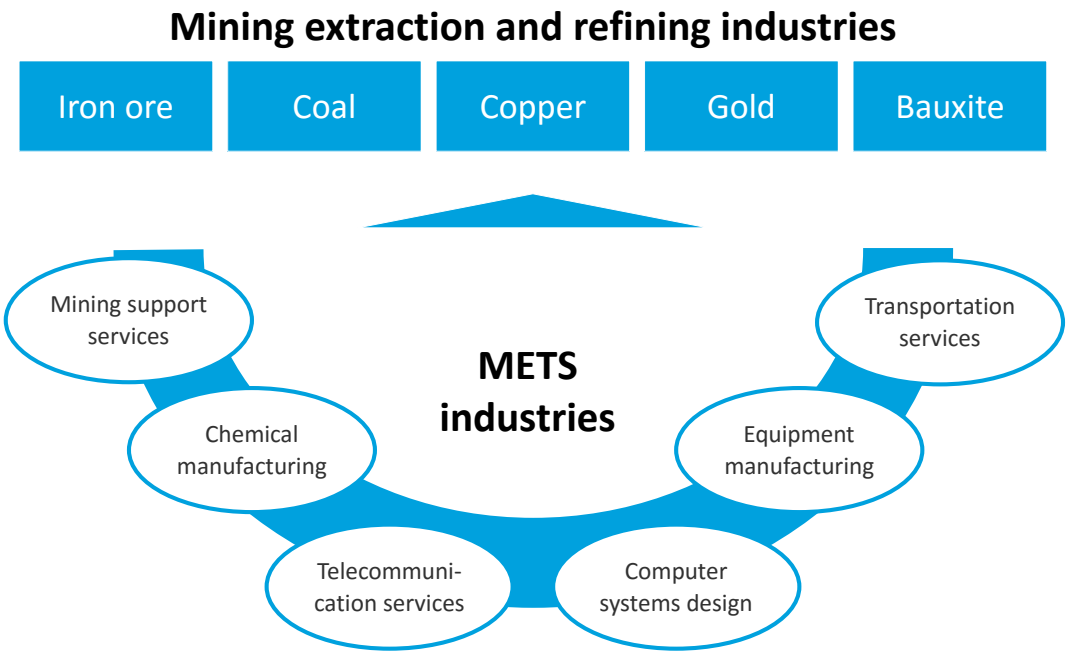
1 Mining and METS in Australia

The mining and METS sector comprises a diverse range of economic activity across all States and Territories in Australia. Since at least the 1850s, mining has played a significant role in shaping the country and, more recently, mining has been a major driver of economic growth.

This chapter provides an overview of mining and METS in Australia and summarises how the most recent mining boom has developed and matured.

Australia's mining sector has historically played an important role in shaping the national economy and society. The mining extraction and refining industries themselves – as well as the various industries that supply mining equipment, technology and services (METS) – continue to make a significant contribution to the Australian economy as a source of income and a driver of rising living standards.

Figure 1.1: Examples of mining and METS industries*



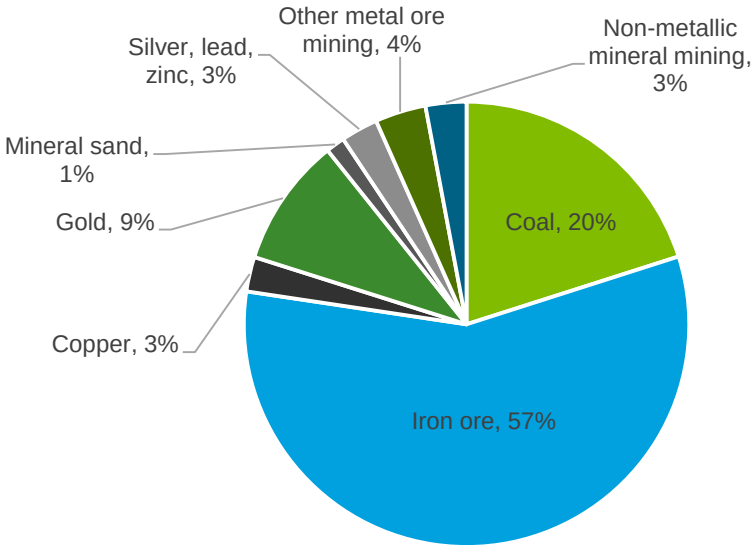
* A detailed description of industries included and excluded in the definitions of mining and METS for the purposes of this report is provided below in Section 2.1.1.

Source: Deloitte Access Economics (2017)

The size and scale of mining and METS in Australia owe much to the unique geology of the Australian landscape. The country is extremely rich in natural mineral resources. For example, Australia has the world's largest economically demonstrated reserves of iron ore and gold, second largest reserves of bauxite and copper, and the fifth largest reserves of black coal (Geoscience Australia 2016). These significant natural endowments form the basis of Australia's comparative advantage in mining production, which is realised by innovative and competitive firms and (ideally) supported by sound policies and efficient regulatory practices.

The Australian economy is a world leader in the production of a number of minerals, including iron ore, bauxite, gold, lead, zinc and coal. As illustrated in Chart 1.2, iron ore production represents over half of the resources extraction component of the sector in value-added terms.

Chart 1.2: Composition of Australia's mining industry value added, 2014-15



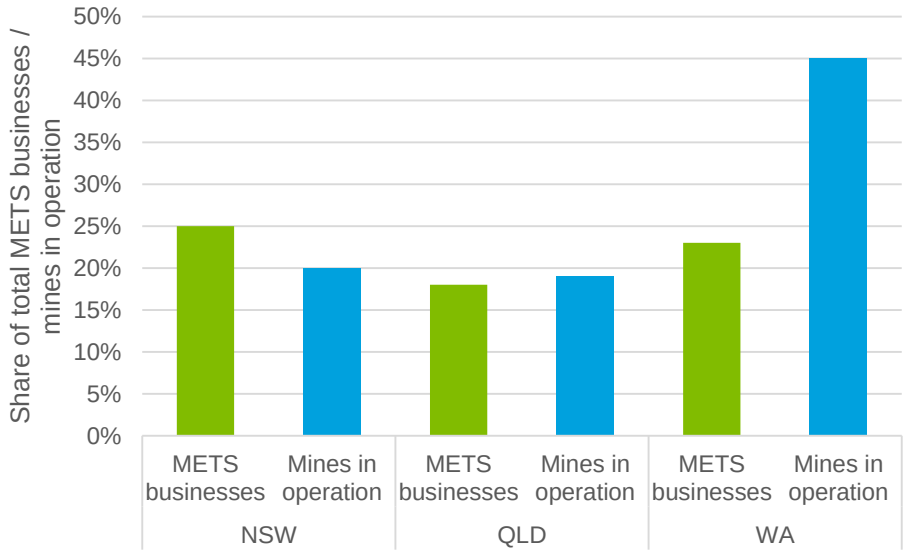
Source: ABS cat. 8415.0 *Mining Operations, Australia* (2016)

A number of key features of the mining and METS sector in Australia are discussed below.

Mining and METS businesses operate across Australia

Australia has a rich and diverse natural endowment of minerals, which are located across the country. Correspondingly, mining and METS businesses also operate in various states and territories across Australia. In particular, 77% of total mines in operation and 66% of METS businesses are located in New South Wales, Queensland and Western Australia (Chart 1.3).

Chart 1.3: Share of mines in operation and METS businesses in selected states



Source: Geoscience Australia (2015), Austmine (2013)

While a large share of mining activity is conducted at or within close geographic proximity of mine sites in regional areas, the mining and METS sector also has a strong presence in metropolitan centres across Australia. The head offices of mining companies are typically located in capital cities (such as Melbourne), and

their operations include corporate functions such as management, finance, marketing and legal. In addition, METS businesses tend to be located in metropolitan areas, which facilitates their ability to supply goods and services to non-mining markets where their products and skills may be transferable, such as infrastructure, defence and renewable energy.

Exporting to overseas markets is a significant part of mining and METS activity

A key feature of the Australian mining sector is its export-intensive nature. In 1969, the minerals and fuels industry comprised only 17% of Australian exports and was dwarfed by agriculture (Anderson 2014). There has been substantial growth since then - minerals and energy exports accounted for 64% of Australia's merchandise exports by value in 2015-16 (DIIS 2016). The increasing importance of the sector has been driven by the rising demand for resources in Asia due to continued economic development and the advance of urbanisation.

Exports are also a key component of the METS industry, with over half of all businesses operating in the METS sector exporting products, services or technology to mines around the world (Department of Industry 2016). A 2015 survey of METS companies in Australia found that the top export market for the sector was Indonesia, with other important overseas markets including New Zealand, the United States, Chile, Papua New Guinea and the Philippines (Austmine 2015). The survey also found that the number of METS companies exporting to overseas markets has increased over recent years, rising by 11 per cent since the previous survey conducted in 2013. The Australian METS sector's global success in export markets has been, in large part, enabled by the experience and established expertise of METS companies developed over time by engagement with domestic mining operations.

The capital intensity of mining operations is high but varies for METS companies

Most mining operations require significant upfront capital investment in machinery and equipment. By contrast, the capital intensity of METS activity varies depending on the products and services offered.

For example, METS businesses that provide mining support services such as exploration, as well as manufacturers of heavy mining equipment and instruments, require significant capital investment, while the capital intensity associated with professional services such as consulting, legal and accounting services is generally lower.

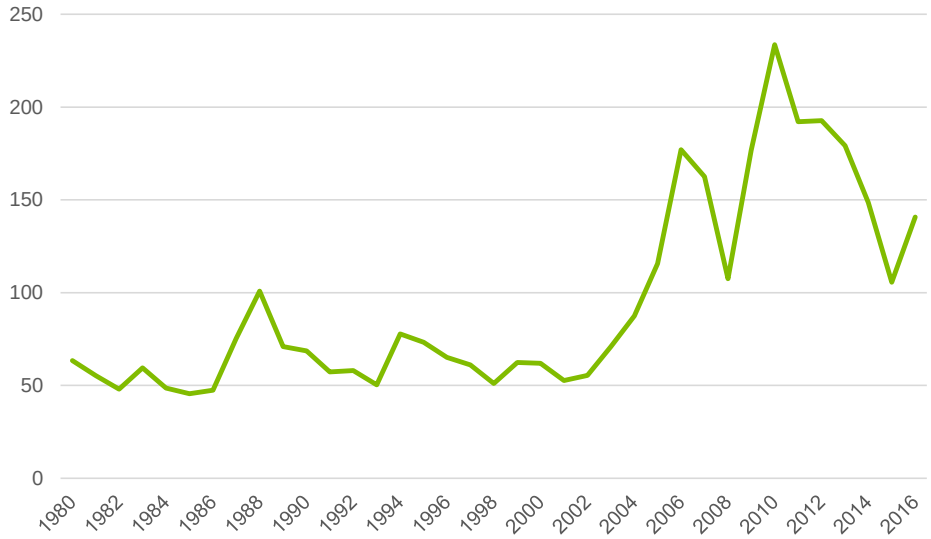
There has been a boom in mining and METS activity over recent years

Over the past decade, the Australian mining industry has experienced one of the largest and longest mining booms in history. The boom can be divided into three stages:

- **Price increase phase**, in which the prices for resources such as coal and iron ore increased rapidly during the 2000s, resulting in a sharp rise in Australia's terms of trade;
- **Investment phase**, in which Australian mining companies made additional capital investments in mining projects to expand their productive capacity; and
- **Production phase**, when the additional capacity from the investment boom becomes operational, resulting in an increased volume of minerals being extracted and exported.

Chart 1.4 illustrates the *rapid increase in commodity prices* observed throughout the 2000s. This sharp rise was driven by growth in global demand for resources, particularly from China in the context of the significant construction booms and rapid urbanisation experienced in major cities across that country. This in turn raised Chinese demand for commodities, outstripping increases in supply and significantly boosting world commodity prices.

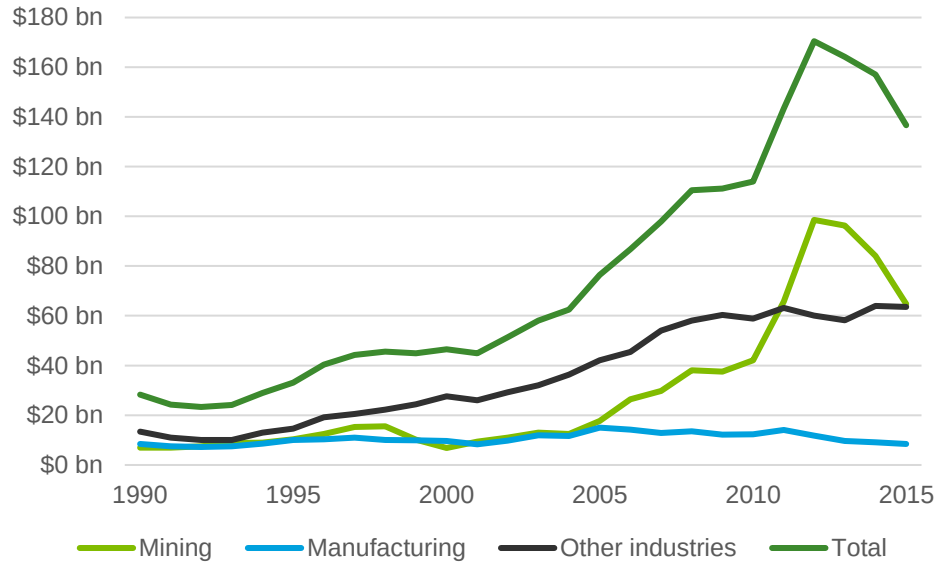
Chart 1.4: Price movements in metals commodities*



* Data presented is the IMF's metals price index which includes the prices of copper, aluminium, iron ore, tin, nickel, zinc, lead and uranium, with a reference year of 2005 = 100.
Source: IMF (2017).

Given the long-term nature of investment decisions and the high capital intensity of mining projects, it can take some time for companies to respond to increased demand and prices with an increase in production. Increased productive capacity is created through *net positive investment in real capital goods*, which in the most recent Australian mining boom occurred over the decade to the early 2010s, as can be seen in Chart 1.5. At the peak of the investment boom in 2012, resources investment (including oil and gas) represented 58% of total investment in the Australian economy.[2]

Chart 1.5: Investment by industry type



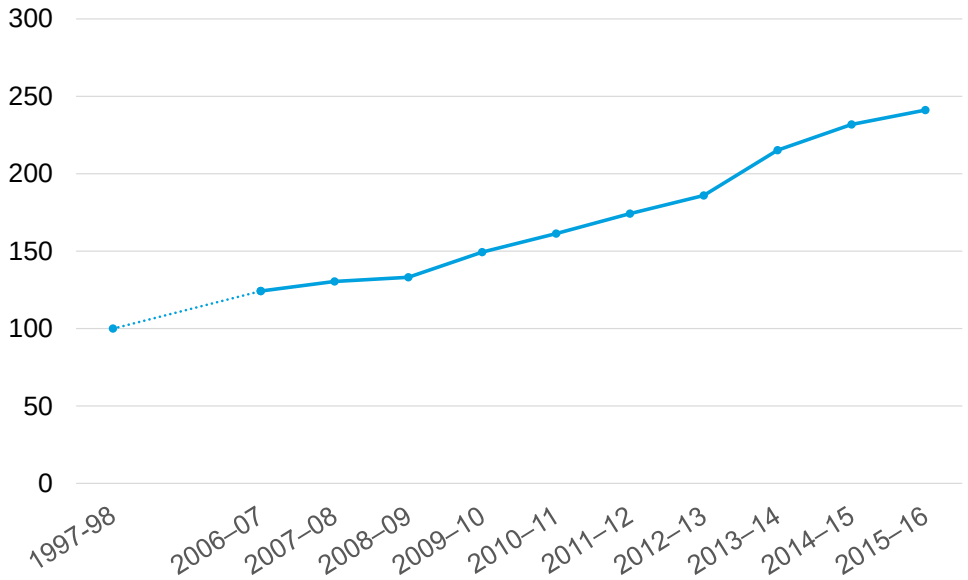
Source: ABS cat. 5625.0 *Private New Capital Expenditure and Expected Expenditure, Australia* (2016)

[2] Note that this figure includes investment in both the minerals sector and the oil and gas sector, the latter of which is not included in the economic analysis presented throughout this report.

Having passed through the price and investment phases, the mining boom has now entered the production phase, in which previous investments in new mining projects are now operational, thereby increasing the capacity of the industry to extract and export a larger volume of resources (Chart 1.6).

However, this period has coincided with a decline in commodity prices over recent years (see figure 1.4 above), and so mining companies have sought cost reductions and productivity improvements in order to maintain profitability (or positive cash flow). The Productivity Commission (2016) recently reported that the mining sector has made efficient use of the large capital stock built up during the boom, with output growth of 7.6% over the 2014-15 financial year and growth in inputs of only 2.1%.

Chart 1.6: Annual volume of mine production indexes (metals and other minerals)



* Data series from the Department is only available from 2006-07; the index has been calculated with a reference year of 1997-98 = 100.
Source: Department of Industry, Innovation and Science *Resources and Energy Quarterly* (2016)

Overall, the most recent mining boom has had a long-term positive impact on the broader Australian economy. A Reserve Bank of Australia research discussion paper (Downes, Hanslow and Tulip 2014) estimates that the boom:

- Resulted in a permanent increase in living standards, measured by real household disposable income per capita, of around 13% in 2013. Approximately half of this increase (6%) is the result of increases in relative prices (that is, a 'purchasing power' effect), while the other half (6%) is the result of increased volume of output.
- Lowered the unemployment rate by around 1.25 percentage points in 2013, from an unemployment rate of around 6.6% without the mining boom to around 5.3% with the boom.

The RBA also highlighted that industries outside the mining sector have benefited indirectly from aspects of the mining boom; for example, Australian manufacturing has benefited from the higher demand for equipment needed to support the higher levels of mining activity.

2 The economic significance of mining and METS

The mining and METS sector has made a significant contribution to driving growth in Australian living standards, particularly over the course of the most recent boom. Australia's significant natural endowments form the basis of the nation's comparative advantage in mining production, which is realised by innovative and competitive firms and (ideally) supported by sound policies and efficient regulatory practices (discussed in Chapter 3). Because Australia is a small open economy, its comparative advantage in minerals and energy exports makes the mining and METS sector an important driver of broader economic growth.

In this chapter, we examine the critical role played by the mining and METS sector in the Australian economy:

- First, we quantify the contribution of the sector using economic modelling, in order to capture the full economic footprint resulting from production in the mining and METS sector in 2015-16 – both nationally and in regions of significant mining and METS activity.
- Second, we highlight the importance of innovation in driving economic growth and competitive advantage, and present case studies that illustrate the benefits of new technologies in the mining and METS sector.

We estimate that in 2015-16, the mining and METS sector's total economic contribution to Australia was $236.8 billion, representing around 15% of the Australian economy. This economic activity supported a total of 1,139,768 FTE jobs across Australia, which represents around 10% of total FTE employment.

2.1 Contribution to the Australian economy

2.1.1 Modelling framework

An economic contribution study estimates the impact of an industry (or firm) on the economy, both directly though the operations of the industry itself, and indirectly as the impact of its activities filter through the broader Australian economy. More specifically, our economic contribution analysis includes estimates of:

- the **direct contribution** of the mining and METS sector – calculated using the income approach to Gross Domestic Product (GDP) as the returns to labour in the form of wages and salaries, and the returns to capital in the form of gross operating surplus from the sector's activities; and
- the **indirect contribution** or flow-on impacts of the sector – generated by the industry-specific inputs required to support activity in the mining and METS sector, which considers demand for upstream inputs and further interlinkages with other sectors of the Australian economy.

The economic contribution of the mining and METS sector is estimated using Input-Output (IO) modelling. Our overall approach to economic contribution modelling is consistent with the framework used by the Australian Bureau of Statistics (ABS) in compiling the Australian National Accounts. A general discussion of the use of input-output tables in economic contribution modelling, including interpreting the results, is provided in Appendix A.

Our modelling framework also follows on from the methodology applied in the RBA's 2013 Research Discussion Paper *Industry Dimensions of the Resource Boom: And Input-Output Analysis* (Rayner and Bishop, 2013).

In this research paper, input-output tables are used to identify industries in the "resource economy", which comprises resource extraction (including resource-specific manufacturing e.g. refining activities) and other resource-related activity (e.g. constructing mines, related transportation, engineering services). This approach meant that the economic contribution of the overall resource sector could be more accurately captured, with the paper highlighting that the ABS's definition of the "mining industry" corresponds only to the resource

extraction component of the "resource economy", less resource-specific manufacturing. We therefore take a similar approach in our modelling framework to ensure that the economic analysis provides a suitable representation of the contribution of mining and METS activity in Australia.

Defining the mining and METS sector

In order to model the economic contribution of mining and METS, industries relevant to the sector within the ABS's standard Input-Output Industry Group (IOIG) classifications need to be identified.

The mining sector has been defined to capture the activities of mining companies operating in Australia. This includes minerals extraction industries (i.e. excludes oil and gas), exploration activities and metal processing to a primary product (i.e. in refined metal form).

The Australian mining sector is therefore defined to comprise the IOIGs listed below in Table 2.1, noting that in some cases only a portion of the relevant IOIG has been included in the definition.

Table 2.1: Industries comprising the "mining sector"

Code	Input-Output Industry Group	Inclusions
601	Coal Mining	All
801	Iron Ore Mining	All
802	Non Ferrous Metal Ore Mining	All
901	Non Metallic Mineral Mining	All
1001	Exploration and Mining Support Services	Exploration only
2101	Iron and Steel Manufacturing	Iron Smelting and Steel Manufacturing only
2102	Basic Non-Ferrous Metal Manufacturing	Alumina Production; Aluminium Smelting; Copper, Silver, Lead and Zing Smelting and Refining; Other Basic Non-Ferrous Metal Manufacturing only

Source: Deloitte Access Economics (2017)

Defining the Australian METS sector is a more complex task, as there is no widely agreed or accepted definition of what activities are included in "METS", and the breadth of industries that supply specialised inputs to the mining sector is wide.[3] This means that the scope of the METS sector is somewhat ambiguous, particularly in the context of applying standard ABS industry definitions.

Consequently, a number of steps were taken to isolate the METS sector as part of the economic contribution modelling process, starting with a principles-based approach to identifying industries that are heavily focused on supplying the mining industry.

The mining equipment, technology and services (METS) sector comprises companies that are heavily focused on supplying the mining industry. They provide goods and services that are innovative, technologically advanced or distinctive in their use by the mining industry.

[3] Indeed, previous studies on METS and mining-related economic activity have typically used different methods for defining the sector, including in Austmine's 2013 report *Australia's New Driver for Growth: Mining Equipment, Technology and Services*; a 2014 Research Discussion Paper published by the RBA on *The Effect of the Mining Boom on the Australian Economy*; and a Lateral Economics (n.d.) report on the gross value added of the METS sector.

In this context:
- Mining equipment includes manufactured items (plant, machinery, equipment) that contribute to the capital stock of the mining industry; parts for machinery and equipment; industry-specific supplies such as chemicals and explosives (i.e. excluding multi-purpose generic supplies such as food, fuel and furniture); and construction and civil engineering.
- Mining technology includes engineering design; information and communications technology (such as data analytics, real-time monitoring and sensors); and scientific research into geoscience, mine engineering, mineral processing or other mining industries.
- Mining services include applied sciences such as laboratory work, environmental sciences, geospatial data processing; equipment maintenance and repairs; specialised mining consulting; and transportation.

In order to provide a quantitative foundation for identifying relevant METS sector industries, we examined the IOIGs that are key suppliers of inputs to the mining sector in the Pilbara, Bowen-Surat and Hunter regions – that is, in areas across Australia where there is significant mining activity – as well as industries whose output at a national level is heavily focused on supporting the mining sector.

Aligning the above principles with the industries that are key regional and national suppliers to the mining sector enabled us to determine the IOIGs that could be specialised enough in their mining-related activities to be classified as METS (e.g. machinery and equipment manufacturing, civil engineering construction, road and rail transport). It also allowed us to identify and exclude from the METS definition those industries that represent more 'generic supplying' industries, whose inputs to the mining sector are also broadly relevant to other sectors (e.g. petroleum, finance, accommodation).

These industries have been excluded from the modelling definition in order to take a relatively conservative approach to quantifying the economic contribution of the mining and METS sector. However, it is important to note that these 'generic supplying' industries – which also include areas such as electricity generation, clothing manufacturing, food and beverage services, and construction services – also make a significant contribution to one or more of the key mining regions in Australia.

IOIGs that support economic activity in the mining sector are listed below in Table 2.2.

Table 2.2: Industries partially classified as the "METS sector"

Code	Input-Output Industry Group
1001	Exploration and Mining Support Services – *Mining Support Services component only*
1803	Basic Chemical Manufacturing
1902	Natural Rubber Product Manufacturing
2303	Railway Rolling Stock Manufacturing
2401	Professional, Scientific, Computer and Electronic Equipment Manufacturing
2403	Electrical Equipment Manufacturing
2405	Specialised and other Machinery and Equipment Manufacturing
2801	Water Supply, Sewerage and Drainage Services
2901	Waste Collection, Treatment and Disposal Services
3101	Heavy and Civil Engineering Construction
4601	Road Transport
4701	Rail Transport
4801	Water, Pipeline and Other Transport
4901	Air and Space Transport
5201	Transport Support services and storage

Code	Input-Output Industry Group
5701	Internet Service Providers, Internet Publishing and Broadcasting, Websearch Portals and Data Processing
5801	Telecommunication Services
6001	Library and Other Information Services
6601	Rental and Hiring Services (except Real Estate)
6901	Professional, Scientific and Technical Services
7001	Computer Systems Design and Related Services
8110	Technical, Vocational and Tertiary Education Services (incl undergraduate and postgraduate)
9401	Automotive Repair and Maintenance
9402	Other Repair and Maintenance

Source: Deloitte Access Economics (2017)

However, not all economic activity within these industries can be considered to support the mining sector. We therefore define the METS sector as comprising specified portions of each of these IOIGs. The split between the METs component and the non-METS component in each industry was determined based on the proportion of each industry's total supply to the mining IOIGs listed in Table 2.1.

The mining industries and the identified METS components of the METS industries were then aggregated to form a combined "mining and METS sector" within a new IO table. This new table is then used to estimate the direct and indirect contributions of the overall mining and METS sector to the Australian economy.

2.1.2 National economic contribution

The *direct* economic contribution of the mining and METS sector is represented by the sector's total value added. In economic terms, value added measures the value of output (i.e. goods and services) generated by the mining and METS sector's factors of production (i.e. labour and capital) as measured by the income earned by these factors of production – that is, the returns to labour (wages) and capital (profit).

Value added is therefore a smaller figure than the sector's revenue, as it does not account for the cost of purchasing inputs from other firms – these are measured as part of the sector's *indirect* economic contribution. In economic terms, this indirect contribution is a measure of the demand for goods and services produced in other sectors as a result of demand generated by the mining and METS sector itself; that is, it represents the sector's flow-on impacts to other parts of the economy through its use of intermediate inputs.

Deloitte Access Economics estimates that in 2015-16 the mining and METS sector directly contributed $133.2 billion in value added to the Australian economy and supported 484,114 full-time equivalent (FTE) jobs (see Table 2.3 below). The indirect economic contribution is estimated to be $103.6 billion, supporting an additional 655,654 FTE jobs.

The average dollar of revenue from the mining and METS sector contributes $0.48 and $0.37 in direct and indirect value added, respectively, to the Australian economy.

Table 2.3: Economic contribution of mining and METS sector in Australia, 2015-16

	Direct contribution	Indirect contribution	Total contribution
Value added ($m)	133,244	103,552	236,797
Value added / revenue ($)	0.482	0.37	0.857
Employment (FTE)	484,114	655,654	1,139,768

Source: Deloitte Access Economics (2017)

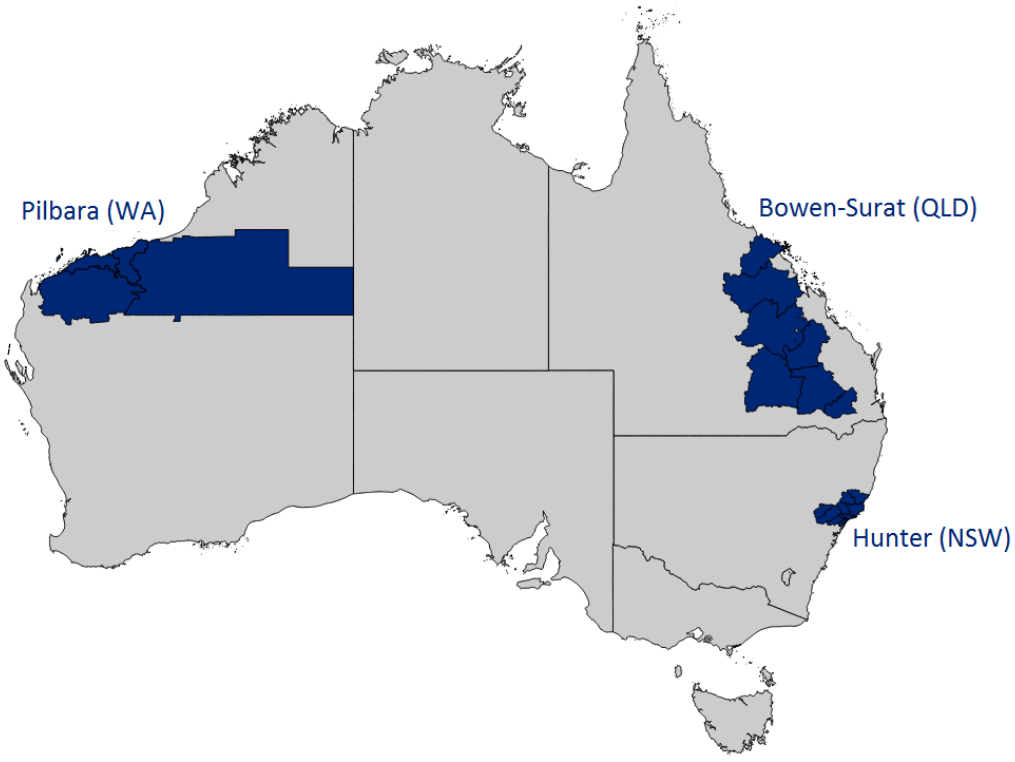
Combining the direct and indirect economic contributions yields the sector's total economic contribution. In 2015-16, the mining and METS sector's total economic contribution to Australia was $236.8 billion, representing around 15% of the Australian economy. This economic activity supported a total of 1,139,768 FTE jobs across Australia, which represents around 10% of total FTE employment.

2.1.3 Regional economic contribution

In addition to making a significant contribution to the overall Australian economy, the mining and METS sector is particularly important across a number of key regions within the country. We have therefore examined the direct and indirect contributions of the mining and METS sector specific to several different regions across Australia.

The method used to calculate the direct and indirect contribution of the mining and METS sector at a regional level largely follows the approach used for the Australia-wide results, outlined in the previous section. However, instead of using the national IO tables, bespoke regional tables were constructed for the three relevant regions: Pilbara (WA), Bowen-Surat (QLD) and Hunter (NSW) (Figure 2.1).

Figure 2.1: Regions modelled in this study



Source: Deloitte Access Economics (2017)

Pilbara (WA)

The Pilbara is a large, arid area in north-west Western Australia, known for its large iron ore and petroleum reserves.[4] 96% of Western Australia's iron ore exports come from the Pilbara. Including both iron ore and petroleum, the region produces over two-thirds of the State's commodity exports and roughly 20% of Australia's total merchandise exports by value (RDA Pilbara, 2014). The Pilbara has a low population density and its economy is dominated by the mining and METS sector; economic activity outside of mining and METS includes some basic services, pastoralism, tourism and fishing (RDA Pilbara, 2014).

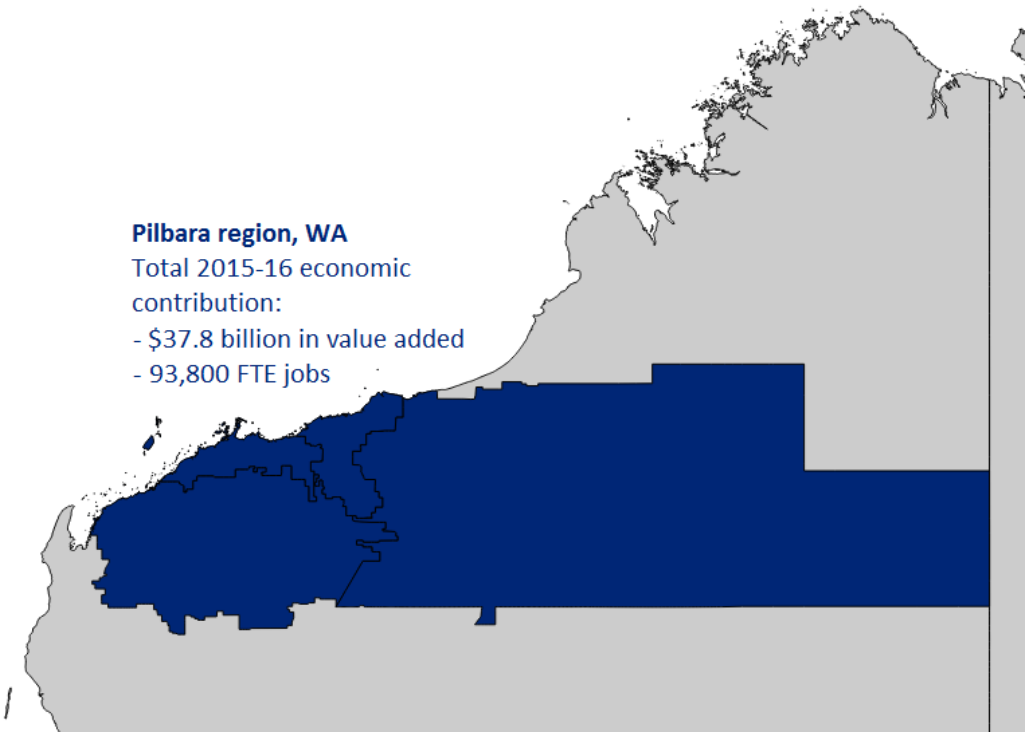
Deloitte Access Economics estimates that, in the Pilbara region of Western Australia, the mining and METS sector directly contributed $30.9 billion in value added to the regional economy in 2015-16, and supported around 47,100 FTE jobs (see Table 2.4 below). Many of the mining and METS jobs that have been created in the Pilbara region are fly-in fly-out (FIFO) positions, which allow resource companies to draw from a wider pool of workers while also providing the opportunity to spread the economic benefits of resource industry employment to the rest of the State (Commonwealth of Australia, 2013). The indirect economic contribution to the Pilbara region is estimated to be $6.9 billion, supporting approximately 46,700 jobs in FTE terms. Overall, the total direct and indirect contribution of $37.8 billion in value added represented 88% of economic activity in the Pilbara region in 2015-16.

Table 2.4: Economic contribution of mining and METS sector in Pilbara region, 2015-16

	Direct contribution	Indirect contribution	Total contribution
Value added ($m)	30,894	6,882	37,776
Employment (FTE)	47,142	46,697	93,839

Source: Deloitte Access Economics (2017)

Figure 2.2: Summary of Pilbara region



Source: Deloitte Access Economics (2017)

[4] It should be noted the petroleum production is beyond the scope of this report.

Bowen-Surat (QLD)

The Bowen and Surat basins are located in central and south-west Queensland. Bowen basin contains Australia's largest coal reserves (especially high quality metallurgical coal), with almost all of Queensland's operating coal mines in 2014-15 being located in the Bowen basin (DNRM 2016). Due to this abundance of coking coal, Queensland has become the world's largest exporter of seaborne-traded metallurgical coal (TMR 2016). The region is serviced by a number of ports, which export a majority of the coal mined in the region. In 2014-15, the ports of Abbot Point, Hay Point and Gladstone, respectively, exported 29, 72 and 68 million tonnes of metallurgical and thermal coal (TMR, 2016).

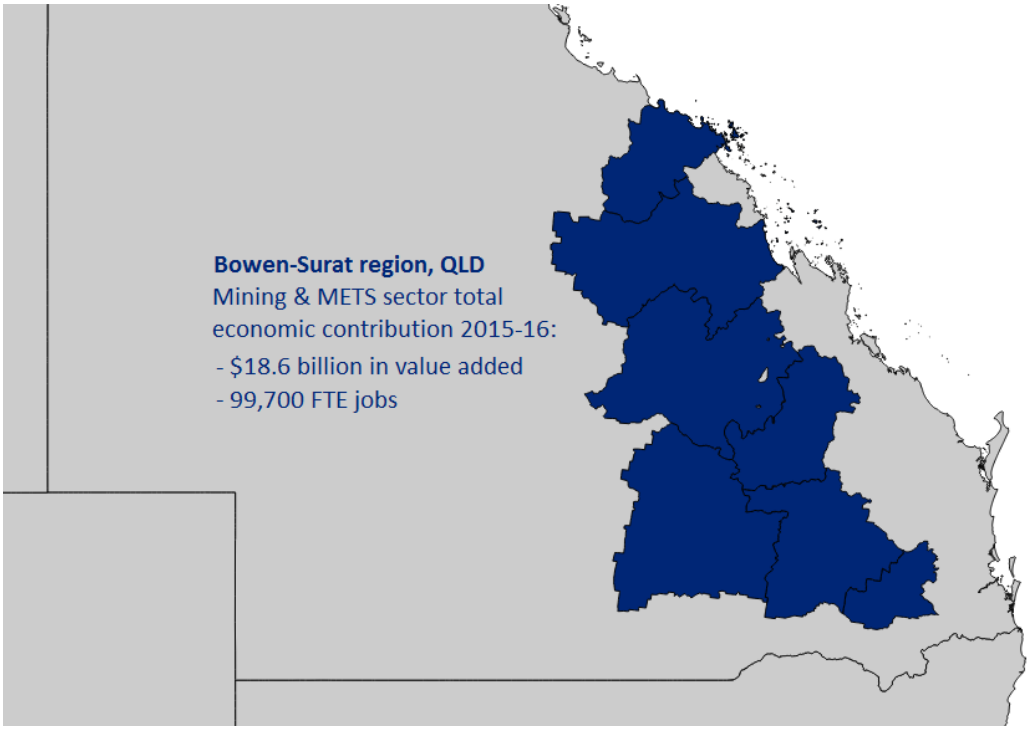
Deloitte Access Economics estimates that, in the Bowen-Surat region of Queensland, the mining and METS sector directly contributed $11.3 billion in value added to the regional economy in 2015-16, and supported around 49,200 FTE jobs (see Table 2.5 below). The indirect economic contribution to the Bowen-Surat region is estimated to be $7.3 billion, supporting approximately 50,600 jobs in FTE terms. Overall, the total direct and indirect contribution of $18.6 billion in value added represented 63% of economic activity in the Bowen-Surat region in 2015-16.

Table 2.5: Economic contribution of mining and METS sector in Bowen-Surat region, 2015-16

	Direct contribution	Indirect contribution	Total contribution
Value added ($m)	11,251	7,343	18,594
Employment (FTE)	49,186	50,566	99,752

Source: Deloitte Access Economics (2017)

Figure 2.3: Summary of Bowen-Surat region



Source: Deloitte Access Economics (2017)

Hunter (NSW)

The Hunter region is located in New South Wales, around 100 to 300 kilometres north of Sydney. The Hunter has a long history of coal mining: the area was first settled by Europeans due to its extensive coal reserves and its major city, Newcastle, was named after the British coal-shipping town. Coal from the Hunter was among Australia's first exports, as coal was shipped from the colony of New South Wales to Bengal in 1799 (Kininmonth 2002). The region continues to be NSW's major source of mining and METS activity, with the Hunter coalfields accounting for over half of NSW's overall coal production (CIE 2014). Moreover, Newcastle is the world's largest coal export port.

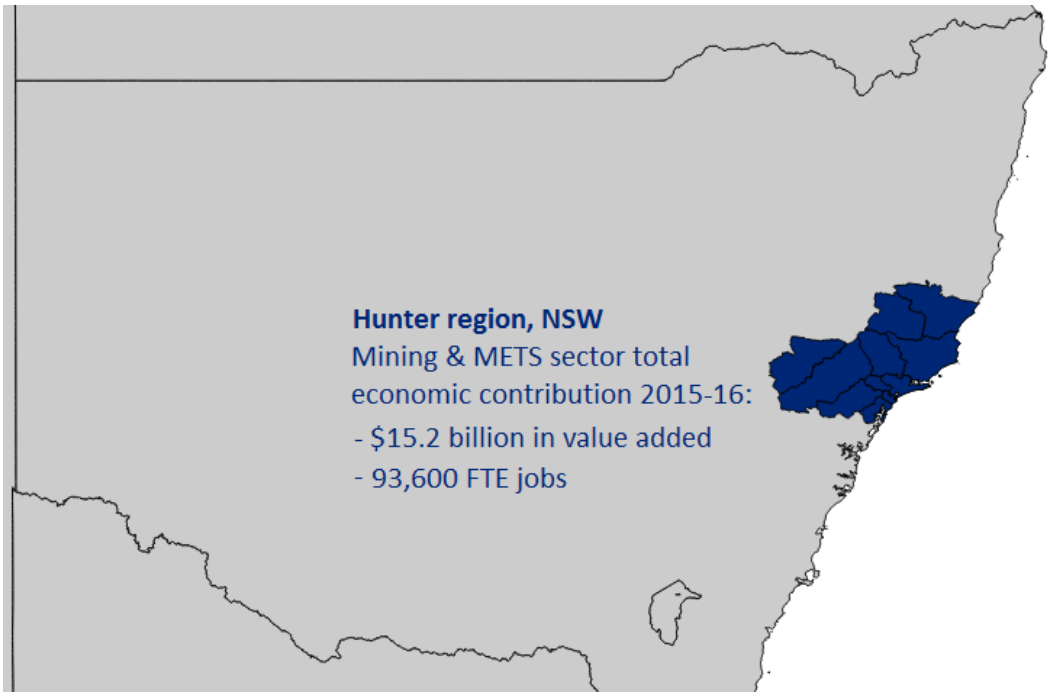
Deloitte Access Economics estimates that, in the Hunter region of NSW, the mining and METS sector directly contributed $8.5 billion in value added to the regional economy in 2015-16, and supported around 50,400 FTE jobs (see Table 2.6 below). The indirect economic contribution to the Hunter region is estimated to be $6.7 billion, supporting approximately 43,100 jobs in FTE terms. Overall, the total direct and indirect contribution of $15.2 billion in value added represented 34% of economic activity in the Hunter region in 2015-16.

Table 2.6: Economic contribution of mining and METS sector in Hunter region, 2015-16

	Direct contribution	Indirect contribution	Total contribution
Value added ($m)	8,501	6,698	15,199
Employment (FTE)	50,416	43,138	93,554

Source: Deloitte Access Economics (2017)

Figure 2.4: Summary of Hunter region



Source: Deloitte Access Economics (2017)

2.2 Innovation as a key growth driver

Innovation is integral to the performance of the mining and METS sector. It is a global and highly competitive sector, and as such companies that are slower to create or adapt to new products and processes – including new technologies – risk fewer growth opportunities and lower returns.

Australia's comparative advantage in minerals and energy exports is not simply a function of its natural endowments, important as they are. Rather, this comparative advantage has to be achieved by productive firms that are prepared to bear the risks of investing, employing and innovating to derive market value from mineral resources.

Innovation enables the mining industry to extract and process ores more efficiently, and to extract deposits that are deeper or more remote. Innovation also improves safety and environmental outcomes. Australia's mining industry is increasingly focused on integrating new technology and ideas into its operations. Consequently, the METS sector is likely to become ever more important.

Although Australia is blessed with large natural endowments of iron ore, coal, bauxite, base metals and many other minerals, the same is also true of other countries such as South Africa, Canada, Indonesia and Brazil. Innovation is a key differentiator for Australian-based mining and METS companies to ensure they, and Australia, continue to be global leaders – not only as a mining nation, but also as an innovation nation.

Innovation is not new to the mining and METS sector. Miners rely on continual innovation and technological improvement, and innovations in mining often lower the costs of basic inputs (such as energy or metals) to other economic activities, thereby helping to build a foundation for further innovation in other supply chains.

The mining industry has changed radically in the past century, and has transitioned from a largely labour intensive industry to a highly capital intensive industry. In recent years, there have been significant developments in innovative transformations being implemented across the Australian mining and METS sector. No part of the production process remains unimproved, and in this context, our case studies highlight 10 Australian innovators from across the sector. We find that across these companies, innovation has been implemented through a diverse range of approaches, which include:

- The creation of new technologies that improve efficiencies in the production process;
- Adopting existing technologies for new applications to realise additional productivity gains;
- Collaborating with academic institutions and scientific research bodies in order to develop and integrate research ideas with industry applications;
- Pre-competitive technological collaboration between companies in the same industry to realise benefits across all stakeholders;
- Collaboration between producers and suppliers in order to increase efficiency throughout the supply chain; and
- Improving company processes by using the knowledge and experience of workers to drive innovative activities.

These case studies represent not only some of the largest miners listed on the ASX but also smaller service companies that support the industry. They cover a range of impacts from the corporate and strategic level through to specific applications of innovations in day-to-day tasks, and illustrate how innovation can be a key driver of business growth and enable Australian mining and METS companies to be globally competitive. Some of the benefits of innovation highlighted in these case studies include:

- Reduced operating costs reflecting efficiency gains from using new technologies;
- Extending the productive life of mines, such as by enabling the extraction of deposits that are deeper or more remote;
- Higher yields, such as increased metal recovery from ores;
- Safety improvements flowing from simplified processes and earlier detection of hazards;
- Higher workforce satisfaction and productivity in translating innovative ideas suggested by employees into operational improvements;

- Applying knowledge from research institutions to implement new or improved processes and products; and
- Brand development and generating new opportunities by enabling access to new markets overseas.

There is a common theme that flows through all of the case studies presented – innovation is about unlocking individual ideas and improving what workers do every day. The case studies illustrate that no matter what the size of the company or the worker's position in the organisational chart, good ideas are recognised for their merits and quickly adopted.

2.2.1 Newcrest

Newcrest Mining Limited was formed in 1990 following Newmont Australia Limited's acquisition of Australmin Holdings Limited and its subsequent merger with BHP Gold Mines Limited. Newcrest is one of the largest gold producers in the world with 77.4 tonnes, or 2.4% of global gold produced in 2015.

The biggest Australian gold producer

Newcrest owns and operates a total of five gold mines internationally including Cadia in New South Wales and Telfer in Western Australia with combined production of over 1.13 million ounces of gold in FY2016 (46% of Newcrest's global production) worth as much as US$1.32 billion (AU$1.81 billion) a year. Newcrest's gold production increased 1% from FY2015, an increase driven by the implementation of operational improvement initiatives.

An innovator's mindset driving faster adoption of innovation

Newcrest's approach to innovation is about setting a transformative vision to drive breakthrough thinking, and encouraging a culture of experimentation, collaboration and fast adoption. The company has a wide range of industry collaborations in place with research institutions, suppliers in the METS sector and other mining companies and is using these to drive faster development and application of innovative solutions and technologies.

Newcrest is developing the capability to engineer harder rock masses to enable caving at depths of greater than 1 kilometre. This innovation can turn a short life underground mine into a long-life series of block caves, through more efficient use of block caving mining techniques and through improved management of safety at the mine. This in turn increases the likelihood of further development of low-grade, previously uneconomic orebodies as well as improving returns from existing operations.

Innovation drives Australia's largest underground mine

One of the world's most advanced and innovative gold mines can be found 25 kilometres south of Orange in central-west New South Wales.

Newcrest began developing the Cadia East deposit in 2010 and has invested more than AU$2 billion to build the first underground cave of this design in the country. As part of Newcrest's Cadia Valley Operations, Cadia East is at the forefront of mining innovation, using a cutting-edge caving technique and the latest technology to deliver safe, low-cost production.

Innovation process engineering enabled a faster production ramp-up at Cadia East's Panel Cave 1 than any comparable underground mine in the world. This was achieved through high-capacity ore transportation design, intensive preconditioning, an innovative undercutting strategy and a high-efficiency loading configuration.

Newcrest worked closely with Codelco, a Chilean mining company with expertise in bulk underground mining techniques, to assist in developing technologies and maximise efficiency at Cadia East.

Cadia East is Australia's largest underground mine and when it reaches full capacity it will be one of the largest tonnage hard rock underground mines in the world with a potential life of more than 30 years.

Cave process monitoring and control

Cave process monitoring is the state of the art capability to 'see' what's going on within the complex cave propagation and draw process.

Innovative technologies such as 'cave tracker' developed by Elexon Mining in collaboration with CRC Mining (now Mining3), Newcrest and Rio Tinto deliver productivity improvements and make cave mining safer by detecting the formation of air gaps before they pose a hazard.

Electric drive loaders

Innovations in hybrid electric drive technology are increasing underground loader productivity due to improved work cycle performance, reduced operating costs, increased durability and reduced emissions from the reduced engine size. Simplification of the all-electric driveline leads to fewer failures.

Newcrest has trialled Joy Global's initial 18 tonne capacity prototype hybrid loader for over 12 months and is now progressing trials for the larger 22 tonne loader.

Mechanical cut tunnelling

Rock strength presents a challenge to effective mining and new methods for excavation such as Joy's 'Dynacut' system enable the creation of compact mining equipment capable of excavating rock with strengths in excess of 250MPa. The benefit of this technology is the design of small and highly manoeuvrable continuous excavation machines.

In effect, if correctly implemented, continuous mining processes (vs. typical batch processes) may yield a 20% reduction in operational costs by increasing advance rates and reducing equipment requirements and energy use.

2.2.2 Peabody

Peabody Energy serves metallurgical and thermal coal customers in 25 countries and holds majority interests in 26 coal operations located in the U.S. and Australia. The company reported improved Australian costs per tonne in the order of 24% in 2015, delivering savings of some $620 million globally.

The largest private coal producer in Australia

Peabody Energy operates three mines in New South Wales and six in Queensland. The Wilpinjong mine operation in New South Wales employs a workforce of approximately 400 people (including subcontractors) and sold 12.5 million tons of high quality thermal coal to Australian and Asian operators in 2015.

Driving down costs and incidents with innovation

Innovation at the Wilpinjong mine is conducive to achieving Peabody's safety and productivity improvement targets in several aspects of the miner's operations. Partnerships with leading industry players and research bodies like Caterpillar (CAT) and the University of Queensland (UQ) are key to allowing Peabody access to new technologies to sustain its values for safety and cost-competitiveness through continuous improvement. As stated by Blair Jackson, the General Manager of the Wilpinjong mine:

> *"A key advantage of gaining early access to new technology is that you can be part of product development to ensure they fit a practical application."*

Semi-autonomous bulldozers

In collaboration with the University of Queensland and Caterpillar (CAT) and with funding from the Australian Coal Association Research Program (ACARP),[5] Peabody Energy is trialling the integration of a semi-autonomous bulldozer into its bulk dozer pushing operations at its Wilpinjong Mine.

The benefit of this technology is increased safety via the removal of operator exposure to whole body vibration and mounting and dismounting incidents as well as a productivity increase by:

- Increased daily hours of operation from the current 18.5 hours to 23.5 hours in remote operation;
- More cubic meters pushed per hour;
- Reduced energy use (fuel) per cubic meter pushed.

Drones

The Wilpinjong mine introduced drone use in mid-2014 with a hire unit to start with and, once benefits were made evident, the miner moved to purchasing its own unit.

Drones reduce risks of incidents by allowing monitoring of tailings and carrying out inspections in dangerous areas (for example, due to slope or height). They are used for aerial fly-overs and the temperature monitoring of stockpiles. The other key component the drone allows is quick turn around on survey volumes. These pick-ups are completed with the drone with no interaction with any mining equipment. This eliminates the need to have surveyors on the ground doing survey work amongst the mining equipment.

Another benefit is the ability to overcome stigmas associated with coal mining. Mining operations are often pictured as gaping open pits with long lasting visual impacts. Drones enable open cut mines like Wilpinjong to use media to correctly represent their operations to remotely located stakeholders.

[5] ACARP aims to improve the industry's competitiveness, safety and environmental performance, and has provided $273 million in funding to 1,468 projects since its inception in 1992.

2.2.3 BHP Billiton

For more than 130 years, BHP Billiton has been contributing to Australian industry development and economic growth. The company has grown into one of the world's leading resources companies, with its Minerals Australia business directly employing around 16,000 people across four States with a diversified asset portfolio including iron ore, metallurgical coal, copper and nickel.

Ensuring the benefits of its operations flow back to the community is a priority for BHP Billiton, with A$10 billion in goods and services for its operations sourced from over 11,500 Australian suppliers during the 2016 financial year. Its focus on local industry participation coupled with the scale of its operations provides significant opportunities for the nation's mining, engineering and technology services (METS) sector.

Over recent years, BHP Billiton has made several changes to drive productivity across its business and empower its frontline employees to pursue safer, more efficient and innovative ways to work. This included a concerted effort to significantly improve the inclusiveness of its culture and diversity of its workforce. This concerted focus has underpinned US$11 billion in annualised productivity gains across its global portfolio over the last four years.

Also facilitating this result was the evolution of the BHP Billiton operating model, which in early 2016 saw assets previously divided on commodity lines consolidated under a single regional management model supported by globalised functions such as Supply and Technology that now free its operations to focus on safety and productivity. Specifically, the Supply function is now coordinating and standardising its activities providing a single accountable interface for our supplier relationships and commercial activities. The model will improve the ability of our suppliers to connect with BHP Billiton's operations, offering a wider set of opportunities for the METs sector. A great example of this is the work done by the maintenance team at the Blackwater coal mine with the Supply and Technology functions who, have been working closely with Brisbane-based software provider Dingo to develop a mobile device application that is helping improve the speed, efficiency and quality of in-field equipment inspections.

Once the Field Inspection App is installed on mobile plant such as draglines and coal wash plants, it records data on oil levels, vibration, thermography, magnetic plug and filter inspections and integrates it automatically with Dingo's condition management software. This allows BHP Billiton's maintenance teams to review and analyse the information, and make adjustments to their work to deliver greater value. This collaboration has benefitted both parties, with BHP Billiton reducing break-in maintenance costs by over A$5.5 million and the successful commercialisation of Dingo's App, which is now being utilised by a range of mining companies globally.

Another success story is BHP Billiton's collaboration with mining software developers Runge Pincock Minarco (RPM). Together they developed Open Pit Metals Solution (OPMS) and the company's Western Australia Iron Ore business was the first to purchase the software. Since then, the company and RPM have worked closely to further refine the product. OPMS has streamlined the two year mine planning process and made it less resource intensive. The software has since been commercialised and is quite prevalent in open pit coal and oil sands mining operations in Australia and abroad.

BHP Billiton's simplified operating model where functions can aggregate activities across multiple operations is also enabling the rapid replication of innovation across its operations. This will facilitate continued integration of technology throughout the supply chain to bring about step changes in safety, productivity and environmental impact. Partnerships with innovative companies, universities and strategic vendors will be critical in this process.

BHP Billiton's new organisational structure is also facilitating the replication of best practice, including approaches to social investment such as its science, technology, engineering and maths (STEM) education partnerships aimed at building skills to create diverse and innovative employment pathways and boost the international competitiveness of the Australian economy. Our Local Buy Program which has been successfully supporting sustainable businesses in regional Queensland since 2012, has already been expanded to the Hunter Valley reviewed for expansion to BHP Billiton's other regional communities.

Through this multi-faceted approach to fostering innovation within its business, through collaboration with suppliers and the research sector, and by investing in developing capacity and capability in its host communities, BHP Billiton hopes to continue its strong contribution to the economy, community and industry for another 130 years and beyond.

2.2.4 Rio Tinto

The Rio Tinto Centre for Mine Automation (RTCMA) is the product of a unique partnership between Rio Tinto and the University of Sydney. Established in 2007 within the University's Australian Centre for Field Robotics, with a renewed agreement in 2014, the centre was created to develop and implement the company's vision for the Mine of the Future.™

Automation technology is playing an increasingly important role in mining. The RTCMA draws on the expertise of university researchers who have worked on cutting edge research and development (R&D) automation technologies across diverse industries such as defence, aerospace and agriculture.

The RTCMA oversees a range of programmes that incorporate sensing, machine learning, data fusion and systems engineering, with technologies developed including automated drilling and algorithms for interpreting drilling data. The work of the centre has resulted in a number of major research advancements in both basic and applied areas.

As well as supporting the development and implementation of technology into mine operations, work at the centre has yielded more than 150 papers for high-quality conferences and journals, as well as a substantial patent portfolio for Rio Tinto and the University of Sydney.

Focus and achievements

From initial development of a prototype, an Automated Drill System (ADS) comprised of seven automated drills has now been fully deployed at Rio Tinto's West Angelas mine. This technology increases the safety of the operator while also improving drilling precision and, by extension, drilling productivity. With more than 3 million metres drilled by mid-2016, deployment will be extended to other Rio Tinto Iron Ore sites during 2017.

Even more ambitious has been the implementation of Rio Tinto's Mine Automation System (MAS) that combines all data from Rio Tinto mines into a single set of models which can then be used to task and coordinate manned and autonomous equipment. MAS is now deployed at more than 85 per cent of the company's surface mines - including iron ore, copper, coal and bauxite operations - and accessed by more 1000 Rio Tinto employees through the RTVis 3D visualisation software.

Alongside this work, a number of novel in-ground data processing algorithms have been developed. These algorithms allow Rio Tinto geologists to get unique perspectives on the construction and make-up of ore bodies. Trials of new orebody modelling techniques are ongoing, and are in the process of being deployed.

Partnership in practice

Rio Tinto's Growth and Innovation (G&I) group acts as a conduit between Rio Tinto's mine operations and the researchers and technical staff at the university. Both Rio Tinto and University of Sydney personnel make up the Technical Steering Group that oversees and manages the work programme of the RTCMA. Effective communication and agreement on milestones are essential at the start of a project and throughout R&D stages.

Successful industry-academic partnerships need to balance differing objectives. Industry will necessarily look for a timely return on investment while university research is an often time-consuming process guided by academic peer review.

Simply owning a new technology is not sufficient for it to make a difference to operations. A plan for careful integration with existing systems and processes is essential. The G&I team within Rio Tinto fulfils this function, pulling through technologies when they are ready, taking responsibility for trials and working with

mine site employees to pilot, integrate, adapt and deploy technologies where they can add most value to Rio Tinto's business.

With some ideas and projects taking years to mature from the identification of a problem by Rio Tinto, maintaining a wide portfolio of projects allows for progressive validation and commercialisation of technologies.

2.2.5 Glencore

Glencore is a global major producer of natural resources including coal, copper, nickel and zinc. The company is one of Australia's largest coal producers with 17 operational mines across New South Wales and Queensland. Glencore's coal business employs more than 7,000 Australians and in 2016 managed the production of nearly 93 million tonnes of thermal and coking coal, predominantly for export.

The importance of low emissions coal technologies

Glencore acknowledges the need for the world to continue reducing carbon emissions and believes that government policies globally should support low emission coal technologies – including high efficiency, low emissions (HELE) generation and carbon capture and storage (CCS) technologies.

HELE coal technologies allow power generators to operate at higher temperatures and pressures, reducing by up to 40 per cent.[6] The emissions per unit of electricity generated HELE coal-fired power stations integrated with CCS can reduce CO_2 emissions by approximately 90 per cent.[7]

CCS is the capture, transport and storage of CO_2 from coal or gas fired power stations as well as emissions from the production of cement, iron, steel, fertilizers and chemicals. CO_2 is captured from a large emission sources, it is then compressed into liquid form and transported to a suitable storage site, where it is stored permanently deep underground. This technology is proven and is operating at numerous sites around the world.

The Intergovernmental Panel on Climate Change has projected that an already very expensive global solution to climate change will be almost two and a half times more costly without CCS.[8]

CTSCo Integrated Surat Basin CCS Project

Over the past eight years, Glencore has participated in a number of low emission technology projects in Australia and overseas. Glencore's Integrated Surat Basin CCS Project is a demonstration project that aims to test the Surat Basin in Queensland for the suitability of deep carbon storage. The geology of the Surat Basin has up to 2.9 billion tonnes of CO_2 storage potential and there are a number of coal-fired power stations nearby.

The Integrated Surat Basin CCS Project is located within a single greenhouse gas tenement on Glencore-owned land 15 km from Wandoan, granted by the Queensland Government in 2012. The project is being delivered by the Carbon Transport and Storage Company (CTSCo) – a wholly-owned, subsidiary of Glencore.

The project began in 2009 with a pre-feasibility study that ran to 2012. The project is currently in feasibility stage undertaking geological studies and environmental baseline monitoring with a view of gaining permits to inject CO_2. A post-combustion-capture (PCC) plant, attached to a coal power station, is expected to be built by 2021 and CO_2 injection anticipated for 2021 to 2024. It has received strong industry support from the

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[6] ACALET assessment based on publicly available information on world power plant efficiency levels. According to a discussion paper released by the former Gillard Government, new coal technologies can increase the efficiency of Australian plants to over 45 per cent and lower their CO_2 emissions by up to 50 per cent. See the Department of Resources, Energy and Tourism, *A Cleaner Future For Power Stations*, Interdepartmental Task Group Discussion Paper, 1 November 2010, p. 5.

[7] International Energy Agency, *Technology Roadmap High-Efficiency, Low-Emissions Coal-Fired Power Generation*, Paris, originally published in 2012, updated March 2013, p. 19.

[8] IPCC (2014). 'Summary for Policymakers', in: *Climate Change 2014, Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*, edited by O. Edenhofer *et al.,* Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. p. 58.

Australian Coal Association Low Emissions Technologies Ltd (ACALET) and also from the Federal and Queensland Governments.

The project uses existing and proven technology, which reduces both risks and costs. It aims to demonstrate that CO_2 can be safely stored in an 'industrially scalable' manner more than 1km underground, at a cost of millions – rather than billions – of dollars. It aims to benefit all emitters of CO_2 – including coal- and gas-fired power stations as well as industrial producers of cement, iron, steel, fertilizers and chemicals.

Environmental baseline program

CTSCo is undertaking a comprehensive and multi-year environmental baseline program at the Glenhaven Project site to understand the presence and concentrations of naturally occurring gases and chemicals within the project area.

Scientists have installed monitoring sites across the proposed project area, which involves drilling a number of bores at different depths to collect information using special monitoring equipment. This equipment sends readings in real time to a central database via mobile phone technology.

The collection of this comprehensive environmental and geological data will enable CTSCo to accurately monitor the impacts of the sequestration process.

Seismic survey program

A seismic survey is similar to an ultrasound where sound waves are bounced off underground rock formations and the waves that reflect back to the surface captured by recording sensors for later analysis. Analysing the time the waves take to return provides valuable information about rock types, structures and possible gases or fluids in rock formations.

Onshore seismic operations usually use specialised trucks that carry a heavy plate that is pressed against the ground and then vibrated to generate a seismic signal. Seismic processing requires powerful computers, sophisticated software and specialised skills. Once the seismic data has been processed, it must be interpreted by highly trained scientists.

Seismic survey recording vehicle

Community and stakeholder engagement

CTSCo is committed to working closely with local communities and fully investigating the economic, environmental, social and cultural implications of the proposed project.

The first stage of the local engagement program involved a community baseline survey. This helped CTSCo better understand the community and its priorities and potential concerns. The survey's 60% response rate highlighted the community's desire for information about the project and ongoing dialogue with the company.

A number of community leaders (identified through the survey) have helped inform and design an appropriate engagement approach.

Communicating the science and process behind CCS transport and storage is an important part of understanding the project in detail. A science-based engagement program is currently being co-designed with Wandoan State School to help build understanding at a grass-roots level. In addition to this engagement activity will continue at a local community level with one-on-one meetings, group meetings, community presentations and general public library information sessions.

2.2.6 Hedweld Engineering

Hedweld markets and distributes a range of technologically advanced, innovative products specifically designed to improve safety and efficiency within the mining and earthmoving industries.

The design is done in close collaboration with original equipment manufacturers (OEMs) such as CAT and Komatsu, and manufacturing is carried out at the company's Mount Thorley facility in New South Wales. Hedweld also provides after sales support services including commissioning, training and installation and on-site and off-site servicing and spare parts.

Australian grown business with a global reach

Hedweld has grown into an international business, exporting its products to 32 countries. Hedweld employs approximately 85 people across its global workforce, with the bulk of the company's employees located in Mount Thorley.

Driving down costs and increasing safety with innovation

Hedweld Engineering has developed two main categories of products: Trilift and Safe-Away. The former is a range of workshop equipment for the removal, installation and handling of components on mining and heavy earthmoving vehicles. The latter provides a range of ladder and stair access options specifically designed for the mining and earthmoving industries.

Those two ranges are designed in close collaboration with equipment OEMs to custom design new and innovative products to make vehicle access and maintenance safer and more time efficient. Several prototypes may be built before a final one is agreed upon.

Trilift range and dump truck transmission hoist

The Trilift range enables the safe and efficient handling of wheel motors, hoist cylinders, transmissions and other components which can weigh several tonnes.

The Trilift Cat 797 Transmission Hoist was designed for the safe and efficient removal and installation of the transmission block on the largest dump trucks used in Australia. The hoist overcomes one of the main hurdles

faced by maintenance staff globally which is the difficulty of accessing the transmission as a consequence of the truck's staged manufacturing process.

Without the hoist, the dump body which weighs upward of 60 Tonnes must be removed requiring two cranes, a large number of people (operators and spotters), and exposing workers to crushing hazards and falls. This process also requires up to three days from the removal of the body to its replacement after changing the transmission. However this product reduces the time to four hours. Other methods using a single crane are also employed although they also expose the workers to crushing hazards and falls.

Capable of supporting up to 8 tonnes using the truck's chassis as the base and hydraulics for its operation, the hoist provides the following benefits:

- Safer working environment for all maintenance staff;
- Reduced number of personnel required to perform maintenance tasks;
- Reduces truck downtime from 40 hours to 8 hours and labour time from 60 hours to 16 hours;
- Reduced maintenance costs. Hedweld Engineering estimates the Trilift method lowers costs by close to $170,000 each use.

2.2.7 MICROMINE

MICROMINE is privately-owned mining software company, providing innovative solutions that span the breadth of the mining cycle from geological data management, to resource estimation, mine design, planning and production control.

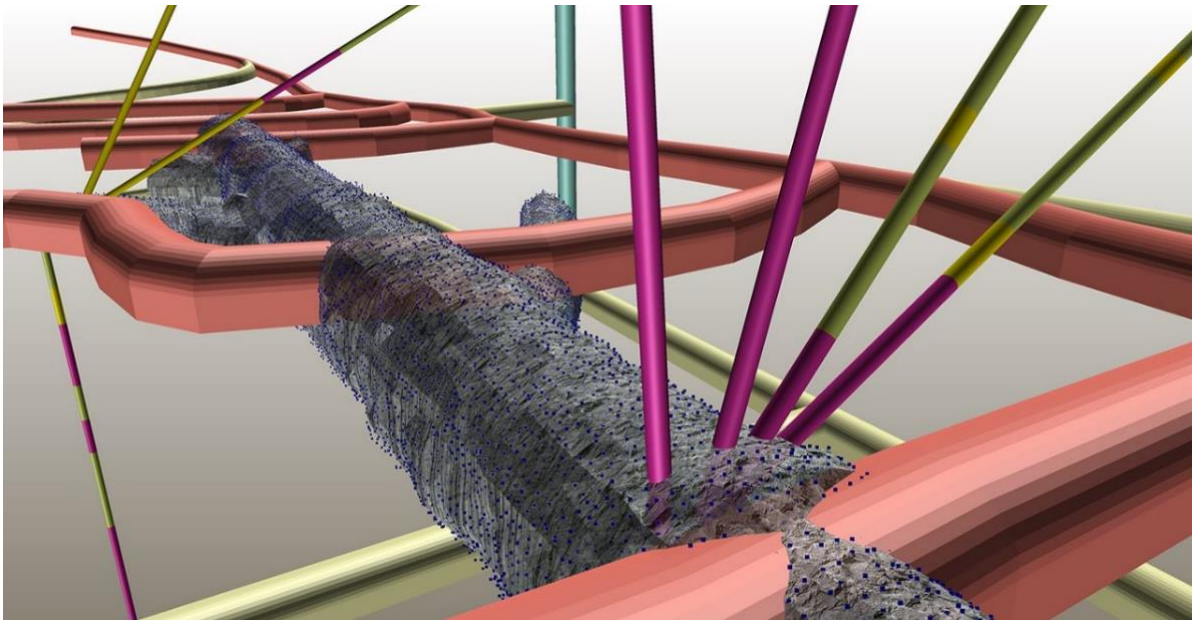
Graeme Tuder founded the company in 1986 after identifying a market opportunity to apply offshore oilfield technology ideas to mineral exploration techniques. He was a surveyor and had spent his early career in seabed mapping, geophysical and hydrographic studies, and bathymetric surveys for the offshore oil industry in the Middle East, North Sea, West Africa, New Zealand and south East Asia.

Primarily, Graeme wanted to build a global company involved in geoscience. His experience overseas, his knowledge of international markets and his exposure to widely divergent cultures meant he had no difficulty operating in foreign markets. MICROMINE first made its way into Indonesia, then China, Mongolia, Russia, Central Asia and Ukraine. Graeme believes it was because other companies had neither the corporate culture of MICROMINE, nor its experience, that the business established itself as a leader in some of these markets. The business has always been an avid employer of talent not based on parochial attitudes.

MICROMINE's products include Geobank, a data management, validation and reporting tool, Micromine, a sophisticated resource modelling, 3D mine design and planning solution, and Pitram, a fleet management and mine control solution that records, manages and processes mine production data in real time. The company also provides services that enable the more complete integration of those products into clients' systems.

MICROMINE's growth can be attributed to Graeme's ability to identify and develop new markets and the company's focus on people - both staff and clients.

The marketplace is very competitive for each of the company's products and MICROMINE draws on the experience and creativity of its staff and operational flexibility gained through its 30 years' exposure to international markets to stay ahead of its competition.



In Micromine 2016, an as-built mine defined by a laser point cloud, surrounded by drillholes and proposed future mine workings

2.2.8 Maptek

Maptek is an innovative software and technology company which designs and develops applications targeting key industry outcomes of productivity, safety and profitability for miners.

Maptek employs 300 staff worldwide and has offices in the Americas (U.S., Canada, Brazil, Mexico and Chile), Australia, South Africa and the UK. The company's first office was opened in Sydney in 1981 – Maptek celebrated its 35th birthday last year. Maptek product technology focuses on collecting, modelling and analysing technical data to solve mining industry challenges.

The range of products includes mine design and modelling software (Vulcan and I-Site Studio) as well as I-Site 3D laser survey) and digital imaging hardware. Vulcan 3D modelling helped with the 2010 San José mine rescue in Chile to identify the location of the 33 men trapped underground. The software was used with the I-Site laser scanning hardware to map and guide drilling of an access shaft to free the miners.

Since this extraordinary event in 2010 Maptek has made its 3D scanning hardware mobile. I-Site Drive enables the continuous acquisition of data using a laser scanner. The vehicle mounted device links the laser scanner which generates a stockpile profile with an inertial navigation system (INS), enabling the continuous acquisition of data and coordinates. The mobile survey system reduces the time spent surveying a typical stockpile from 4 hours down to 45 minutes.

I-Site Studio generates detailed 3D models for geological mapping of mining faces. For underground operations, high resolution models of drifts (passageways that allow access to the ore) can be used to implement ground support measures. Laser scans taken before and after shotcreting (spraying of concrete on the walls of the drift) measures shotcrete thickness. This geotechnical control approach brings the following safety benefits:

- Reduced time in the drift;
- No need to core (drilling the shotcrete to measure thickness can reduce wall integrity); and
- More accurate data for fast validation of design.

Maptek monitoring hardware and software systems have other uses which include monitoring the design of walls during excavation, thereby maximising ore recovery with steeper walls and effectively managing the increased safety risk that derives from that gain.

2.2.9 Orica

Using analytics to drive productivity across the mining value chain
Blasting is a natural strategic enabler

From its early beginnings in 1874 supplying explosives for the Victorian gold fields, Orica has played a leading role in the development of new blasting technologies that have made significant contributions to productivity, safety and environmental outcomes for the mining industry.

With blasting's position so early in the value chain, and its potential to significantly impact the total operating cost and productivity of a mine, it is a natural strategic enabler within the total mining value chain. Advanced blasting techniques and products can generate returns from more productive drilling, digging, hauling and processing. In every sector, including underground, surface, quarrying and construction, blasting holds a key to unlock productivity benefits.

Using explosive energy in the pit can dramatically increase the efficiency and throughput of downstream processing. Orica pioneered ultra-high intensity blasting which reduces ore into smaller particles before the load, haul, crushing and milling stages. This reduces overall energy consumption with a consequent reduction in emissions and energy costs. Orica customers adopting this technology and its variants are achieving mill throughput rates that were simply not previously possible with conventional blasting. This is significant when you consider that as the highest grade ore bodies across the globe are exhausted, average ore grades fall and processing costs rise.

Integrating data across the value chain will drive systemic improvement

One of the real opportunities in speeding up the rate of innovation and the adoption of new technologies lies in the implementation of data management systems. The collection and aggregation of data throughout the value chain enables a fuller understanding of the impact of products and techniques on other activities in the whole mining process. This process can yield performance improvement in blast design and modelling, blast execution, and measurement and analysis. By combining customer data across the value chain, Orica can help drive systemic change for optimal and sustainable mine productivity.

Orica has been at the forefront of innovative blast design and modelling software and advanced blast prediction models for well over 20 years. With the development of the BlastIQ system, its goal now is to connect a suite of technologies throughout the blasting process with data-enabled and autonomous equipment to deliver real time continuous improvement, automated through the use of "smart" algorithms and models. They include:

- Blast design and modelling;
- At site activities to measure and adjust for aspects like drilling accuracy, hole depth, hole temperature, the presence of water and as loaded product information;
- Measurement, interpretation and reporting systems, such as blast-related environmental effects analysis and fragmentation monitoring on shovels and conveyors;
- Sophisticated systems to analyse the collected data and report useful information on outcomes and trends.

A selection of Orica customer pilot sites are integrating blast design, visibility of conformance to design, and measurement of results on a Cloud-based platform. The visual integration is providing powerful insights into better understanding geological domains for blasting and allowing design adjustments and suitable explosives selection to better manage achievement of targeted results.

The use of BlastIQ at customer sites has driven:

- Better geological domaining to obtain more consistent fragmentation in blasting
- Improved drilling quality, leading to less wastage and reduced costs
- Improved compliance with environmental limits
- Alteration of blast patterns and explosives selection to achieve improved outcomes
- Increased interaction between the mine and the plant, improving understanding of the effect of fragmentation in various domains on the plant and jointly administering improvements

The greatest opportunity comes through strong relationships between Orica and customers, in which data exchange and analysis is a principle. It's through the collection and aggregation of data throughout the value chain that the impact of product and technique selection on other functional mining activities like the drilling, excavation and processing can be truly understood. By combining data from across the whole mining value chain, Orica can help drive systemic change for optimal and sustainable mine productivity.

Orica is excited by the possibilities BlastIQ will unlock to leverage blasting for improved productivity and is encouraged by customers' feedback to date.

2.2.10 Donhad

Donhad Pty Ltd is an Australian-based manufacturer of technically advanced grinding media and forged products servicing the global mining industry. Founded in Bassendean Western Australia in 1965, it forms part of the US-listed Valmont Incorporated - Mining & Energy Division. Donhad manufactures semi-autonomous grinding (SAG) and roll forged ball grinding media, engineering forgings and a range of specialised forged fasteners for use in the mining, mineral processing and engineering industries. Donhad primarily serves the Australia, New Zealand and Asia-Pacific markets, and over the past 50 years has exported products to customers in Africa, Europe, North and South America and the Middle East. It operates three grinding media manufacturing operations strategically located in Perth, Newcastle and Townsville.

Donhad's principal products are grinding media balls and rods used in the comminution processing mills (SAG/Ball/Rod) and forged products (bolts, pins, fasteners and accessories). The business also provides technical services and support to its mining customers to optimise process parameters and product performance, in order to reduce operating costs and improve productivity. It maintains an in-house research, development and testing capability which is NATA and SGS Quality accredited, supported by industry-experienced metallurgists and engineers. Employing a LEAN operating system approach, Donhad has been on the continuous improvement journey for a number of years, with increasing levels of automation and robotics in its manufacturing plants and investment in process improvement, quality and product development.

Improving grinding media performance and reducing costs

Grinding media comes in a range of forms (balls, rods, cylpebs), sizes (27mm to 140mm balls) and composition (alloy, carbon, ceramic). The principal use for grinding media is to crush or grind mineral ores into various sizes, liberate minerals from gangue and increase surface area for chemical extraction using further downstream processing. This is termed "comminution" within the mining and metallurgical industry. The mineral ores which are typically processed include iron ore, gold, platinum, nickel, copper, zinc, alumina,

silver, lead, uranium, tin and lithium. The comminution process accounts for a significant cost in the mineral processing cycle through the consumption of grinding media and power, and is an important determinant of processing volume – and therefore productivity – on mine sites.

Donhad has developed a range of branded "Hi Carb" grinding media for which it has a number of patents, and represents the latest technical development from its continuous improvement initiatives. The HiCarb™ product demonstrates the latest improvement in terms of lower wear rate in service and potential to reduce milling costs through improved throughput on a "cost/tonne" basis.

The HiCarb™ ball has two main advantages. For one, it is designed to be manufactured to consistent high quality levels with improved throughput (tonnes per hour) in manufacture, making the business more competitive. This benefits the customers, who can access the next generation of grinding media more cost effectively.

Second, the performance of the media is improved in the customer's grinding process, particularly in ball mills (in contrast with semi-autonomous grinding [SAG] mills). The specific properties of HiCarb™ grinding media is derived from a combination of its composition with a higher carbon level (>1%C), alloying additions, and the heat treatment process during manufacture. This imparts improved wear resistance compared to traditional carbon grades of grinding media under like conditions. The performance of grinding media is typically measured in its consumption on a kilograms per tonne processed (kg/T) basis. The lower the value, the better the performance of the media, assuming other variables (ore characteristics, operating parameters, mill speed/condition, power) are stable.

Donhad HiCarb™ grinding media has been found to improve wear rates in excess of 3.5% in laboratory and in-market trials. Customers that have switched to the HiCarb™ product have communicated improvements in wear rates ranging from 3.5% to 10%+, compared to grinding media previously in use. Improved grinding media wear rates combined with increased volume of ore processed per hour can deliver tangible cost reductions to customers measured on a $/T processed or all in sustaining cost (AISC $/oz) metrics.

Donhad is building on the HiCarb™ success with further product and process development initiatives with a range of collaboration partners including customers and industry stakeholders. Of particular focus is technology to provide big data modelling of key mill process metrics. This capability would enable operators to optimise the comminution process and achieve a step change in power usage, processing rates and grinding efficiency.

3 Policy environment for a productive mining and METS sector

The most recent mining boom in Australia continues to have a significant impact on the Australian economy, resulting in substantially higher living standards. The sustained nature of the boom since the early 2000s was facilitated by earlier structural reforms that made Australia a more open and flexible economy. These include the floating of the exchange rate for the $A, as well as reforms in finance, product, labour and energy markets. Previous achievements have established favourable conditions to support a prolonged investment and production cycle.

In looking to the future of the mining and METS sector in Australia, policymakers must ensure that the economic environment continues to remain open to cross-border flows of trade, investment, technology, knowledge and skills.

This chapter provides some background on how previous microeconomic reforms helped to create a supportive environment for growth in mining and METS, and discusses areas where further reform can be prioritised. These areas include:

- Increased flexibility in workplace arrangements, including the industrial relations framework and skilled migration policy;
- Taxation policy settings that are competitive and fair, and also stable so as to avoid negative impacts on sovereign risk;
- Ensuring access to affordable and reliable energy;
- Maintaining an open policy to foreign investment and trade;
- More simplified or streamlined regulation where efficiency gains can be made without compromising the goals of the regulation; and
- Continued support for bodies that enhance collaboration between the mining and METS sector and research organisations.

3.1 Previous structural reforms

A range of structural reforms implemented over the previous three decades has contributed to the scale and length of the most recent mining boom. In particular, **openness to foreign investment** has been a significant enabler of Australia's mining-led growth.

A key principle of economic policy is that an economy should focus production in areas where it has a comparative advantage – that is, in areas where it can produce goods and services relatively more efficiently. As a resource-rich country, Australia is likely to have a comparative advantage in mining. However, as a relatively capital-intensive industry, significant investment by mining companies is required to ensure this potential comparative advantage is realised. Foreign investment can be an important source of funding for the industry's capital needs.

During previous mining booms in Australia, foreign investment was not encouraged – for example, in 1976, there was a requirement that new mining projects be funded by at least 50% Australian equity. This policy was repealed in 1986 (Hanratty 1996). In the same year that the equity requirement was introduced, the Foreign Investment Review Board (FIRB) was established – which is responsible for determining whether large foreign investments are contrary to the national interest.

Nowadays, FIRB approval is required for all mining projects funded by foreign investors (with exceptions for investment from particular countries under various threshold levels[9]). While this approval can be blocked if the FIRB assesses that the project is contrary to the national interest, there are no minimum restrictions placed on the proportion of a project required to be domestically funded once approval has been granted.

This increasing openness to foreign funds as a source of financing for large and capital-intensive mining projects has been a key factor in facilitating the significant investment that took place as part of Australia's most recent mining boom. An example of this is the Roy Hill iron ore mining project in WA's Pilbara region, which is 30% owned by an overseas consortium comprised of Marubeni Corporation (15% equity interest), POSCO (12.5%) and China Steel Corporation (2.5%).

More broadly, Australia's openness to foreign investment has provided the opportunity to start mining projects that may not otherwise have attracted sufficient capital investment. Borrowing funds from foreign investors has enabled an increase in the size of the nation's capital stock and, following the productive application of this capital, an increase in national income – beyond what the growth in capital and income would otherwise have been. While some of these income benefits accrue as returns to overseas investors, research by the Committee for Economic Development of Australia (CEDA) has found that "the extra production made possible in Australia from using foreign funds has indeed on average significantly exceeded interest and other investment income paid abroad" (CEDA 2009).

In addition, **openness to trade** is also an important element of Australia's microeconomic policy environment that has encouraged and sustained the most recent mining boom. During earlier mining booms Australia maintained a more protectionist trade environment, with high tariffs on imports of manufactured goods. This arguably leads to a misallocation of resources by Australian mining companies that utilise these goods as inputs to their production process. That is, import tariffs raise the production costs of exporters who, due to global competition, cannot raise their prices. Consequently, protectionist trade environments that place tariffs on imports can, inadvertently, result in Australian mining output falling.

More recently, the Government has continued to make progress in lowering trade barriers with Australia's key regional trading partners. Australia's openness to trade and investment facilitated the development of a highly productive mining sector. The Productivity Commission has stated that the improvement in Australia's position on international rankings of per capita GDP over the past 2-3 decades "has been linked to sustained economic reforms during the 1980s and 1990s, including the opening up of trade and capital markets to competition" (PC 2016a). These reforms have enabled significant economic growth in an area of Australia's comparative advantage, generating additional mining activity and contributing to the creation of jobs around the country.

Recent years have seen this trend continue as new free trade agreements were signed with China, Japan and Korea in 2014 and 2015. These agreements included reductions in tariffs placed on resources, particularly the China-Australia Free Trade Agreement, which involved the immediate elimination of tariffs on copper, aluminium oxide and nickel, and the phased elimination of tariffs on coal and titanium.

Continuing to develop an open environment for foreign investment and trade, such as through the ongoing negotiations with India in relation to establishing a comprehensive economic cooperation agreement, will be an important factor in supporting ongoing growth in Australia's mining and METS sector. Multilateral trade agreements such as current negotiations for the Regional Comprehensive Economic Partnership (RCEP) – an ASEAN-centred proposal for a regional free trade area – can also deliver significant global opportunities for mining and METS businesses in Australia.

Further to this, reforms across a number of other microeconomic policy areas also contributed to the open and flexible conditions that facilitated the mining sector's sustained growth over the most recent boom. In some cases these policies have been of direct benefit to mining and METS activities. In others, they have assisted in managing the booming sector and maintaining a stable macroeconomic environment, which has meant that

[9] Exceptions exist for Chile, New Zealand and United States for projects under $1,095 million and for projects under $15 million for China, Japan and Korea. Any acquisition of mining tenement by a foreign government requires approval. There is also approval required for acquisition of interest of at least 10% in securities in a mining, production or exploration entity.

broader policy adjustments that may have dampened the boom have not been required over the most recent period.

Relevant policies have included:

- **Financial markets** – Previous export booms in Australia had taken place under a fixed exchange rate regime. As such, the structural macroeconomic adjustments to the rise in exports occurred through increased domestic inflation, which had disruptive impacts throughout the broader economy. The most recent mining boom has been the first since the floating of the Australian dollar in 1983, which has allowed for smoother structural adjustments as the appreciation of the exchange rate has assisted in keeping inflation relatively low. According to the Productivity Commission, the floating exchange rate has given the Australian economy an "external 'shock absorber', [and as such] the Reserve Bank has been able to keep inflation within its target band on average since the boom began, and we have not seen the rapid economy-wide wage increases experienced in previous booms" (Banks 2011).
- **Labour markets** – At the time of previous commodity booms, Australia had a centralised wage-setting system that had the effect of transmitting demand pressures from the mining sector to aggregate wage outcomes across the economy. This meant that nominal wage growth reached double digits during previous booms (for example, accelerating to 30% during the early 1970s mining boom), destabilising conditions across the broader economy.
  The transition from centralised wage-setting to productivity-focused enterprise bargaining began in the early 1990s with reforms continuing under successive governments. The decentralisation of wage-setting arrangements enabled wages to adjust differentially across various markets and industries, resulting in a more economically efficient alignment of wages and productivity across the economy than had been seen previously. In essence, previous reforms ensured that wage increases in the mining industry did not cause economy-wide disruption. The appreciation of the exchange rate has also assisted in this respect, by keeping downward pressure on the prices of traded goods.
- **Energy markets** – Prior to the 1990s, Australia's energy sector was characterised by vertically integrated, publicly owned enterprises. Energy markets as we know them today did not exist and prices did not reflect efficient costs. Investment decisions were seldom made with efficiency in mind. Throughout the 1990s and into the 2000s a series of energy market reforms were undertaken. A milestone reform was the formation of the National Electricity Market (NEM), which revolutionised Australia's electricity sector by (among other things):
  - Introducing a uniform single wholesale electricity market across eastern and southern Australia which could move energy from where it was most efficiently produced to where customers required it;
  - Disaggregating the vertically integrated electricity sector into competitive sectors of generation and retail, and monopoly sectors of transmission and distribution network service providers;
  - Harmonising laws and regulations across participating jurisdictions, including rules for the wholesale electricity market and access to the networks; and
  - Transitioning towards full retail competition and the deregulation of retail pricing (AEMC 2013).

However, it should be noted that these past successes in microeconomic policy do not ensure that the initial benefits associated with reform will continue into the future. There is a need for ongoing attention to the policy environment in order to enable the mining and METS sector to continue to innovate, grow and contribute to the Australian economy. Potential areas of future policy focus are discussed in the following section.

3.2 Future areas of policy focus

In the 2014 report *Positioning for prosperity? Catching the next wave*, Deloitte Access Economics identified the mining and METS sector as a key driver of Australia's economic growth over the next 20 years , highlighting the need to "extend the [mining] boom for as long as possible and make sure we do not burden it with disadvantage through unwise regulation and taxation". As this section discusses in detail, open and flexible policy settings will be required to ensure that mining and METS continues to be a growth industry in the future. These include:

- Increased flexibility in workplace arrangements, including the industrial relations framework and skilled migration policy;
- Taxation policy settings that are competitive and fair, and also stable so as to avoid negative impacts on sovereign risk;
- Ensuring access to affordable and reliable energy;
- Maintaining an open policy to foreign investment and trade;
- More simplified or streamlined regulation where efficiency gains can be made without compromising the goals of the regulation; and
- Continued support for bodies that enhance collaboration between the mining and METS sector and research organisations.

3.2.1 Flexible workplaces

The mining and METS sector makes a significant contribution to employment in Australia, as highlighted in the economic contribution analysis above. There was a significant growth in labour demand over the investment phase of the most recent mining boom, and it has been noted that as the boom has transitioned into the production and operational phase, "employment in the resource sector remains higher than pre-boom levels as production of resource commodities has increased" (Kent 2016). Labour availability and workplace flexibility are therefore key to ensuring that the mining and METS sector can continue to grow and innovate in the future.

Industrial relations

An industrial relations framework that is both equitable and productive is a critical determinant of workplace flexibility. The Productivity Commission's 2015 report on Australia's workplace relations system noted that it has "several major deficiencies [that] need addressing" (PC 2015, p.2). The Productivity Commission made recommendations that are particularly relevant to the Australian mining industry.

For example, the Productivity Commission found that enterprise bargaining arrangements for greenfields agreements "pose risks for large capital-intensive projects with urgent timelines" (PC 2015, p.3), with the unique circumstances characterising these agreements warranting a different regulatory approach. The review raised concerns about the ability of unions to hold out in these negotiations, creating significant uncertainties about project start dates, which can reduce companies' capabilities in securing finance, project planning and managing risk. It was noted that this 'hold-up problem' could potentially provide unions with excessive bargaining power (PC 2015, p.36). Several recommendations were proposed, including allowing the employer to request 'last offer' arbitration by the Fair Work Commission after three months, and allowing the nominal expiry date of an enterprise agreement to match the life of the project.

The Productivity Commission's review also commented on the Fair Work Act's current provisions governing industrial action. It stated that, while strike activity is not a major problem in Australia at present, there are shortcomings in current arrangements that can result in strategic use of industrial action. The review made a number of recommendations about how the Act could be amended to address these deficiencies, such as proposing that the Fair Work Commission be able to suspend or terminate protected industrial action "where it is causing, or threatening to cause, significant economic harm to either the employer or the employees covered by the agreement" (PC 2015, p.889).

The Productivity Commission also recommended reforms in areas such as:

- Disputes about the frequency of entry by union officials so that the cumulative impact on the employer and the likely benefit to employees are considered
- The scope of permitted content by removing issues pertaining to the relationship between an employer and employee organisations from the list of permitted matters in enterprise agreements and specifying that an enterprise agreement may only contain terms about permitted matters
- Adverse action including aligning discovery processes with those of the Federal Court and more clearly defining the meaning and application of workplace rights.

Beyond the scope of the Productivity Commission's review and recommendations, there are fundamental changes affecting the labour requirements of the mining and METS sector. As illustrated through the innovation case studies presented above, mining and METS production is becoming increasingly technologically advanced, which will potentially reduce companies' labour requirements for low-skilled workers (e.g. truck drivers on mine sites) and increase demand for highly skilled workers who can develop and operate these technologies. Furthermore, workplaces of the future are likely to look different from workplaces of today, as changes in the nature of work, workplace diversity and locations where work is performed continue to take place.

In this context, the relevance of historical approaches to labour and industrial relations may need to be reconsidered, to ensure Australia's industrial relations system is able to support continued productivity growth by adapting to an increasingly dynamic and knowledge-based workplace.

For example, over recent times there has been growth in non-traditional working arrangements in the mining and METS sector and across the broader economy, such as casual employment, fixed-term contracts and self-employed contractors. However, the current industrial relations framework essentially provides a binary classification of an 'employee' as compared to a 'contractor', with arrangements under the latter classification characterised by considerably fewer worker protections and entitlements. The increasing incidence of unconventional forms of employment highlights the need for the workplace relations system to evolve to suit a wider range of agreement options.

Skilled migration

The availability of skilled workers from overseas through Australia's migration program has been important for meeting mining companies' demand for skilled labour over the course of the most recent mining boom, and this will continue as the boom moves through the production phase. The list of eligible occupations for skilled immigration visas and the associated quotas should therefore continue to be updated in line with the industry's requirements, to ensure that companies in the sector have adequate flexibility across their workforce.

For example, the Mining Engineer occupation was removed from the Department of Immigration and Border Protection's Skilled Occupations List (SOL) in July 2016. Occupations on the SOL can be used to apply for permanent and temporary skilled migration programs such as the 186 (Employer Nominated Scheme), 187 (Regional Sponsored Migrations Scheme), and 485 (Temporary Graduate) visas. While this change may hinder the ability of mining and METS companies to access skilled migrants under this specific occupation, the inclusion of related occupations in the SOL such as Engineering Manager, Geotechnical Engineer, or Engineering Technologist may still provide companies with an adequate level of flexibility in sourcing skilled migrants to address domestic workforce gaps. It will be important that this flexibility be retained as the SOL continues to change in future years.

The Productivity Commission has suggested that temporary skilled visas such as the 457 visa may be preferable for adjusting to increased demand for skilled labour, rather than a general increase in skilled immigration (Banks 2011). 457 visas allow employers experiencing domestic skills shortages to hire skilled migrant workers for up to four years. The 457 programme uses a broader list than the Skilled Occupation List and is based on the Consolidated Sponsored Occupation List (CSOL). These visas allow for more flexibility in responding to shorter-term fluctuations in demand for labour in the mining and METS sector and also provide a pathway to permanent migration for employees.

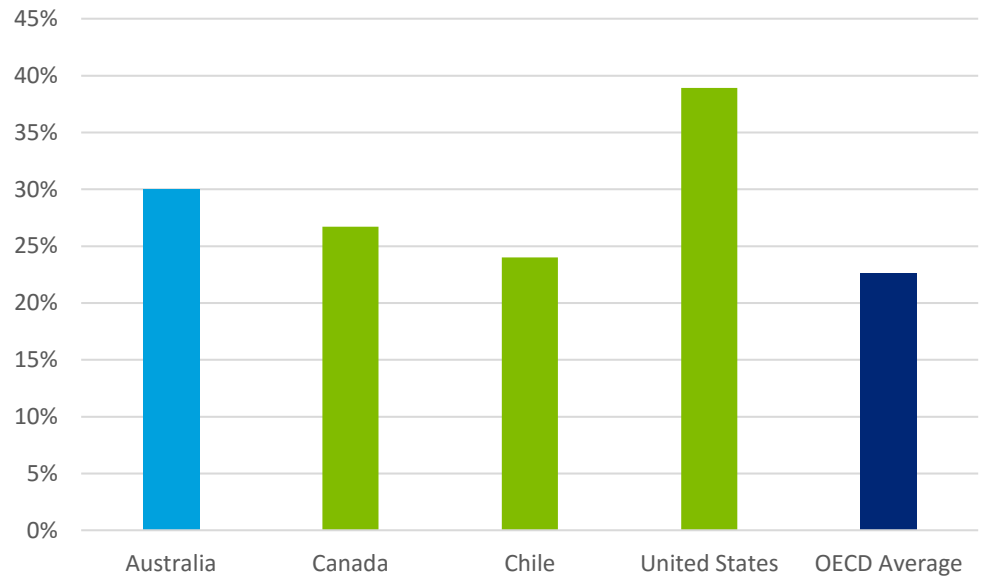
3.2.2 Competitive and fair taxation system

A competitive and fair taxation system is critical to support investment in globally competitive industries such as mining. Mining projects involve high-risk exploration outlays, large upfront capital commitments, long-life assets, sophisticated technologies and long lead times to profitability. Competition from other resource-rich economies to capture future opportunities in resource development is intense. In this environment, it is important the taxation system be not only competitive but also predictable, as stability supports long-term capital investments by minimising Australia's sovereign risk profile.

Federal and State taxation

Australia's corporate tax rate of 30% is at the upper end of the band of comparable countries, and is above the OECD average of 22.6% (OECD 2016, see Chart 3.1). More specifically, with regard to global competition for attracting investment in mining-related projects, Australia's 30% corporate tax rate is higher than other OECD countries with significant mining activity, such as Canada (26.7%) and Chile (24%).

Chart 3.1: Corporate taxation rates for selected OECD countries

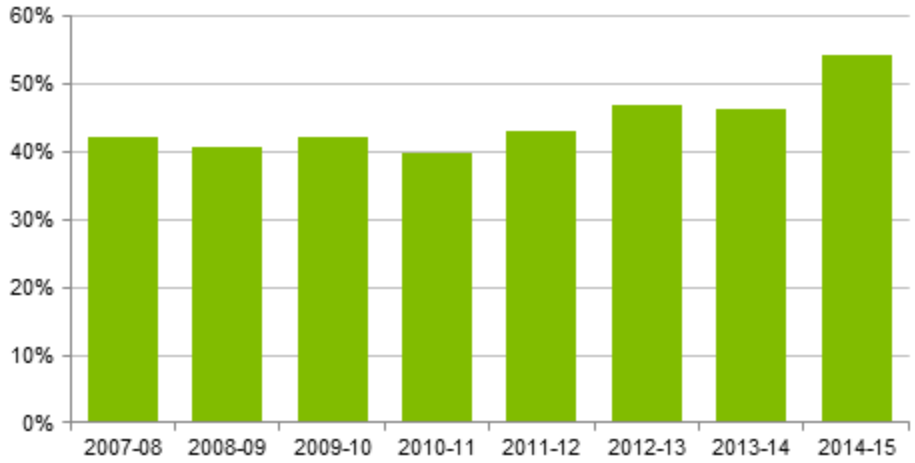


Source: OECD tax database (2016)

This higher taxation rate in turn lowers returns on foreign investment in mining, which can influence the decision making of foreign investors determining where to invest capital.

Considering mining in particular, the interaction of state and territory royalties with federal company tax means Australia is a relatively high-tax jurisdiction for mining. The *Minerals Industry Tax Survey 2016* undertaken by Deloitte Access Economics (2016c) found that the minerals industry faced an effective tax rate (company tax plus royalties) of 54.3 per cent in 2014-15. This is the highest tax ratio recorded since the survey began and the first time it has exceeded 50 per cent.

Chart 3.2: Total tax take ratio on mining



Source: Deloitte Access Economics (2016)

This finding is similar in nature to other studies such as Chen and Mintz (2016) who found that Australia had the second-highest tax burden on iron ore of nine countries examined. A previous study by Goldman Sachs (2013) has also found that Australia has a higher tax burden for mining companies than Brazil, Indonesia, Canada, Peru and the United States.

While there have been various policy discussions and proposals around lowering the corporate tax rate in recent years, none of these has yet been implemented. Most recently, the 2016-17 Commonwealth Budget included an announcement to progressively reduce the corporate tax rate from 30% to 25% by 2026-27 (Morrison 2016). If realised, this reduction could improve the relative competitiveness and attractiveness of Australian mining projects compared with those in other countries and would bring Australia closer to the OECD average corporate taxation rate.

More broadly, taxation reform can lead to growth benefits across the Australian economy. A growth-oriented tax system should work to "minimise the distortions of market signals by the tax system, [and] create as few obstacles as possible to investment, innovation, entrepreneurship and other drivers of growth" (OECD 2010). Empirical research by the OECD ranks corporate income taxes as the most harmful type of tax for economic growth, suggesting that a growth-oriented taxation reform agenda would seek to shift the tax burden from such income taxes towards less distortionary areas, such as consumption or property taxes (OECD 2010). This suggests that a reduction in Australia's corporate taxation rate will benefit the growth potential of mining and METS companies more generally, in addition to the specific benefits of attracting foreign investment.

Other areas that can affect the competitiveness of the taxation system in relation to the Australian mining and METS sector are state-specific rents and royalties that are paid on minerals extraction and production. While these are an important means by which State governments can price the right to extract state-owned mineral resources, uncertainties and inconsistencies surrounding the rents and royalties charged can negatively affect the industry, particularly given the long-term investment decisions required when commencing a mining-related project.

For example, the National Party in Western Australia has recently proposed to increase the production rental levy paid by BHP Billiton and Rio Tinto from 25 cents to $5 per tonne. Modelling conducted by Deloitte Access Economics (2016a) found that an extra $4.75 charge on iron ore production would lead to an annual cost to the Australian economy of $2.9 billion, as compared to revenue raised of $2.3 billion. The costs to the Australian economy come through the fact that lower returns mean that fewer investments are viable, and so marginal deposits in existing mines are likely to remain untapped.

Fuel Tax Credits Scheme

In considering the fairness of the taxation system, a key principle of public finance theory is that taxes on intermediate goods – that is, goods used as business inputs as part of the production process – can cause significant economic distortions. Reducing taxes on intermediate goods decreases this distortion and can therefore increase overall economic growth (Treasury 1998).

This principle is particularly relevant to the mining and METS sector in the context of fuel-related taxes, with diesel fuel representing a critical input for the heavy mining equipment and off-road vehicles used by the mining industry. The Fuel Tax Credits Scheme recognises this policy principle by providing all businesses with a credit for the fuel tax (excise or customs duty) that is included in the price of fuel used as a business input. It also recognises that fuel excise is designed to fund expenditure on public roads, and many of the businesses receiving Fuel Tax Credits operate in industries that do not use public roads – such as mining, agriculture and forestry.

While some have argued that Fuel Tax Credits represent an industry subsidy to these fuel-intensive sectors, Treasury has previously noted that "fuel tax credits are not a subsidy for fuel use, but a mechanism to reduce or remove the incidence of excise or duty levied on the fuel used by businesses off-road or in heavy on-road vehicles" (Webb 2012). In addition, the Productivity Commission's annual trade and assistance review does not include rebates paid under the Scheme as a form of government assistance to industry, stating that "it is not considered assistance as the excise tax on fuel is purported to be a mechanism to pay for roads, which are not used by those receiving the fuel rebate" (PC 2016b).

R&D Tax Incentive

Innovation is critical in ensuring that Australia's mining and METS sector remains globally competitive. As illustrated in the case studies above, the increasing integration of new technology and ideas into mining and METS operations results in significant economic benefits, such as reduced operating costs, higher yields and better safety outcomes.

It has long been understood that businesses' research and development (R&D) activities – which then drive innovation throughout the economy – have positive spillovers. Official data show that the mining sector spends nearly $3 billion on R&D annually, or nearly $1 in $6 of all business R&D spending in Australia (ABS 2015).

While individual businesses do benefit from their own R&D activities, the additional benefits realised by consumers, suppliers and competitors justify government support for these activities. In Australia, the largest form of Commonwealth Government support for private sector innovation is the R&D tax incentive, which provides businesses with a tax offset for eligible R&D activities.

Estimates of the size of spillover benefits suggest that the Government should continue to provide incentives for R&D activities that may not otherwise have been viable. For example, the CIE has found that each dollar of tax foregone through the R&D tax incentive is associated with between 0.9 and 1.5 additional dollars of R&D for small and medium-sized enterprises, and between 0.3 and 1.0 additional dollars of R&D for large companies (CIE 2016; cited in Ferris, Finkel and Fraser 2016). In this context, the broad-based nature of the R&D tax incentive ensures that it provides support for additional innovative activity across all industries and for a range of R&D investments. This has allowed mining and METS companies to engage in the productivity-enhancing innovation that, as our case studies highlight, generates significant wider economic and social benefits across Australia.

3.2.3 Affordable and reliable energy

Affordable and reliable energy is vital to the productivity and competitiveness of the Australian economy and the Australian mining industry. Ready access to reliable and affordable energy is crucial to heavy industrial users such as mining operations, refineries and smelters. Mining accounts for 9 per cent of national energy consumption and 11 per cent of electricity use. Affordable and reliable energy also underpins the high standard of living of households and supporting the competitiveness of Australian industry more broadly.

The two decades long task of creating the NEM and building the regulatory frameworks which encourage competition in electricity markets can be seen as one of the major microeconomic reforms achieved in Australia. However, there is the potential for further reform of the electricity industry to ensure affordability. Current market conditions, particularly the recent blackouts in South Australia, are highlighting the need to ensure that energy supply is also reliable.

Energy users have, in recent years, seen increasing electricity prices. These increases can, in some cases, be attributed to a lack of efficiency gains in the electricity transmission and distribution (PC 2013d). Lack of efficiency gains have been attributed to a combination of ownership structures and regulatory approaches. In some NEM states, government ownership is prevalent in generation, transmission and distribution and there are strong economic regulatory controls in markets where competition could be more heavily relied upon (retail in particular). Regulatory approaches could also be refined to ensure that energy users do not bear increases in costs from a lack of efficiency gains.

In addition to poor efficiency performance, electricity prices are directly increased by the range of Green and energy conservation schemes that are in place around Australia. Green schemes aim to encourage the use of low emission generation sources, while energy conservation schemes aim to encourage the pursuit of energy efficiency measures by energy users. Together these schemes add an additional cost component to the final cost of electricity faced by energy users, as liable entities under these schemes are typically generators or retailers who are likely to pass associated costs onto customers. In aggregate, the subsidies paid to producers of renewable electricity amounted to almost $3 billion in 2015-16 (BAEconomics 2017). When subsidies and feed-in tariffs are all included, the extra cost to consumers is 6 to 9 per cent of their total power bill (Principal Economics 2015). For large businesses, the cost of all government schemes can be as much as 20 per cent of their total power bill (Principal Economics 2015).

The NEM is also facing challenges in delivering reliable energy. The recent blackouts in South Australia are the prime example of the challenges that the NEM is facing in terms of delivering reliable energy to consumers. However, the experience of South Australia is just an extreme version of factors that are being seen across the NEM. The Independent Review carried out following the 2016 blackout in SA has identified that increasing complexity in the NEM is causing concerns about the reliability of the system. The review identifies that increased complexity is being caused by factors such as an increasing share of intermittent renewable energy sources (e.g. wind power), distributed generation (home solar panels), increasing costs for peak generators (gas) and more complex consumer behaviour.

The value that electricity customers place on a reliable electricity supply can be quantified using the value of customer reliability (VCR), measured by the AEMO (2014). The VCR estimates consumers' willingness to pay for reliable electricity supply in dollars per kilowatt hour. This includes residential, commercial, agricultural and industrial users, and customers directly connected to the transmission network. To calculate the values, the AEMO conducted surveys asking consumers how much they would pay to avoid various outage situations. Based on a standard weighting of electricity user types in Victoria, the VCR is estimated at $32.98 per kilowatt hour, in 2015–16 price terms. The impacts valued in this VCR estimate include:

- Loss of work from paid staff
- Lost production
- Extra time taken to complete tasks
- Loss of revenue from fewer sales
- Spoilage of perishable products
- Loss of livestock
- Business downtime
- Loss of heating or air-conditioning

To put this value into context, Deloitte Access Economics (2016b) has previously estimated the costs of a significant blackout in Victoria in 2007. During the blackout, about 7,100,000 kilowatt hours of electricity was lost to 620,342 households and 66,890 businesses, as well as disruptions to major public infrastructure and public hospitals (Nous Group, 2007). Using the VCR, the cost of this blackout was estimated to be around $293 million (Deloitte Access Economics 2016b). This is similar in scale to the initial estimate by Business SA of $367 million for the cost of the 2016 South Australian blackout.

The importance of electricity as an input used throughout the economy, combined with the sharp increase in the costs paid by consumers and industry over the past few years and increasing unreliability means that ongoing reform of the NEM can contribute real and significant economic gains that will benefit households, business and the mining industry. These reforms would need to focus on increasing competition where appropriate, generating the right incentives for cost minimisation and providing efficient levels of reliability.

3.2.4 Openness to foreign investment

As a significant enabler of the most recent mining boom and broader mining-led economic growth in Australia, maintaining an open approach to foreign investment is important for facilitating future industry growth. The extent to which the Australian economy was able to benefit from the recent mining boom was in part dependent on the country's openness to foreign capital, and our ability to capitalise on mining-led growth in the future would likely be compromised if Australia were to move towards a less welcoming investment regime. In addition to providing an additional source of capital funds, foreign direct investment also benefits the Australian mining and METS sector as an important mechanism through which new technologies, equipment and knowledge can be transferred between jurisdictions (Treasury 2016).

Uncertainties in the foreign investment approvals process can be a factor that deters investors from overseas from selecting Australia as an investment destination. For example, recent decisions taken by the FIRB and the Commonwealth Government resulted in the blocking of several significant foreign investment proposals in the energy industry. Separate bids for a majority stake in NSW's Ausgrid from the state-owned China State Grid Corporation and Hong Kong's Cheung Kong Infrastructure were blocked late in the bidding process due to national security concerns (Williams and Foley 2016).

Uncertainty in foreign investment approvals could have broader implications in raising questions about Australia's openness to foreign investment more generally, potentially dissuading inbound investment to other sectors such as mining and METS projects. While it is important to have protections and regulations in place in the interests of national security and similar concerns, the significant degree of uncertainty for foreign investors in relation to the interpretation of these criteria – such as in the Ausgrid case – could deter future investment. Consistent application of these rules is therefore essential in supporting the confidence of foreign investors.

In this context, greater clarity and consistency in FIRB decisions around the factors influencing investment approvals could provide more certainty for overseas companies and funds looking to invest in the sector. This is particularly relevant in encouraging foreign investment to the mining and METS sector, given that much of the future foreign investment in mining is likely to come from China – a country that has experienced uncertainties in FIRB decision-making processes in recent years.

In addition, it will be important for Australia to continue to engage with the region and ensure that trade and investment negotiations remain open. To the extent that Australia's recent free trade agreements with China and Japan facilitate greater trade and investment flows, this will provide a positive indication to foreign investors that Australian policy generally favours openness and regional engagement.

In the coming years, a successful trade negotiation with India will boost opportunities for the minerals industry to supply India's growing demand for resources, including coal and uranium. In 2015, exports of resources accounted for 57 per cent ($7.6 billion) of Australia's total exports to India ($13.4 billion), including coal ($5 billion), gold ($930 million) and copper ores and concentrates ($682 million) (DFAT 2016).

3.2.5 Efficient approaches to regulation

Within the minerals industry, regulatory requirements cover all stages of industry activity from grant of tenure, exploration, extraction, processing, transport and mine closure through to relinquishment of tenure. With the presence of this thorough set of regulations, it is important to ensure that regulatory requirements are simplified or streamlined when efficiency gains can be made without diminishing the goals of the regulation (such as maintaining environmental standards).

For example, there are currently complex and duplicative processes for environmental assessments and approvals. The Productivity Commission has concluded that overlap and duplication between federal and state processes can be greatly reduced without lowering the quality of environmental outcomes (PC 2013c). Inefficient regulatory processes that do not enhance outcomes contribute to lengthy approval timeframes and delays and pose an unnecessary risk to the industry's global competitiveness.

A 2013 Productivity Commission inquiry *Mineral and Energy Resource Exploration* highlighted environmental approvals as one area where regulatory processes may place unnecessary burdens on the mining and METS sector, noting that "addressing state, territory and Commonwealth environmental approvals processes that are duplicative and are not commensurate with the risk and significant of the environmental impacts of exploration" should be an area for improvement (PC 2013b). The report included several recommendations for reform in order to reduce duplication of environmental approvals within and between jurisdictions, including strengthening arrangements between the Commonwealth and states and territories, such as by establishing bilateral agreements for the accreditation of environmental approvals where state and territory processes meet appropriate standards.

Uncertainties and inconsistencies in the various approvals processes are costly for mining and METS companies and the Australian economy more broadly. The benefits of the streamlined project approvals are significant; for example, analysis by the then Department of the Environment concluded streamlining federal and state environmental approval processes would save Australian businesses $426 million annually (Department of the Environment 2014). In addition to these costs, uncertainties and inconsistencies in approval processes affect the willingness of the sector to plan for and invest in future projects.

Furthermore, third party appeals against valid environmental approvals can increase delays and compliance costs for major mining projects that have already been assessed to adequately meet environmental standards. For example, some organisations have been known to employ a "strategy of 'lodging legal challenges' to delay [mining] projects and therefore cause companies to give up, down scale or lose investment" (PC 2013b). While appeal and review mechanisms are important to ensure that approvals are made in a transparent and accountable manner, the Productivity Commission's 2013 research report *Major Project Development Assessment Processes* noted that vexatious litigation or commercially motivated appeals can create unwarranted delays for major projects.

3.2.6 Support for collaboration and entrepreneurship

As noted throughout this report, the mining industry is becoming increasingly knowledge-intensive and open to the adoption of evolving and step-change technologies. A total of 6,539 Australian mining inventions were filed for patent between 1994 and 2011. Australian mining technology is exported globally, with patent filings overseas showing major markets include the United States, Canada, China, Japan, Europe, Russia, Brazil and Mexico (Francis 2015).

The Australian mining and METS sector contributes hundreds of millions of dollars annually through a range of innovative partnerships with research bodies. These include cooperative research centres (CRCMining and CRC Ore), the Australian coal industry's research program (ACARP), the COAL21 Fund for low emissions coal technologies and AMIRA International – which leverages mining R&D. The dividend from this collaboration has been substantial across mine safety, extractive technologies, automation, energy efficiency, low emissions technologies and environmental practices and biodiversity protection.

In addition, analysis by the Department of Industry, Innovation and Science has shown that mining has accounted for the largest industry share of micro start-up businesses and has been one of the largest contributors to job creation by these businesses over the past decade (Hendrickson 2015).

Mining, METS and research organisations are working closely together to develop and accelerate the adoption of innovation into global mining supply chains. METS Ignited is an industry-led, government-funded, Growth Centre for the mining equipment, technology and services sector. The Industry Growth Centre initiative focuses on areas of competitive strength and strategic priority, with the goal of enabling national action on key issues such as regulation reform, skills, collaboration and commercialisation. METS Ignited works with Australian suppliers to the mining industry, global miners, research organisations and capital providers to improve the competitiveness and productivity of the Australian METS sector.

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Appendix A: Economic contribution modelling framework

Economic contribution studies are intended to quantify measures such as value added, exports, imports and employment associated with a given industry or firm, in a historical reference year. The economic contribution is a measure of the value of production by a firm or industry.

All direct, indirect and total contributions are reported as gross operating surplus (GOS), labour income, value add and employment (with these terms defined in Table A.1).

Table A.1: Definitions of economic contribution estimates

Estimate	Definition
Gross operating surplus (GOS)	GOS represents the value of income generated by the entity's direct capital inputs, generally measured as the earnings before interest, tax, depreciation, and amortisation (EBITDA).
Labour income	Labour income is a subcomponent of value add. It represents the value of output generated by the entity's direct labour inputs, as measured by the income to labour.
Value add	Value add measures the value of output (i.e. goods and services) generated by the entity's factors of production (i.e. labour and capital) as measured in the income to those factors of production. The sum of value add across all entities in the economy equals gross domestic product. Given the relationship to GDP, the value add measure can be thought of as the increased contribution to welfare.
Employment (FTE)	Employment is a fundamentally different measure of activity to those above. It measures the number of workers (measured in full-time equivalent terms) that are employed by the entity, rather than the value of the workers' output.
Direct economic contribution	The direct economic contribution is a representation of the flow from labour and capital committed in the economic activity.
Indirect economic contribution	The indirect contribution is a measure of the demand for goods and services produced in other sectors as a result of demand generated by economic activity.
Total economic contribution	The total economic contribution to the economy is the sum of the direct and indirect economic contributions.

Source: Deloitte Access Economics (2017)

Definitional notes

When calculating the GOS for a typical for-profit firm or industry, income streams from government (such as transfers or production subsidies) are excluded as they are a transfer of public funds, not reflective of income generated by the activities of the firm or industry.

Similarly, value added is typically calculated as GOS plus labour income net of subsidies; under the ABS Australian System of National Accounts (ASNA)[10]:

> *A subsidy on a product is a subsidy payable per unit of a good or service. An enterprise may regard a subsidy as little different from sales proceeds. However, in the national accounts, subsidies are regarded as transfer payments from general government, enabling enterprises to sell their output for less than would otherwise be the case.*

In this context, it should be noted that according to the Productivity Commission: 'The estimated effective rate of assistance from tariff and budgetary assistance for mining is negligible' (PC 2016b, 26). The PC defines the effective rate of assistance as the ratio of total assistance to unassisted output, with an effective rate of assistance for the mining sector estimated to be 0.1 per cent.

Value added

The measures of economic activity provided by this contribution study are consistent with those provided by the Australian Bureau of Statistics. For example, value added is the contribution the sector makes to total factor income and gross domestic product (GDP).

There are a number of ways to measure GDP, including:

- **expenditure approach** – measures expenditure: of households, on investment, government and net exports; and
- **income approach** – measures the income in an economy by measuring the payments of wages and profits to workers and owners.

Below is a discussion measuring the value added by an industry using the income approach.

Measuring the economic contribution – income approach

There are several commonly used measures of economic activity, each of which describes a different aspect of an industry's economic contribution:

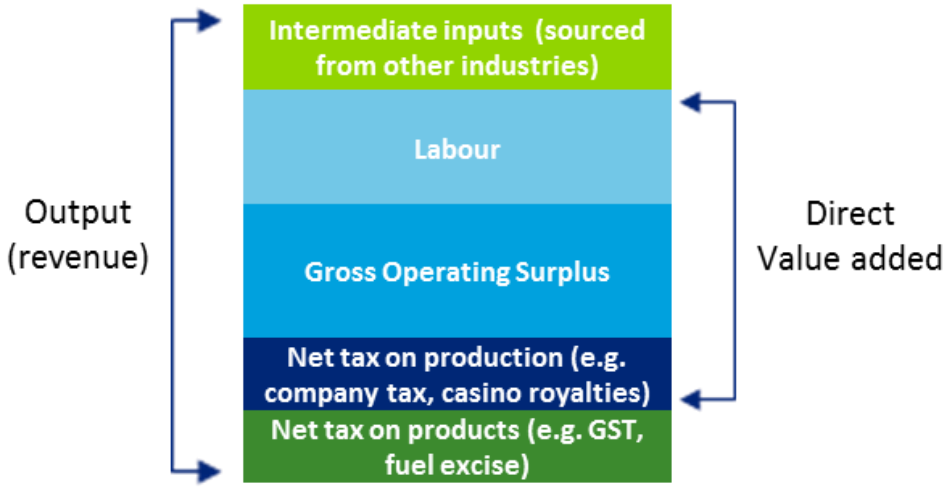
- **Value added** measures the value of output (i.e. goods and services) generated by the entity's factors of production (i.e. labour and capital) as measured in the income to those factors of production. The sum of value added across all entities in the economy equals gross domestic product. Given the relationship to GDP, the value added measure can be thought of as the increased contribution to welfare.
  Value added is the sum of:
  - Gross operating surplus (GOS) represents the value of income generated by the entity's capital inputs, generally measured as the earnings before interest, tax, depreciation and amortisation (EBITDA).
  - Tax on production less subsidy provided for production. Note: given the manner in which returns to capital before tax are calculated, company tax is not included or this would double-count that tax. In addition it excludes goods and services tax, which is a tax on consumption (i.e. levied on households).
  - Labour income is a subcomponent of value added. It represents the value of output generated by the entity's direct labour inputs, as measured by the income to labour.

Figure A.1 shows the accounting framework used to evaluate economic activity, along with the components that make up *output*. Output is the sum of value added and the value of intermediate inputs used by the firm or industry.

The value of intermediate inputs can also be calculated directly by summing up expenses related to non-primary factor inputs.

[10] Australian Bureau of Statistics (2013). *Australian System of National Accounts – Concepts, Sources and Methods*

Figure A.1: Economic activity accounting framework



Source: Deloitte Access Economics (2017)

Contribution studies generally outline employment generated by a sector. Employment is a fundamentally different measure of activity to those above. It measures the number of workers that are employed by the entity, rather than the value of the workers' output.

Direct and indirect contributions

The **direct** economic contribution is a representation of the flow from labour and capital in the company.

The **indirect** contribution is a measure of the demand for goods and services produced in other sectors as a result of demand generated by the direct economic activity of the mining and METS industry. Estimation of the indirect economic contribution is undertaken in an input-output (IO) framework using Australian Bureau of Statistics IO tables which report the inputs and outputs of specific sectors of the economy (ABS 2013).

The total economic contribution to the economy is the sum of the direct and indirect economic contributions.

Other measures, such as total revenue or total exports are useful measures of economic activity, but these measures alone cannot account for the contribution made to GDP. Such measures overstate the contribution to value added because they include activity by external firms supplying inputs. In addition, they do not discount the inputs supplied from outside Australia.

Limitations of economic contribution studies

While describing the geographic origin of production inputs may be a guide to a firm or industry's linkages with the local economy, it should be recognised that these are the type of normal industry linkages that characterise all economic activities.

Unless there is unused capacity in the economy (such as unemployed labour) there may not be a strong relationship between a firm's economic contribution as measured by value added (or other static aggregates) and the welfare or living standard of the community. The use of labour and capital by demand created from the industry comes at an opportunity cost as it may reduce the amount of resources available to spend on other economic activities. This is not to say that the economic contribution, including employment, is not important. As stated by the Productivity Commission in the context of Australia's gambling industries:[11]

[11] Productivity Commission (1999), *Australia's Gambling Industries*, Report No. 10, AusInfo, Canberra, (page 4.19).

> *Value added trade and job creation arguments need to be considered in the context of the economy as a whole … income from trade uses real resources, which could have been employed to generate benefits elsewhere. These arguments do not mean that jobs, trade and activity are unimportant in an economy. To the contrary they are critical to people's well-being. However, any particular industry's contribution to these benefits is much smaller than might at first be thought, because substitute industries could produce similar, though not equal gains.*

In a fundamental sense, economic contribution studies are simply historical accounting exercises. No 'what-if', or counterfactual inferences – such as 'what would happen to living standards if the firm or industry disappeared?' – should be drawn from them.

The analysis – as discussed in the report – relies on a national IO table modelling framework and there are some limitations to this modelling framework. The analysis assumes that goods and services provided to the sector are produced by factors of production that are located completely within the state or region defined and that income flows do not leak to other states.

The IO framework and the derivation of the multipliers also assume that the relevant economic activity takes place within an unconstrained environment. That is, an increase in economic activity in one area of the economy does not increase prices and subsequently crowd out economic activity in another area of the economy. As a result, the modelled total and indirect contribution can be regarded as an upper-bound estimate of the contribution made by the supply of intermediate inputs.

Similarly the IO framework does not account for further flow-on benefits as captured in a more dynamic modelling environment like a Computerised General Equilibrium (CGE) model.

Input-output analysis

Input-output tables are required to account for the intermediate flows between sectors. These tables measure the direct economic activity of every sector in the economy at the national level. Importantly, these tables allow intermediate inputs to be further broken down by source. These detailed intermediate flows can be used to derive the total change in economic activity associated with a given direct change in activity for a given sector.

A widely used measure of the spill-over of activity from one sector to another is captured by the ratio of the total to direct change in economic activity. The resulting estimate is typically referred to as 'the multiplier'. A multiplier greater than one implies some indirect activity, with higher multipliers indicating relatively larger indirect and total activity flowing from a given level of direct activity.

The IO matrix used for Australia is derived from the ABS 2012-13 IO tables (2013), the latest available IO data at the time of the analysis. The industry classification used for IO tables is based on the Australian and New Zealand Standard Industrial Classification (ANZSIC), with 114 sectors in the modelling framework.

In order to produce economic contribution estimates for 2015-16, the figures in the 2012-13 IO tables were updated using the latest National Accounts figures from the ABS. It was assumed that the mining proportion of the overall mining and METS sector grew at the same rate from 2012-13 to 2015-16 as the three key ANZSIC mining industries: Coal Mining, Iron Ore Mining and Other Mining. It was assumed that the METS proportion of the overall mining and METS sector grew at the same rate as the ANZSIC Exploration and Mining Support Service industry.

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