The Mining Industry: From Bust to Boom

Ellis Connolly and David Orsmond*

1. Introduction

The Australian mining industry experienced a remarkable revival over the 2000s. At the beginning of the decade, mining was dismissed as emblematic of Australia's 'old economy', with prices for key resource exports at their lowest levels in real terms for a century.[1] This seemed to corroborate the Prebisch-Singer hypothesis that commodity prices would continue to fall over time relative to other goods and services.[2] However, the rapid urbanisation and industrialisation of emerging economies in Asia dramatically transformed global commodity markets over the 2000s. This paper highlights the turnaround in the fortunes of the mining industry, and discusses the effects on the economy more generally.

Australia has been particularly well placed to benefit from the rise in demand for commodities. As discussed in Section 2 of the paper, the prices of commodities used in steel and energy production rose particularly sharply over the decade. In response, the composition of the Australian mining industry shifted towards the extraction of coal, iron ore and liquefied natural gas (LNG), and away from metals processing, as outlined in Section 3. In the second half of the decade, mining investment rose to its highest recorded levels as a share of the economy. Along with expansions in coal and iron ore, several very large LNG projects commenced in response to strong demand for natural gas, with a number of Asian economies looking to diversify their sources of energy. The high level of investment is expected to result in substantial increases in resources production by the mid 2010s.

The rise in global commodity prices has boosted activity and incomes in the economy and encouraged the factors of production to shift towards the mining industry. Section 4 outlines the strong growth in labour, materials and investment in the mining industry, along with its effect on national incomes and domestic demand. The effects were initially more easily identifiable in the resource-rich states of Western Australia and Queensland, although by the end of the decade, the benefits appeared to be flowing more evenly across the country.

* Thanks to our colleagues at the RBA for many helpful comments. The views expressed are those of the authors and do not necessarily reflect the views of the RBA.

1 For instance, Macfarlane (2002) noted the criticism Australia received during the World Economic Forum in Melbourne in 2000 for not making more IT and telecommunications investments.

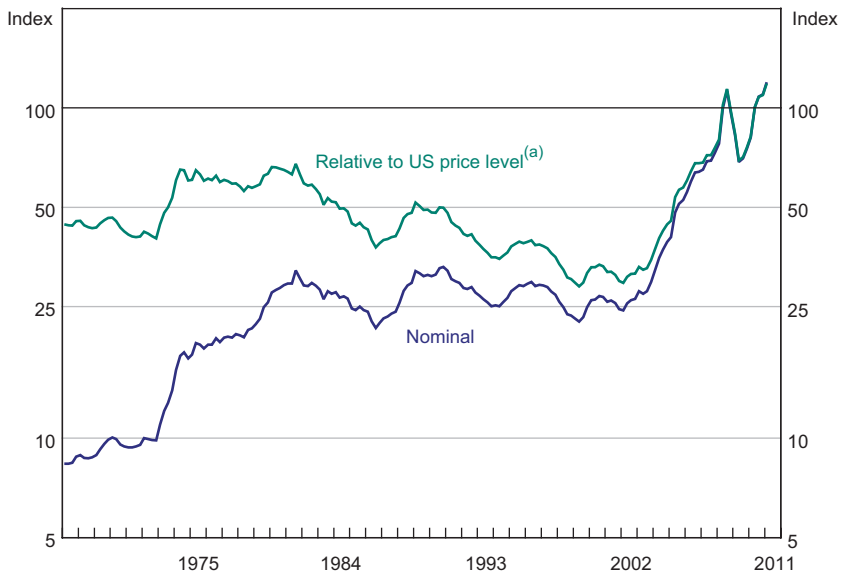
2 See Gillitzer and Kearns (2005) for a discussion of the Prebisch-Singer hypothesis.

Australia's macroeconomic performance during this period has been much more stable than in the earlier mining booms between the late 1960s and early 1980s. Section 5 argues that part of the explanation is a stronger institutional framework, with a floating exchange rate, decentralised wage bargaining, an inflation-targeting regime and more flexible product markets. The clear price signals and flexible economic environment helped to encourage resources to shift towards the mining industry without destabilising broader inflation expectations.

2. Global Demand, Supply and Commodity Prices

Global commodity prices soared during the 2000s, driven by strong demand from emerging economies, with the boom exceeding both in duration and magnitude the period of high commodity prices in the 1970s. From 2003 to 2011, global prices for Australia's resource exports (in US dollar terms) increased by more than 300 per cent, after having been flat in nominal terms over the preceding two decades (Figure 1). While the rise has been broad based, there were particularly large increases in the prices of the key steelmaking commodities that Australia exports. Prices of energy commodities, such as oil and thermal coal, also increased strongly. The extraordinary increase in commodity prices highlights that global supply has had difficulty keeping pace with the growth in demand.

Figure 1: Resource Export Prices
US$, 2010 average = 100, log scale

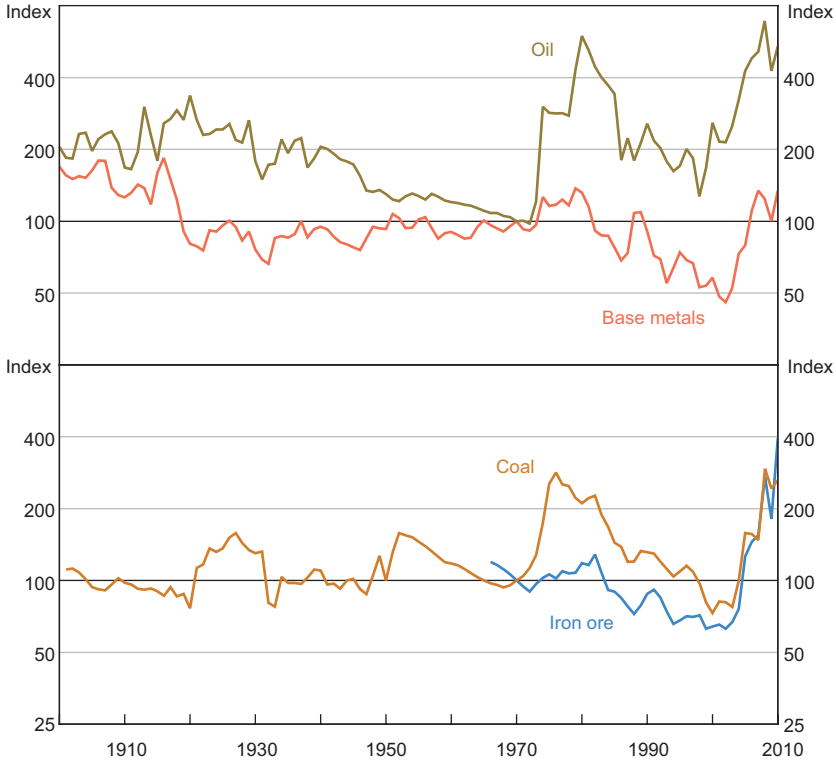


Note: (a) Using US GDP deflator, given that commodities are priced globally in US dollars
Sources: ABARES; ABS; RBA; Thomson Reuters

The pick-up in commodity prices over recent years followed a period from the late 1980s to the early 2000s when real prices were unusually low by historical standards. Compared with the average price level in the United States, commodity prices fell noticeably from their peak in 1981,

to be well below historical averages in the late 1990s; the oil price troughed near US$10 per barrel in late 1998, its lowest inflation-adjusted price since 1974, while real base metals and coal prices were at their lowest levels in at least a century (Figure 2).

Figure 2: Resource Prices
Relative to US GDP deflator, 1970 = 100, log scale

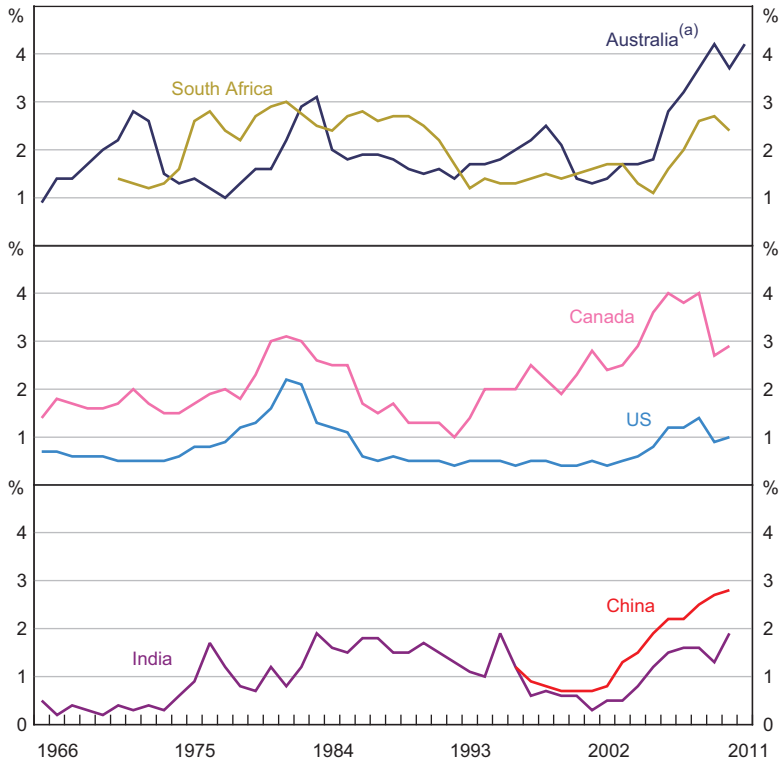


Sources: ABARES; ABS; Bureau of Mineral Resources, Geology and Geophysics; Global Financial Data; IMF; RBA; US Geological Survey; World Bank

The stagnation of commodity prices through the 1980s and 1990s discouraged producers from investing in capacity expansions. The 1990s saw Japan's 'lost decade' and the collapse of the former Soviet Union where steel production and energy consumption fell by more than a third. Later in the 1990s, a number of Australia's major trading partners were affected by the Asian financial crisis, which was followed by the early 2000s global recession and a sharp slowdown in world trade. With depressed commodity prices and a subdued outlook for demand, mining investment as a share of the economy was relatively low in a range of commodity producers including Australia, while global exploration expenditure was also weak (Coombs 2000; Metals Economics Group 2011; Figure 3). There was a wave of mergers in the global mining industry, as companies sought economies of scale in an attempt to offset sliding profitability. This is also likely to have contributed to the reduction in mining investment, as the merged companies consolidated their capital expenditure and exploration budgets (Hogan *et al* 2002). As a result

of this prolonged period of low investment, the mining industry was not in a strong position to quickly increase supply when global demand for commodities finally picked up strongly in 2003.

Figure 3: Mining Investment
Per cent of nominal GDP



Note: (a) Financial years; 2010/11 estimate based on partial indicators to March 2011

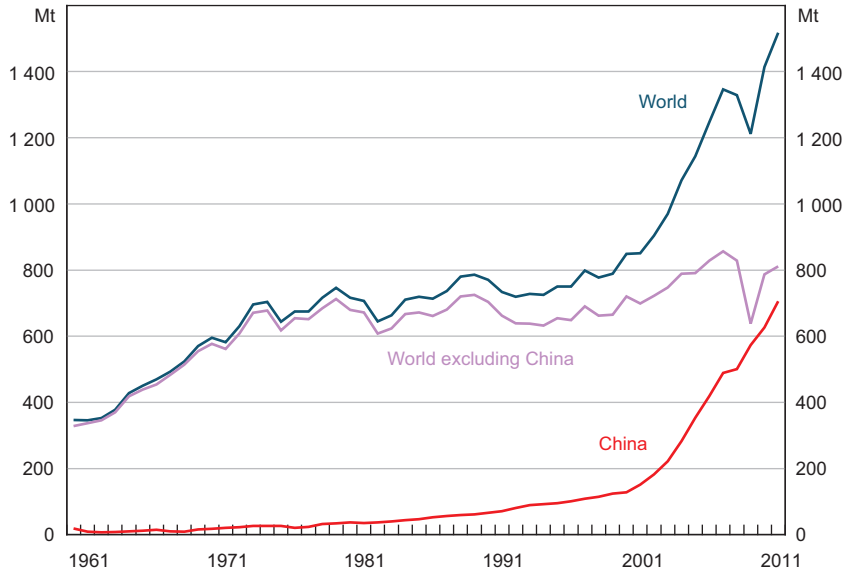
Sources: ABS; Bureau of Economic Analysis; CEIC; IMF; OECD; RBA; Statistics Canada; Thomson Reuters

The global steel industry – the source of demand for Australian iron ore and coking coal – suffered a particularly long period of stagnation from the mid 1970s to the early 2000s, with production in the G7 economies and the former Soviet Union falling significantly (Figure 4). This followed a golden period for the steel industry until the onset of the first oil shock in 1973, with strong demand from Japan spurring the development of the Australian seaborne trade in iron ore. After the Asian financial crisis and the 2001 recession in the United States, there was perceived to be considerable overcapacity in the global steel industry. Steelmaking countries – mindful of the US Government's plans to raise trade barriers on steel – agreed in 2002 to significantly reduce steel capacity,[3] while the Chinese Government placed a prohibition on building new steelmaking facilities and sought to close down obsolete steel mills (OECD 2001). While these announcements

3 The agreement was to cut steel capacity equivalent to 14 per cent of global production over three years and included countries that accounted for 80 per cent of global steel production in 2000. The key producer not party to the agreement was China (OECD 2002).

highlight how grim the outlook for steelmaking commodities appeared at the beginning of the decade, Chinese steel production nonetheless began accelerating and production in the rest of the world recovered after the 2001 recession.

Figure 4: World Steel Production

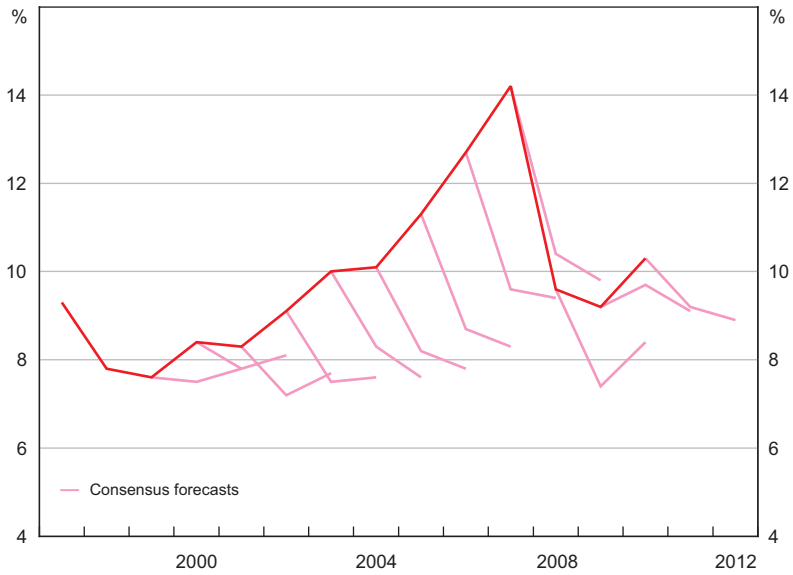


Note: 2011 based on data to June

Sources: CEIC; World Steel Association (worldsteel)

Emerging economies have been the key drivers of global growth and the surge in commodity prices since 2003. China's steel production picked up strongly in the early 2000s, driving growth in global production as rapid as that seen in the 1960s and early 1970s. While the potential of China's large domestic market was recognised in the early 2000s, the rapid pace at which it would industrialise through the decade and the implications for commodity prices were not widely anticipated. For instance, consensus forecasts consistently under-predicted China's growth from 1999 through to 2007; it was not until the second half of the 2000s that analysts began to forecast that the medium-term rate of growth had increased above the Chinese Government's 7–8 per cent targets in their five-year plans (Figure 5). Similarly, mining companies took some time to be convinced that the pick-up in commodities demand would be sustained, with mining investment as a share of GDP not rising to above-average levels until the second half of the 2000s.

Figure 5: China – GDP Growth
Annual average

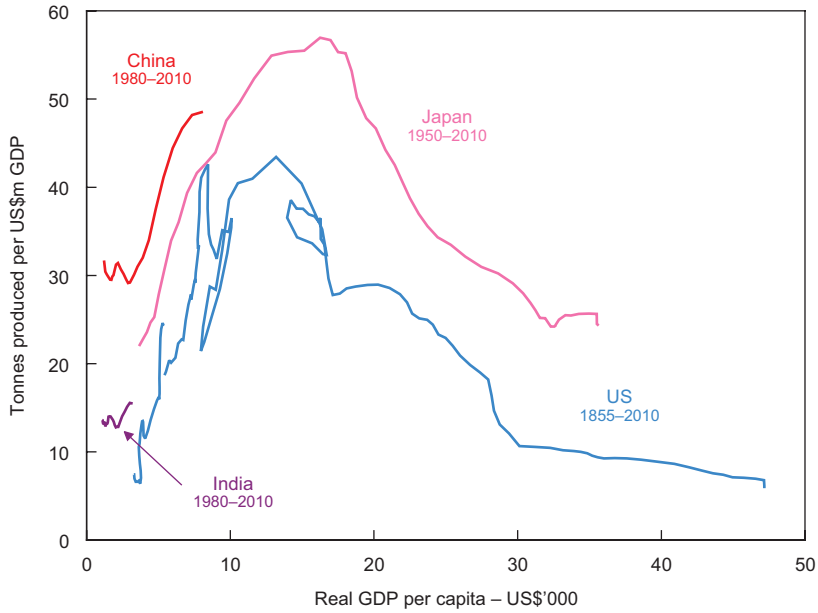


Note: As at January of first forecast year
Sources: CEIC; Consensus Economics

China's demand for steel has been driven by a sustained period of rapid industrialisation and urbanisation, requiring high levels of investment in infrastructure, buildings and machinery.[4] The 'steel intensity' of the Chinese economy has risen over the past 30 years, as occurred during the industrialisation phases in the United States in the late nineteenth century and Japan in the 1950s and 1960s, with resources in the economy shifting away from agriculture towards manufacturing as real incomes rise (Figure 6). Past experience suggests that the process of steel intensification eventually slows and reverses once infrastructure is in place and households begin to demand more services, as occurred in the US post-WWII and in Japan since the 1970s. However, the period of high steel intensity in China has the potential to continue for some time given the relatively low level of per-capita income and the continuing process of urbanisation. The United Nations (2009) projects that China's urban population will grow by around 50 per cent in the next 25 years – an increase of over 300 million people – requiring ongoing investment in housing and infrastructure. Furthermore, there is considerable scope for demand from India to rise in the future as it moves into the phase of steel-intensive growth. India's Government is promoting the development of its steel industry to meet the country's substantial infrastructure needs, with the United Nations projecting that India will become the most populous country in the world in the next 20 years (see Cagliarini and Baker (2010) for further discussion).

4 For more detail on developments in the Chinese steel industry, see Holloway, Roberts and Rush (2010). Also see Roberts and Rush (2010) for an analysis of the sources of Chinese demand for steel, which include construction and manufacturing exports.

Figure 6: Steel Production Intensity and Economic Development

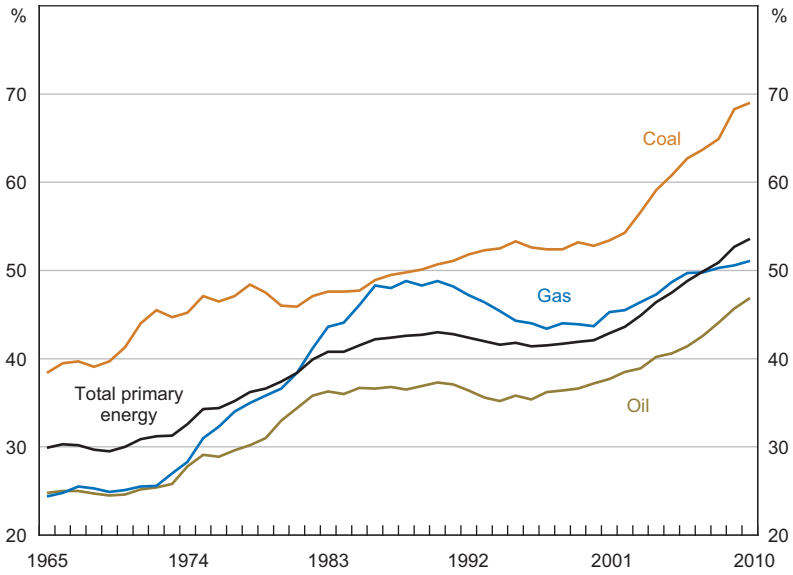


Notes: 2010 prices converted at 2005 PPP exchange rates; 5-year moving-averages; US iron production intensity prior to 1897; Japan steel production is by JFY prior to 1980

Sources: The Conference Board, Total Economy Database™ (January 2011); IMF; The Japan Iron and Steel Federation; Johnston and Williamson (2010); Maddison (2009); RBA; US Bureau of Mines; US Geological Survey; World Steel Association (worldsteel)

Strong demand from emerging economies is also affecting energy markets, with the share of global energy consumed by these economies rising from a little over 40 per cent in 2000 to above 50 per cent in 2010, driven by China, India and the Middle East (Figure 7). China is the world's largest consumer of coal – both for steelmaking and electricity generation – while India is the third largest. China's share of global coal consumption rose from around 30 per cent in 2000 to 50 per cent in 2010, with China switching from being a net exporter to an importer of coal later in the decade. While China and India consumed only 5 per cent of global natural gas in 2010, the growth in their consumption has been much more rapid than the world average. Globally, there is also likely to be some substitution towards natural gas as a way to reduce carbon emissions, since it is the cleanest burning fossil fuel. The IEA (2010) projects that China and India will contribute half of the growth in global energy use over the period to 2035, with their energy mix shifting towards gas, supporting the expansion of the LNG industry in Australia.

Figure 7: Emerging Economies' Share of Global Energy Consumption



Note: Emerging economies include all non-OECD economies

Source: *BP Statistical Review of World Energy*, June 2011

3. The Australian Mining Industry during the 2000s

Australia is a significant producer and exporter of a wide range of commodities, and is well placed to benefit from the rise in demand for steel and energy. The country is endowed with reserves of coal, iron ore, bauxite, copper and gold that rank in the top six worldwide (Geoscience Australia 2010). These reserves are sufficient to sustain current production levels for many more decades, and ongoing exploration and technological advances are likely to continue to increase supply (Table 1). In contrast to these resources, Australia's reserves of oil and gas are small in a global context. While Australia's oil reserves would be exhausted in around 20 years at current rates of extraction, known reserves of gas have grown strongly over recent decades and would sustain the current production rate for an extended period.

Table 1: Australia's Resource Reserves and Production

	Share of global reserves in 2009[(a)] Per cent	Remaining years of production at 2009 rate	Share of global production Per cent	
			2000	2009
Coal[(b)]	7	98	7	6
Iron ore	17	71	18	25
Bauxite	23	95	39	34
Copper	13	94	6	6
Gold	16	33	11	9
Oil	0.3	21	1	1
Gas	2	61	1	2

Notes: (a) Economic-demonstrated resources for coal, iron ore, bauxite, copper and gold; proved reserves for oil and gas
(b) Excludes brown coal

Sources: ABARES; *BP Statistical Review of World Energy,* June 2011; Geoscience Australia

In the early 2000s, the Australian mining industry was suffering from the weakness in global commodity markets outlined in the previous section. Parts of the industry, including gold and base metals, were in the downward phase of an investment cycle following the Asian financial crisis, and exploration expenditure was at its lowest level as a share of the economy since the early 1960s. The weakness was highlighted by the failures of several mining companies early in the decade, including Pasminco and Centaur Mining in 2001, and Anaconda Nickel defaulting on its bonds in 2002.[5] In a global wave of mergers and acquisitions, several Australian mining companies became part of multinationals as companies sought economies of scale to sustain profitability, with the most notable being the merger of BHP and Billiton, along with the takeovers of Mount Isa Mines (MIM) by Xstrata and North Limited by Rio Tinto. Overall, of the top 20 mining companies on the Australian Securities Exchange (ASX) in 2000, only 7 of these were still listed in Australia at the end of 2005 (Table 2).

5 Pasminco (Australia's largest zinc mining company and owner of the Century Zinc mine) and Centaur Mining (a nickel and gold exploration and mining company) both failed in 2001 as a result of falling commodity prices and their currency hedging strategies. Anaconda Nickel (developer of the Murrin Murrin nickel mine) went into default on its bonds in 2002, although it recovered following an equity raising from existing shareholders and was renamed Minara Resources in 2003.

Table 2: Consolidation of the Australian Mining Industry

Top 20 mining companies listed on ASX in 2000	ASX market capitalisation $ billion		Mergers, takeovers and failures in the first half of the 2000s
	March 2000	July 2011	
BHP	32.0	139.5	2001: merged with Billiton
Rio Tinto[a]	15.4	45.7	
WMC	7.4		2005: taken over by BHP Billiton
Woodside Petroleum	6.6	31.6	2001: attempted takeover by Royal Dutch Shell
Comalco	5.3		2000: taken over by Rio Tinto
North[b]	2.6		2001: taken over by Rio Tinto
Santos	2.4	11.7	
MIM	1.8		2003: taken over by Xstrata
Normandy Mining[c]	1.8		2002: taken over by Newmont Mining (US company)
Pasminco	1.1		2001: placed in voluntary administration
Southern Pacific Petroleum[d]	1.1		2003: went into receivership
Iluka Resources	0.8	7.9	
Newcrest Mining	0.8	30.6	
Anaconda Nickel	0.8	0.8	2002–2003: defaulted on bonds, recapitalised by investors; changed name to Minara Resources
Sons of Gwalia	0.6		2004: placed in voluntary administration
QCT Resources	0.5		2000: taken over by BHP
Delta Gold	0.4		2002–2006: involved in series of mergers and takeovers, eventually taken over by Barrick Gold (Canadian company)
Ticor	0.3		2005: taken over by Anglo American
Novus Petroleum	0.2		2004: taken over by Medco Energi (Indonesian company)
Ashton Mining	0.2		2000: taken over by Rio Tinto

Notes: (a) Includes market capitalisation of Coal & Allied, which was majority owned by Rio Tinto throughout the decade, and ERA following Rio Tinto's takeover of North Ltd
(b) Includes market capitalisation of ERA, majority owned by North Ltd
(c) Includes market capitalisation of Normandy NFM, majority owned by Normandy Mining
(d) Includes market capitalisation of Central Pacific Minerals, which had significant cross shareholdings with Southern Pacific Petroleum, with the two companies merging in 2002

Sources: AFR (2011); BRW (2000); RBA; company announcements

The value of Australia's resource exports rose strongly during the 2000s, to be over half of total exports by the end of the decade, driven by annual average growth in commodity prices of 9 per cent in Australian dollar terms (Table 3). In contrast, the volume of resource exports only increased at an annual rate of 3 per cent over the period, half its rate of growth during the 1990s. Within the mining industry there was considerable structural change over the decade. In the 1990s, processed metals (such as aluminium, copper and gold) made up almost one-third of Australia's resource exports, as large as the combined exports of iron ore and all other ores. However, by the end of the 2000s, Australia's comparative advantage had clearly shifted towards the export of coal and iron ore, where volumes and especially prices growth were high. In contrast, processed metals export volumes contracted, and their share in total exports fell sharply. With the gradual exhaustion of some of Australia's major oil basins, the volume of crude oil exports also fell, although this was offset by the shift in production away from oil towards LNG, which grew at a rapid pace over the decade.

Table 3: Australia's Resource Exports
Per cent

	Average annual growth				Share of total export values		
	Volumes		Prices				
	1990 –2000	2000 –2010	1990 –2000	2000 –2010	1990	2000	2010
Coal	6	6	–1	10	9	6	15
Oil and gas	9	1	6	5	5	9	8
Crude oil	11	–2	5	6	3	6	4
LNG	11	9	6	5	1	2	3
Iron ore	5	10	2	15	4	3	17
Other ores	4	0	0	9	10	6	8
Processed metals[(a)]	5	–2	0	5	13	10	7
Total resources[(a)]	**6**	**3**	**1**	**9**	**40**	**35**	**55**

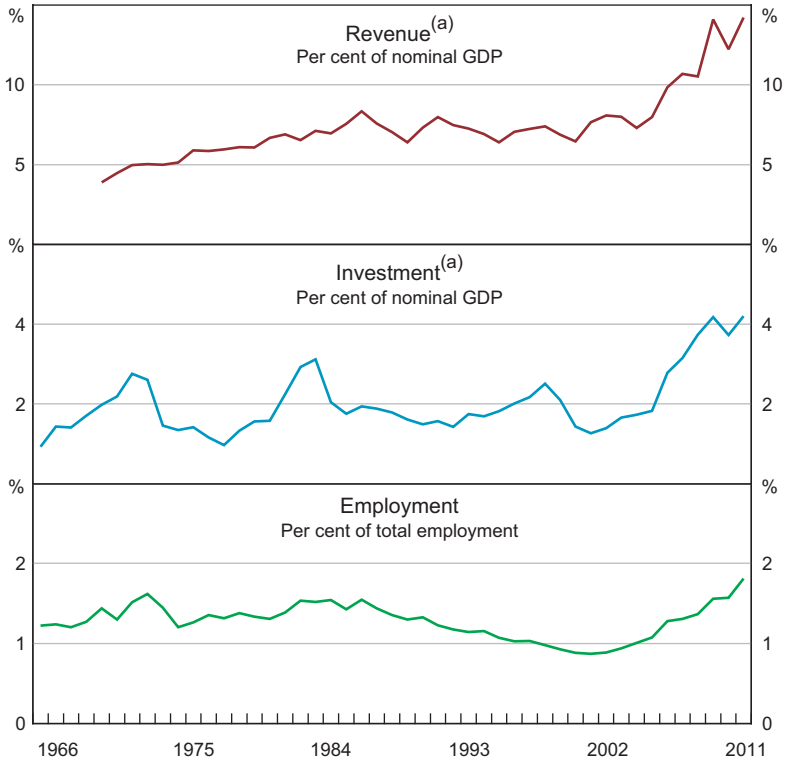
Note: (a) Net of gold imports, which are largely re-exported

Sources: ABS; ABARES; RBA

In a historical context, the mining boom in the 2000s was much larger as a share of the economy than the mining booms in previous decades in terms of sales revenue, investment and employment (Figure 8).[6] Mining revenue increased from 6 per cent of GDP in 2000 to 14 per cent by the end of the decade, driven by the growth in bulk commodity export receipts. Mining investment rose from 1½ per cent of GDP in 2000 to over 4 per cent recently, to be well above the levels during previous booms. Mining employment increased from under 1 per cent of total employment in 2000 – the lowest share in at least a century – to 1.7 per cent by the end of the decade – the highest share in over 50 years. These ratios are continuing to rise into the current decade.

6 Mining revenue is almost entirely sales and service income; it also includes government funding for operational costs, capital work done for own use and the change in inventories.

Figure 8: Mining Industry
Financial years



Note: (a) 2010/11 estimates based on partial indicators to March 2011

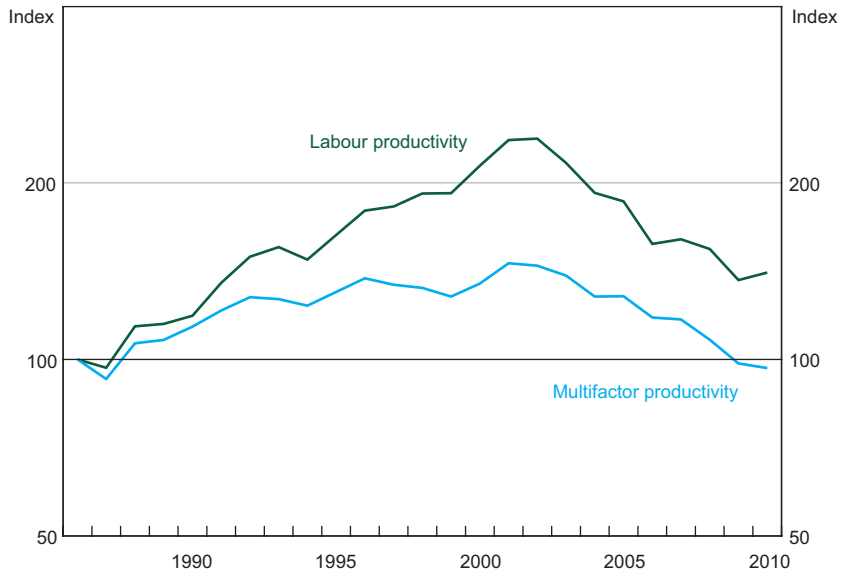
Sources: ABS; RBA; Withers, Endres and Perry (1985)

While mining industry revenue has grown rapidly over the decade, the volume of output has only grown at an annual average rate of 3 per cent, despite mining employment more than doubling and strong growth in the capital stock. As a consequence, both labour productivity and multifactor productivity are estimated to have fallen from around 2003, when commodity prices started rising sharply (Figure 9). This followed a period of strong productivity growth, as mining firms reduced costs through industry consolidation, outsourcing and the adoption of new technologies in response to the low commodity prices around the beginning of the decade (Mélanie *et al* 2002). Topp *et al* (2008) explored the potential explanations for this fall in productivity, highlighting two factors as the most significant, with both related to the mining boom. First, the depletion of reserves for commodities such as oil and copper reduced productivity, as mining companies began to extract lower-grade resources using more inputs.[7] This effect was exacerbated by the rise in commodity prices, which made the extraction of more marginal deposits profitable. Second, there are long lead times between investment in new capacity and

7 Mudd (2010) finds there are long-term declines in average ore grades processed for most metallic minerals in Australia. There is also a compositional element: the oil industry, which is highly capital intensive and therefore has a relatively high level of labour productivity, has been receiving less weight in mining sector productivity measures as its output falls.

the output coming on stream, with Topp *et al* estimating that the lead time had historically been around three years.[8] Looking ahead, production and export volumes of iron ore, coal and LNG are expected to grow strongly over coming years, as currently committed investment projects are completed, which may contribute to a recovery in mining productivity (Christie *et al* 2011).

Figure 9: Mining Productivity
1985/86 = 100, financial years, log scale



Source: ABS

The rise in mining revenue over the 2000s has been dominated by iron ore and coal, while the largest investments have occurred in oil and gas, particularly LNG (Table 4). In contrast, the mining of other ores has experienced a much smaller boom, while metals manufacturing has weakened over the decade. The composition of mining employment is quite different from revenue and investment, with the oil and gas industry employing relatively few workers, reflecting its high capital intensity. Most employees in the industry work in ores mining and mining exploration and support services. The most striking trend in employment has been the steady decline of metals manufacturing, which employed more than twice as many workers as the mining industry at the start of the decade, but ended the 2000s as a smaller employer.

8 Consistent with this, Gruen and Kennedy (2006) noted that it took over five years from the start of the mining boom in the late 1970s for commodity export volumes to start growing strongly. Also see Eslake (this volume) for a discussion of mining productivity.

Table 4: Revenue, Investment and Employment

	Revenue		Investment		Employment	
	1999/2000	2009/10	1999/2000	2009/10	1999/2000	2009/10
Share of total	%	%	%	%	%	%
Coal	25	29	8	14	25	27
Oil and gas	26	18	36	44	5	10
Iron ore	9	23	4	19	8	9
Other ores	35	21	49	16	41	33
Mining services	5	9	3	6	21	21
Totals	$b	$b	$b	$b	'000s	'000s
Mining	43	157	10	48	78	173
Metals manufacturing[(a)]	13	17	3	7	182	147

Note: (a) Metals manufacturing value added is presented instead of revenue to avoid double counting the inputs from the mining industry

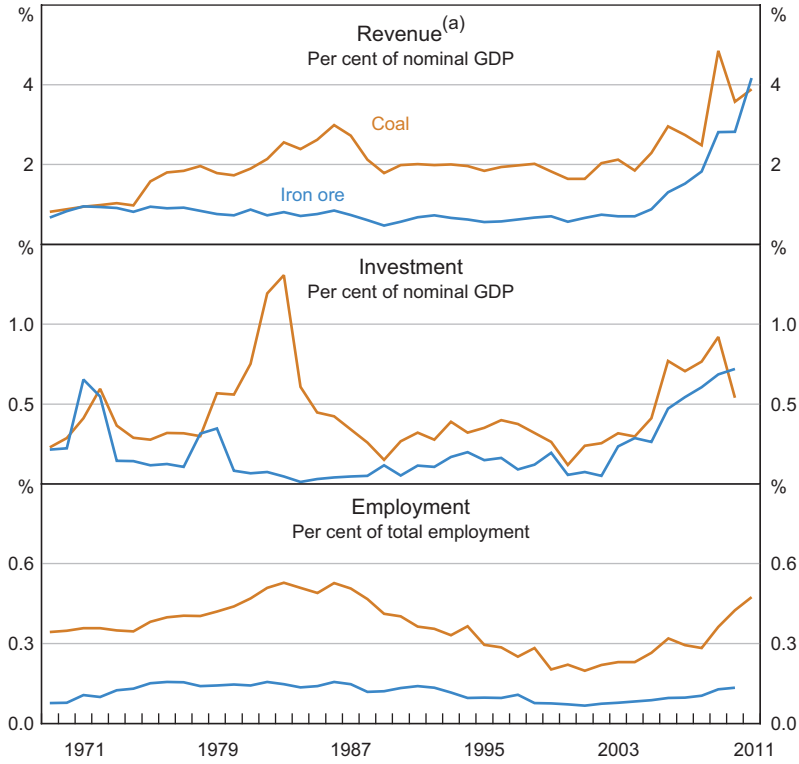
Sources: ABS; RBA; company reports

3.1 The boom in bulk commodities

The rise of Chinese demand for steel and energy has led to significant changes in bulk commodities markets. Iron ore and coking coal are key inputs into the production of steel, while thermal coal is primarily used to generate electricity. Australia is a relatively low-cost supplier of iron ore and coal, with large reserves of hematite iron ore, requiring little processing before export, and good quality black coal, characterised by low ash and sulphur content. Australia's mining operations are also relatively efficient and close to Asian markets, reducing freight costs (Mélanie *et al* 2002). Iron ore has become a larger share of the mining industry over recent years, with revenues rising from less than 1 per cent of GDP through the 1990s to over 3 per cent of GDP by the end of the 2000s, and investment has risen well above historical levels as a share of GDP (Figure 10). Revenue in the coal industry has also risen strongly over recent years, to above the highs following the energy boom in the early 1980s, while investment has risen to its highest levels since that period.

At the beginning of the decade, analysts were forecasting weak growth in demand for coking coal and iron ore. They were expecting moderate increases in world steel production to be partly offset by more efficient steelmaking operations that required fewer raw materials. While growing demand from China was recognised, China was thought to have abundant reserves of coal, and following the Asian financial crisis, the Chinese Government provided incentives for producers to export coal, with the consequent increase in exports depressing international prices (Schneider 2004; Andrews 2009). Following the global wave of consolidation noted earlier, Rio Tinto, BHP Billiton and Vale (in Brazil) accounted for around 70 per cent of the seaborne trade in iron ore (ABARE 2002).

Figure 10: Iron Ore and Coal Mining
Financial years

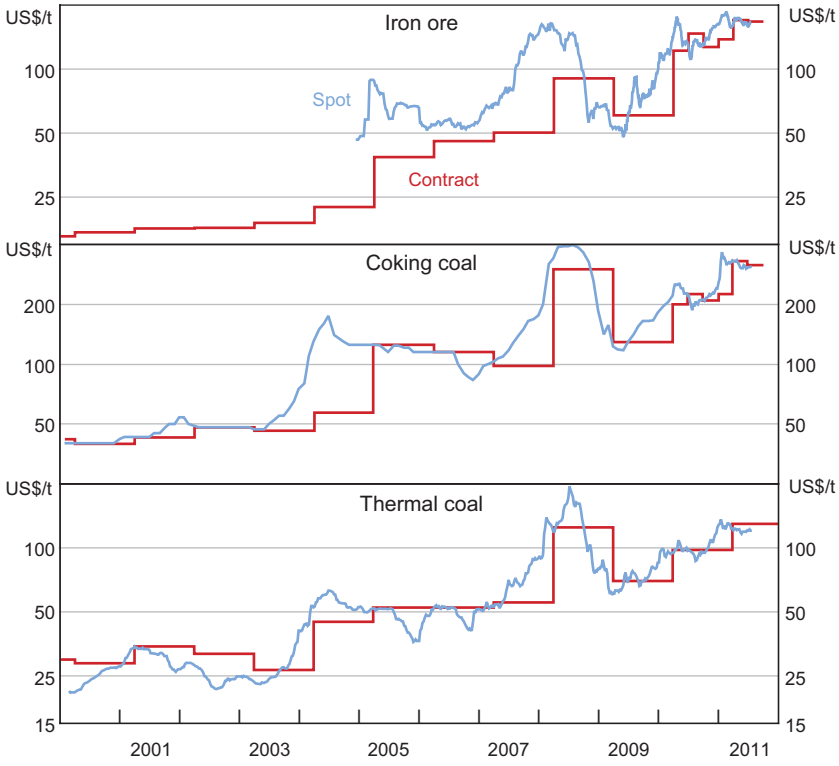


Note: (a) 2010/11 estimates based on partial indicators to March 2011

Sources: ABS; RBA; company reports

The benchmark contract prices for bulk commodities, which had been settled annually with Japanese steel mills and utilities since the 1960s, rose strongly in response to the surge in Chinese demand. Thermal coal contract prices increased by 70 per cent in 2004, while coking coal prices rose by 120 per cent and iron ore prices by 70 per cent in 2005 (Figure 11). These were the largest price increases seen since the energy price boom of the 1970s. However, there were doubts at the time as to whether the rapid growth in demand would be sustained, with commodities analysts predicting longer-term price declines of around 40 per cent (discussed in RBA (2005)). Throughout the remainder of the decade, analysts repeatedly forecast iron ore and coal prices to remain flat or decrease from their relatively high levels, only for them to increase further in subsequent years, consistent with the general under-prediction of Chinese growth. Following the contract price rises of 2004 and 2005, investment in the coal and iron ore industries as a share of the economy increased to above historical averages.

Figure 11: Bulk Commodity Prices
US$ per tonne, free on board basis, log scale



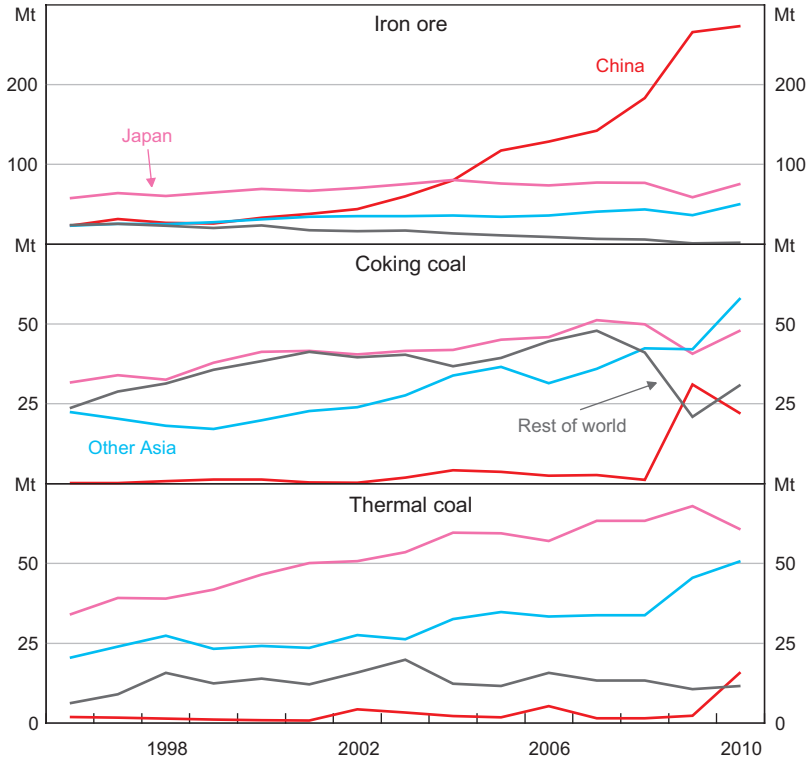
Sources: ABARES; Bloomberg; Citigroup; Energy Publishing; globalCOAL; Macquarie Bank; RBA

There was a second round of very large increases in bulk commodity contract prices in 2008, which was followed shortly after by a collapse in demand during the North Atlantic financial crisis, and eventually an overhaul of the pricing mechanism for iron ore and coking coal when demand recovered. Spot prices soared through 2007, culminating in coking coal contract prices rising by 200 per cent in 2008, and thermal coal prices by 125 per cent. However, iron ore negotiations were unusually protracted. While Vale settled for a 65 per cent increase in iron ore prices, the Australian producers sought a higher price from their Asian customers to take into account the lower cost of shipping iron ore from Australia relative to Brazil. The steel mills eventually agreed to an 85 per cent increase in Australian iron ore prices. When the North Atlantic financial crisis struck in late 2008, the demand for steel collapsed, spot prices fell dramatically, and some customers were unwilling to pay the contract price, preferring instead to purchase more cheaply on the spot market. As the market tightened again in late 2009, producers advocated shorter-term reference pricing to narrow the gap between spot and contract prices. Although customers preferred the certainty provided by the annual benchmark system, they accepted a shift to quarterly reference prices for both iron ore and coking coal in 2010.[9] Since then, the producers have continued to seek short terms for contract prices.

9 Pricing for thermal coal continues to be a combination of annual benchmarks and a relatively liquid spot market.

The increase in Chinese demand through the decade had a very clear effect on the direction of trade in the seaborne iron ore market. However, the effect on the global coal market was more subtle, given China's status as the world's largest producer, as well as consumer. The proportion of global iron ore exports purchased by China rose from around 15 per cent in 2000 to a peak of almost 70 per cent in 2009, with Australian iron ore remaining in high demand due to the lower cost of shipping relative to Brazil. Consistent with this, Australia overtook Brazil during the decade to become the world's largest producer of iron ore, supplying a quarter of the world's production in 2009 (Table 1). While China remained self-sufficient in coal until 2008, its exports began to fall in 2003, as the Chinese Government removed export incentives. During this period, Australia's coal exports to other Asian countries increased, buoyed by Indian demand in particular (Figure 12). While China's demand for steel recovered in 2009 following the North Atlantic financial crisis, lower global prices meant Chinese coal mines – which are relatively high-cost producers – were not able to compete, and imports of Australian coal increased sharply. Chinese steel mills have continued to purchase a significant amount of coal from Australia since then.

Figure 12: Bulk Commodity Export Volumes



Source: ABS

The boom in iron ore demand later in the decade also triggered several attempts to further consolidate the Australian iron ore industry. As spot prices soared in late 2007, BHP Billiton made a bid to purchase Rio Tinto, which was rejected and eventually abandoned in November 2008 during the North Atlantic financial crisis. Rio Tinto was highly leveraged following its takeover of Alcan in 2007, placing the company under financial pressure during the crisis. In February 2009, Rio Tinto entered into an agreement with the Chinese company Chinalco to receive an equity injection. However, following an improvement in market conditions, Rio Tinto withdrew from this deal in June 2009, and instead agreed to an iron ore production joint venture with BHP Billiton. This proposal was opposed by steel producers around the world and competition regulators, and was eventually abandoned in October 2010. So at the close of the decade, the ownership of the existing iron ore mines in Australia remained similar to that in 2001.

The profitability of the iron ore industry also encouraged new companies to enter later in the decade, with Fortescue Metals exporting its first iron ore in 2008. Some of the new developments currently under construction are financed by Chinese steel producers, including CITIC Pacific's Sino Iron project and Ansteel's joint venture with Gindalbie Metals to develop the Karara iron ore project. Joint ventures involving Asian steel producers have historically been important for the expansion of the Australian iron ore and coal industries, with many of the mines opened since the 1960s developed through joint ventures.[10]

The contrast in the ability of the Australian iron ore and coal industries to increase export volumes is partly explained by their differing supply-chain ownership structures. The iron ore industry has a more vertically integrated supply chain, with Rio Tinto and BHP Billiton controlling the mines, railways and ports they use to produce and export iron ore. In contrast, growth in coal exports was slower to pick up, in part reflecting co-ordination difficulties among the many participants in the coal supply chain, where the mines, railways and ports are typically owned and operated by several different private and public corporations. These are most acute in New South Wales, and in response the Hunter Valley Coal Chain Coordinator was established from 2010 to plan and co-ordinate long-term capacity usage in the region, along with a new agreement with the mine owners to fund future infrastructure capacity.[11] Early reports indicate these new arrangements are better aligning incentives and streamlining future capacity expansions.

Looking ahead, the pipeline of committed projects is likely to lead to large increases in global iron ore and coal production capacity over coming years. In Australia, there are around $35 billion worth of iron ore investment projects committed, which are projected to increase Australian iron ore export capacity by a further 50 per cent between 2011 and 2015. Significant iron ore production capacity expansions are also expected to take place in Brazil over coming years. Australia's capacity to export coal in 2013 is projected to be around 20 per cent higher than it was in 2010 (Christie *et al* 2011). Significant expansions in thermal coal capacity are likely to take place over coming years in Indonesia, South Africa and Colombia, although the global supply of coking coal is not expected to increase to the same extent (ABARES 2011).

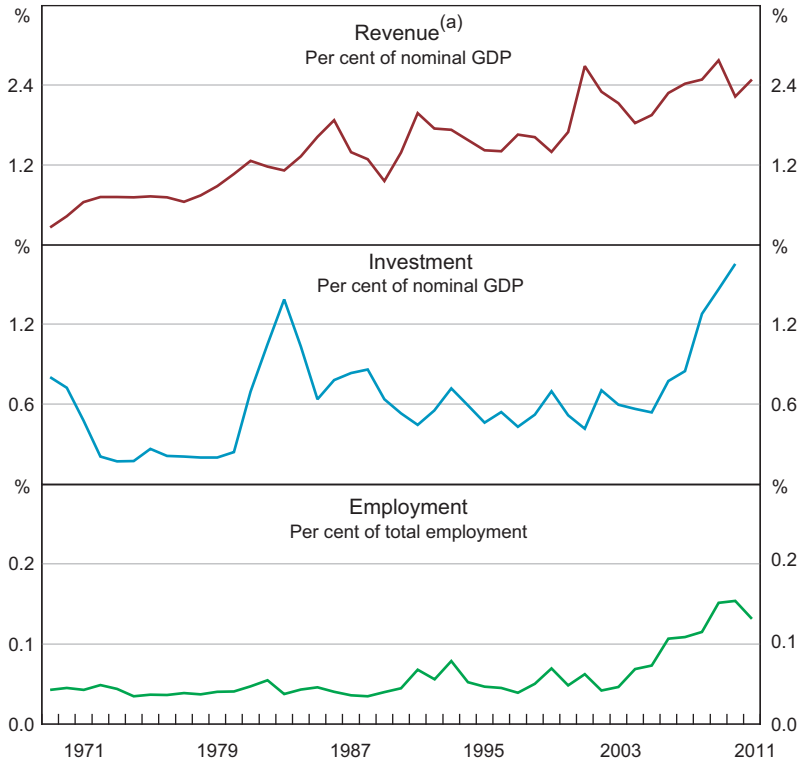
10 Rio Tinto's Robe River mine was developed from 1970 with the Japanese company Mitsui, and the Channar mine from 1987 with SinoSteel, which was the first overseas mining project entered into by a Chinese company. BHP's Mount Newman and Mount Goldsworthy joint ventures were developed in the late 1960s with the Japanese companies Mitsui and Itochu, while BHP's Wheelara joint venture was entered into in 2004 with four Chinese steel mills and two Japanese companies.

11 The process to develop central planning and co-ordination for the Hunter Valley coal chain started earlier in the decade with the establishment of the Hunter Valley Coal Chain Logistics Team in 2005

3.2 The decline of oil and the rise of LNG

In aggregate, oil and gas revenue did not change significantly as a share of the economy over the 2000s, with rising prices and LNG production offset by falling oil production (Figure 13). Australia's oil production peaked in 2000, and since then has fallen by almost 40 per cent due to the maturing of oil wells in the Bass Strait and the basins off Western Australia. In contrast, LNG production more than doubled over the decade, driven by the expansion of the North West Shelf LNG Project off Western Australia, which accounts for over 80 per cent of Australia's total production. As a result of these developments, LNG increased as a share of oil and gas exports from around 20 per cent at the beginning of the decade to 40 per cent by the end. Oil and gas are the most capital-intensive part of the mining industry, with a relatively high level of investment, and although employment has grown strongly during the decade, the industry only accounts for a small share of total mining employment.

Figure 13: Oil and Gas Mining
Financial years



Notes: Data from 1968/69 to 1981/82 include brown coal mining
(a) 2010/11 estimates based on partial indicators to March 2011

Sources: ABS; RBA

The Australian oil and gas industry has contributed around half of the rise in aggregate mining investment, driven by a series of large LNG projects (Table 5). As a share of the economy, oil and

gas investment at the end of the 2000s was well above the peak in the energy boom of the early 1980s, during which investment in the North West Shelf Project commenced. During the 1980s and 1990s, there were large discoveries of gas, including the Gorgon field, while in the early to mid 2000s there were further significant discoveries off Western Australia, with known gas reserves growing by around 40 per cent. The major investments in oil and gas during this period were the expansion of the North West Shelf Project, and the construction of the Darwin LNG plant. Later in the decade, investment in the industry rose sharply, with joint ventures involving multinational and Australian petroleum companies and Asian utilities developing a range of projects. The $15 billion Pluto project commenced in 2007, followed by the $43 billion Gorgon project in 2009, one of Australia's largest ever resource projects.

Table 5: Major Committed LNG Projects Since 2000

Project	Joint-venture partners	Period of development	Cost[(a)] $ billion	Production capacity mtpa
North West Shelf Phases IV and V	BHP Billiton, BP, Chevron, Japan Australia LNG, Shell and Woodside	2001–2008	5	8.8
Darwin	ConocoPhillips, Eni, Santos, INPEX, Tokyo Electric and Tokyo Gas	2003–2006	2	3.6
Pluto Train 1	Woodside, Tokyo Gas and Kansai Electric	2007–2012	15	4.3
Gorgon	Chevron, ExxonMobil, Shell, Osaka Gas, Tokyo Gas and Chubu Electric	2009–2016	43	15.0
Queensland Curtis (CSG-LNG)	BG Group	2010–2014	15	8.5
Gladstone (CSG-LNG)	Santos, Petronas, Total and Kogas	2011–2015	16	7.8
Prelude	Shell	2011–2016	12	3.6
Australia Pacific Phase 1 (CSG-LNG)	Origin Energy, ConocoPhillips and Sinopec	2011–2015	13	4.3

Note: (a) The cost estimates are from company and government announcements; where costs were reported in US$, the exchange rate at the time of the announcement has been used to convert into A$

Sources: RBA; company and government announcements

Over the 2000s, improvements in extraction technology and high energy prices also supported the development of coal seam gas (CSG) reserves in Queensland.[12] At the beginning of the decade, consideration was being given to installing a gas pipeline between Papua New Guinea and Queensland to supply the eastern states of Australia, since gas resources in these states were

12 The development of unconventional gas supplies in Australia is part of a global trend, with companies in North America utilising new drilling technologies to develop large reserves of shale gas during the 2000s. To extract coal seam gas, a large number of wells are drilled over time, and a significant amount of waste water is produced. The environmental impacts of projects are considered by various government bodies before approval is granted.

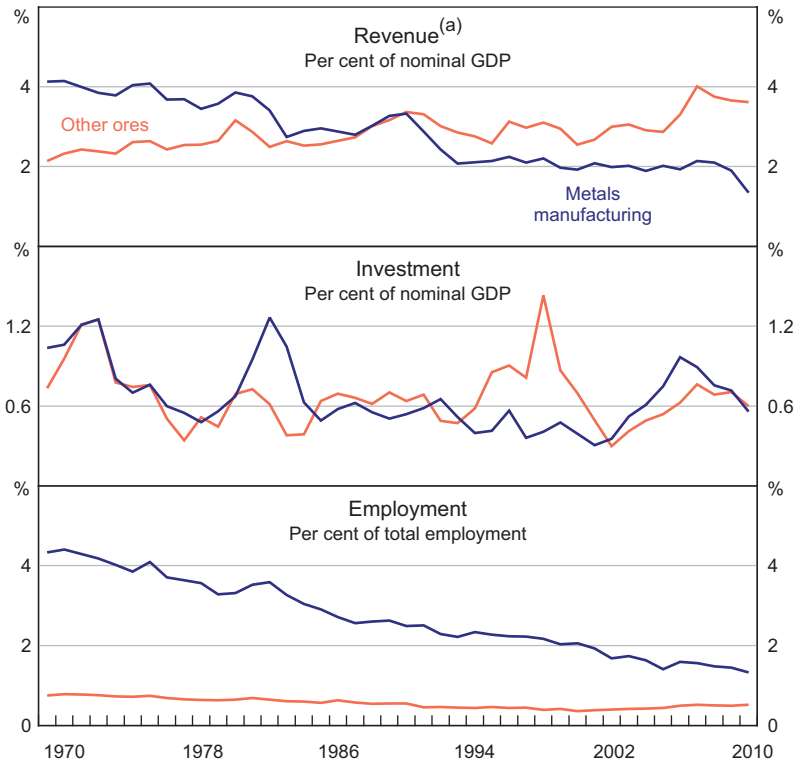
being steadily depleted (Fainstein, Harman and Dickson 2002). At the same time, CSG exploration activity in Queensland started picking up following the development of drilling technologies that significantly decreased the cost of drilling wells. Production of CSG increased in the early 2000s, to the point where it was supplying around 60 per cent of Queensland's gas demand in 2006. From 2006 to 2009, further exploration resulted in a fivefold increase in known CSG reserves, raising the prospect of eastern Australia joining Western Australia as an exporter of LNG to the Asian region (Geoscience Australia 2007, 2010). Three CSG-LNG projects in Queensland have recently received investment approval – the first CSG-LNG projects in the world to progress to this stage of development. When committed projects in Western Australia and Queensland are combined, Australia's LNG export capacity is expected to be almost three times higher in 2016 than it was in 2010 (Christie *et al* 2011).

Rising energy security concerns in Asia have also helped to underpin investment in the Australian LNG industry. As noted above, Australia's reserves of gas are small on a global scale, and Australia's potential customers for LNG in Asia – particularly Japan, Korea, China and India – are all relatively close to countries with large gas reserves, such as Russia, Turkmenistan and Iran, where it is possible to import gas through pipelines potentially more cheaply than importing LNG. However, geopolitical issues have led countries in the region to pursue multiple sources of natural gas. Compared to many of the countries with large gas reserves, Australia is viewed as politically stable, both as a destination for petroleum investment and as a source of supply (Angevine and Cervantes 2011). Consistent with this, the very first contract to supply LNG to China was granted to Australia's North West Shelf project in 2002 (Schneider 2004). The interest in Australian LNG has also been enhanced by Qatar's decision in 2005 to place a moratorium on further development of its North Dome gas field, which is the largest field in the world. In this context, the joint ventures in Australian LNG have been able to secure the long-term supply contracts with Asian energy companies necessary to justify developing such large capital-intensive projects.

3.3 Where the boom passed by: other ores and metals manufacturing

The mining of other ores (which include bauxite, copper, gold, lead, nickel and zinc) did not perform as strongly over the 2000s (Table 3). The decade started poorly, with the mid 1990s investment boom in base metals and gold ending with the Asian financial crisis, and investment and employment falling to record lows as a share of the economy. While revenue and investment increased with base metals prices to a peak in 2007, they then eased with the subsequent sharp price falls during the North Atlantic financial crisis (Figure 14). Many producers scaled back or ceased production, with the most prominent example being BHP Billiton's closure of the Ravensthorpe nickel mine in 2009 after less than one year of operation, while Oz Minerals, Australia's third largest diversified mining company at the time, sold most of its assets to the Chinese company Minmetals to reduce its debt burden. Part of the weakness in export volumes over the decade was also due to declining ore grades, particularly for gold, nickel and lead (Mudd 2010). Nevertheless, with the partial recovery in base metals prices since the crisis and the ongoing strength in gold prices, there have been some capacity expansions. These have included the reopening of the Boddington gold mine in 2009, which is expected to become Australia's largest gold mine once at full capacity. There are also some projects under consideration, including BHP Billiton's plans to significantly expand its Olympic Dam copper, uranium and gold mine (ABARES 2011).

Figure 14: Other Ores and Metals Manufacturing
Financial years



Note: (a) Metals manufacturing value added (revenue less intermediate inputs)
Sources: ABS; RBA; company reports

The metals manufacturing industry, which includes smelting, refining and producing metal products, has not been a significant beneficiary of the mining boom. Metals manufacturing in Australia has faced increased competition from Chinese smelters and refineries with greater scale and lower costs (Maurer *et al* 2004), while profit margins have been affected by higher energy prices and the appreciation of the Australian dollar. The industry's value added remained flat through most of the 2000s as a share of the economy, before contracting sharply over 2008–2010, as it did during the recessions in the early 1980s and early 1990s. The export volume of processed metals fell over the decade as some processing facilities were shut down, with the weakness broad based across a wide range of refined metals. For instance, BHP Billiton and Rio Tinto both developed iron plants in Western Australia during the late 1990s and early 2000s to add value to iron ore, but these plants have since been shut down. Another example is copper smelting and refining, which has been taking place at Mt Isa and Townsville since the 1950s, with the current owner Xstrata announcing in 2011 that these plants would be closed down over coming years. While investment in metals manufacturing picked up in the middle of the decade, it has since fallen back, and according to New, Ball, Copeland *et al* (2011), in 2011 there were only two metals processing projects under construction (both alumina refineries) and no committed projects.

4. The Effect of the Mining Boom on the Broader Economy

Thus far the discussion has focused primarily on trends within the mining industry itself. The growth of the mining industry over the past decade also affected other parts of the Australian economy, as described below.

4.1 Theory and overview of the evidence

Traditional trade theories outline how an economy is likely to evolve following an increase in the price of its major export. Using a Heckscher-Ohlin-Samuelson framework extended to three sectors (commodities, other tradables and non-tradables), a rise in the global price of commodities has a factor transfer and an income effect.[13] Assuming the economy is at full employment, the *factor transfer effect* reflects the movement of labour and other factors towards the production of mining and its intermediate inputs (such as mining equipment and exploration services) as inputs are bid away from the production of other tradables (e.g. non-mining manufacturing, education, tourism) and non-tradables (services like health and child care, dwelling construction, etc) in response to the increase in commodity prices and mining industry profits. As a consequence of this effect, output of other tradables and of non-tradables falls.

The *income effect* reflects the changes in the output of different industries within the economy as the higher commodity export earnings are spent. In addition to payment for the inputs used, mining receipts are distributed as tax and royalty payments to federal and state governments and boost the income and wealth of resident shareholders via dividend payments and higher equity prices. To the extent these income gains are spent rather than saved, demand for other tradables and non-tradables increases. Assuming tradable prices are fixed at global prices, this increase in demand raises the relative price of non-tradables to tradables (i.e. the real exchange rate appreciates) as well as imports of other tradables. Hence, while domestic production of other tradables is lower (due to the factor transfer effect), the final effect on the level of non-tradable output depends on whether the income effect dominates the transfer effect.

While the *direction* of these various effects is well identified by theory, their *magnitude* depends on a range of factors. In general, the transfer effect following an increase in commodity prices will be smaller: the more excess capacity there is in labour and other input markets at the outset of the adjustment; the smaller the amount of inputs used in the production of mining output; and/or the easier the ability to import mining-related labour and capital rather than having to source them domestically. Further, the larger the share of the mining industry owned by foreigners, the smaller will be the income effect. In regard to price movements, the greater the degree of substitutability between non-tradables and tradables in consumption, the smaller will be the change in the real exchange rate. More broadly, the higher the degree of flexibility in the economy, the smaller will be the magnitude of the overall wage, price and exchange rate changes necessary to induce inputs and the pattern of spending to shift in response to the rise in mining production and domestic demand.

In practice, tracking the magnitude of the mining boom's effects on the structure of the overall economy is challenging, not least because the expansion of the mining industry in the 2000s

13 For details and model extensions that cover a variety of special cases, see Gregory (1976), Corden (1982, 1984), Corden and Neary (1982) and Cook and Sieper (1984). See also the discussion in Henry (2008), McKissack *et al* (2008) and Banks (2011).

occurred around the same time as other significant developments, such as the slowing pace of productivity growth and changes in household spending behaviour (discussed in other papers in this volume). Nonetheless, a general overview of the magnitude of the recent changes that have occurred throughout the economy can be provided by calculating structural change indices. Specifically, we examine here the changes in the share of different industries in total nominal output, real output, employment and nominal investment. We also use the same measures to evaluate structural change over time between the Australian states, in order to get a feel for the degree of change in the resource-rich and non-resource parts of the economy.

The structural change index (SCI) used takes the form:

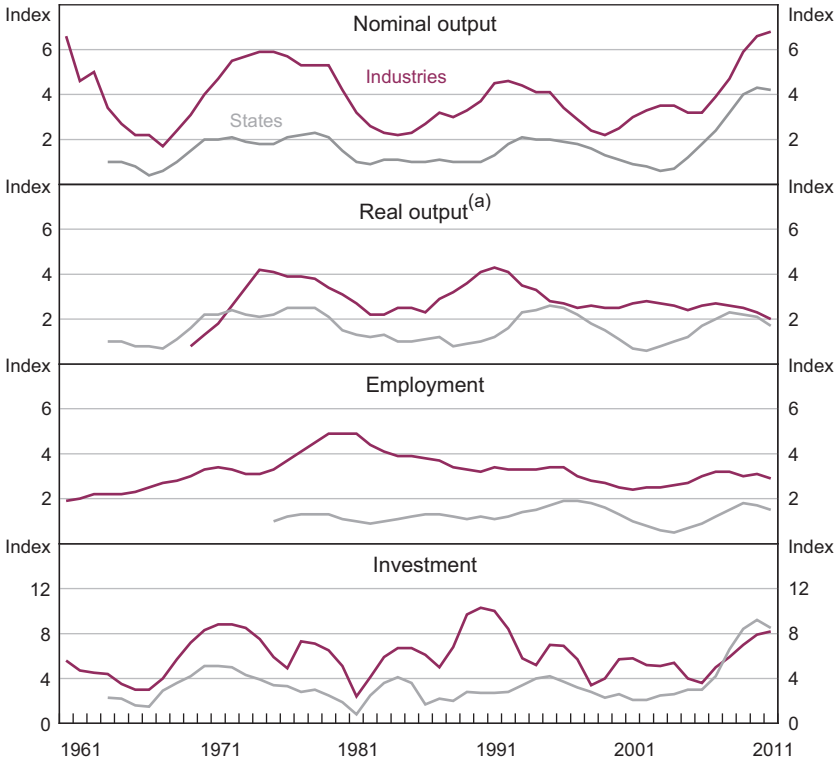
$$SCI = \frac{1}{2}\sum_{i=1}^{n}\left|x_{i,t} - x_{i,t-5}\right|$$

where $x_{i,t}$ is the average share of industry (or state) i in the economy in the five years to year t; we use five-year averages to abstract from short-term variation within the economy.[14] The eight industry groups are: agriculture; mining; manufacturing; construction; distribution services and utilities; business services; social services; and personal services. For the state measures, the Northern Territory is included with South Australia and the Australian Capital Territory with New South Wales for data availability reasons. Under these measures, if there has been no change in the relative importance of different industries (or Australian states) over the period, the indices have a value of zero. If, however, the share of one industry (or state) has increased by say 2 percentage points over the five-year period (with a corresponding decrease in the shares of other industries or states), the index has a value of 2.

As is readily apparent from Figure 15, for several measures the rate of structural change has increased since the early 2000s, which corresponds with the onset of the mining boom. For the industry measures, this is particularly noticeable in the measure for nominal output – reflecting the sharp rise in commodity prices over recent years – and is also evident in the investment measure. In contrast, the degree of structural change in the share of the various industries in real output and employment has not been especially large over recent years. This reflects, in part, the inevitable lags between the start of the large investment projects and the increase in mining output, the fact that much of the change to date has occurred *within* industries rather than *between* them, and that the mining industry directly employs a relatively small share of the workforce (as discussed below).

14 This description updates Connolly and Lewis (2010); for details on the structural change index, see also Productivity Commission (1998).

Figure 15: Structural Change Indices



Notes: Output refers to value added by industry and gross state product; estimates for 2010/11 output and investment based on partial indicators to March 2011

(a) Based on relative prices in 2008/09

Sources: ABS; Donovan (1981); RBA; Withers *et al* (1985)

In the measures covering divergences among the various Australian states, the rate of structural change in their total nominal output and investment has been the highest over the past 50 years, reflecting in part that the current mining boom is larger and more geographically concentrated than the booms between the late 1960s and the early 1980s. While the degrees of structural change in the state shares of real output and employment have increased, they have nonetheless been around levels seen during previous periods of high structural change. In fact, on both measures the degree of structural change within the Australian states has fallen back somewhat of late, as output and employment trends in the resource-rich states have more closely followed those of the other states. We now turn to a more detailed discussion of the various direct and indirect effects of the mining industry expansion on the rest of the economy that lie behind these developments, focusing first on the national and then the state economies.

4.2 Direct effects of the mining industry on the national economy

According to data from the Australian Bureau of Statistics (ABS), mining industry revenue increased from around 6 per cent of GDP in 2000 to 14 per cent of GDP by the end of the decade, an average annual growth rate of almost 15 per cent (Table 6). As noted earlier, much of this reflected the rise in global commodity prices, although increases in mining output also played a part. After paying for the labour and other intermediate inputs used in mining operations, the balance of the revenue (termed the gross operating surplus) is divided between royalty and tax payments, immediate dividend distributions and retained earnings (after deducting interest and depreciation). In the rest of this section, the links between each of these components with the rest of the economy are examined, as well as the large increase in mining investment that has also boosted activity in the national economy.

Table 6: Distribution of Mining Revenue

	1999/2000	2003/04	2008/09	2010/11[(a)]
Revenue – $b	**43**	**63**	**177**	**195**
Labour costs	5	8	18	21
Intermediate input costs	18	28	70	82
Goods and materials	*6*	*9*	*23*	*na*
Services	*13*	*20*	*47*	*na*
Gross operating surplus[(b)]	19	27	89	92
Royalties	*3*	*4*	*11*	*11*
Company income tax	*1*	*3*	*13*	*na*
Other[(c)]	*15*	*20*	*65*	*na*
Memo item: Investment	10	15	52	58
Revenue – per cent of GDP	**6.5**	**7.3**	**14.1**	**14.2**
Labour costs	0.8	0.9	1.4	1.6
Intermediate input costs	2.8	3.3	5.6	5.9
Goods and materials	*0.8*	*1.0*	*1.8*	*na*
Services	*1.9*	*2.3*	*3.8*	*na*
Gross operating surplus[(b)]	2.9	3.1	7.1	6.7
Royalties	*0.4*	*0.5*	*0.9*	*0.8*
Company income tax	*0.2*	*0.3*	*1.1*	*na*
Other[(c)]	*2.2*	*2.3*	*5.2*	*na*
Memo item: Investment	1.4	1.7	4.2	4.2

Notes: (a) Estimates based on partial indicators to March 2011
(b) Gross operating surplus differs from taxable income used in the calculation of company income tax
(c) Includes interest expenses and depreciation

Sources: ABS; Australian Taxation Office; RBA; Australian and state government budget papers

4.2.1 Direct labour usage

Direct labour costs in mining operations have been equivalent to around 10 per cent of total mining receipts.[15] After falling gradually during the 1990s, employment in the mining industry grew rapidly during the 2000s, rising by around 10 per cent a year, compared with growth of around 2 per cent a year in the national economy. Indeed, the pace of mining employment growth during the decade was significantly higher than for virtually all other industries.

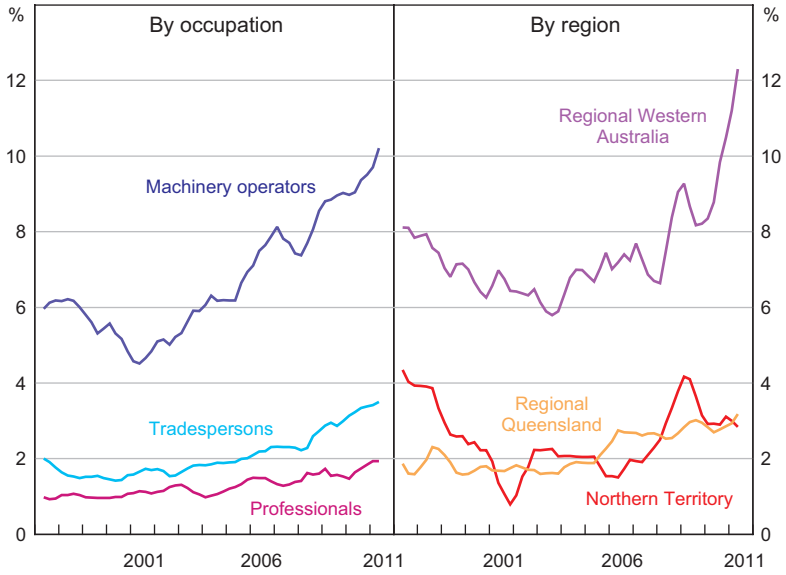
However, mining is very capital intensive and hence the amount of labour used for mining operations has remained comparatively small. Despite its rapid growth over the decade, mining employment increased by only 110 000 over the decade (to around 200 000 or 1.7 per cent of total employment), representing a small share of the 2.2 million increase in employment nationally.[16] Hence, while annual employment *growth* rates were below that of the mining industry, most other industries – especially within the services sector – saw an increase in the *number* of employed persons that was much larger, with health and social services employment in particular rising by a multiple of almost four times that of mining during the decade. The main exception was a decline in employment in manufacturing, but this continued a trend that has been evident for several decades.

Mining employment is dominated by a few occupations, with one-third machinery operators, one-quarter tradespeople, and one-fifth professionals such as engineers. Even within these occupations the increases in the mining industry were small, with the share of machine operators working in mining rising from 6 per cent to 10 per cent of total national supply and tradespersons working in mining increasing from only 2 per cent to a little over 3 per cent (Figure 16). In addition, while mining provided a boost to employment in the regions of the country that have a comparatively high concentration of resources – the Northern Territory, Western Australia excluding Perth, and Queensland excluding Brisbane – the mining industry accounted for at most 12 per cent of these regions' total employment.

15 This section covers only the direct labour used in mining operations. It excludes labour used in the production of intermediate products purchased by mining operations for their operations, and workers used by construction companies that are contracted to build mining projects; these components are discussed below.

16 Nonetheless, mining employment growth was more significant on a state basis; of the 300 000 increase in employment in Western Australia over the decade, almost 50 000 were in the mining sector.

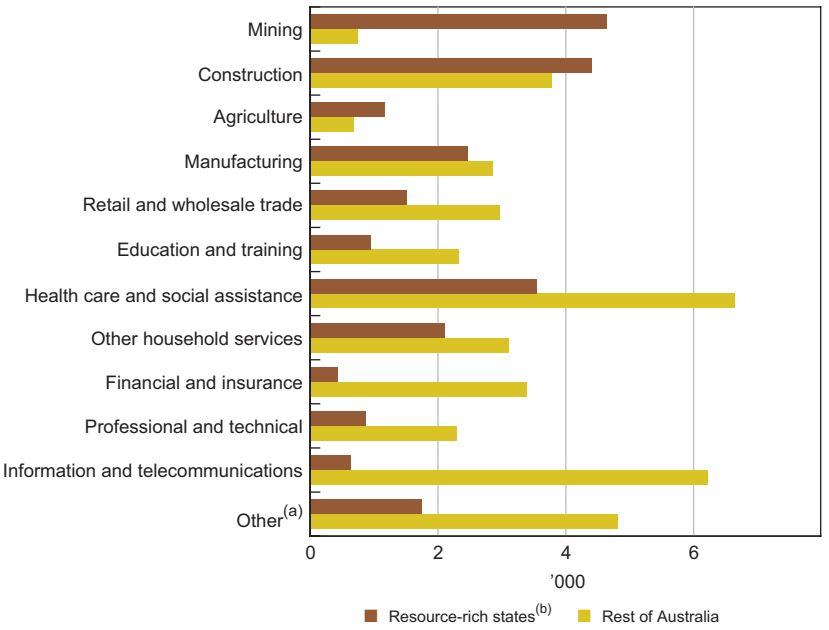
Figure 16: Mining Employment
Rolling annual average share of total



Source: ABS

Some of this increase in mining employment during the decade was accommodated from outside the initial labour force. Coinciding with the onset of the mining boom, the participation rate rose by around 3 percentage points, initially jumping in the resource-rich states and later also rising in other states. The increase in the participation rate was accompanied by a strong rise in immigration to the resource-rich states. In part this reflected an increase in temporary migrants (the 457 business visa category), with the resource-rich states receiving the majority of those working in the mining and construction industries (around 4 500 in each industry; Figure 17). Nonetheless, the total number of 457 visa migrants in Australia has remained fairly low (72 300 as at mid 2011) although there are a range of other business visa categories.

Figure 17: Primary 457 Visa Holders
May 2011

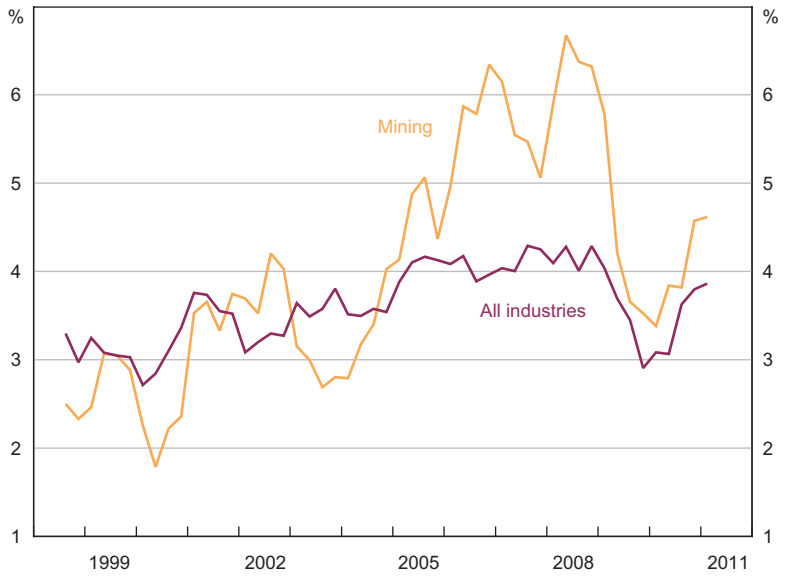


Notes: (a) Includes transport & storage, utilities, rental & real estate and public administration
(b) Includes Northern Territory, Queensland and Western Australia

Source: Department of Immigration and Citizenship

Given the remote areas in which many mines are located, mining wage levels are typically higher than in other sectors in order to attract labour towards the industry. Based on the ABS wage price index – which controls for changes in quality and the composition of the type of labour employed – annual mining wage growth was strong after the onset of the mining boom, peaking at 6½ per cent, and non-wage benefits growth was also reported to have been high (Figure 18). Furthermore, although mining wage growth slowed during the North Atlantic financial crisis, its pace has since picked back up. Nonetheless, there appears to have been only a limited degree of spillover to wages in the rest of the economy, which outside of the period of the financial crisis continued to grow at around 4 per cent. The Bank's recent business liaison also indicates that at least to date there has been fairly little impact of wage growth in the mining industry on wages in the broader economy, even in the occupations where there are early signs of emerging skill shortages.

Figure 18: Wage Price Index Growth
Year-ended



Source: ABS

4.2.2 Intermediate input usage for mining operations

Intermediate input costs have been much larger than direct labour costs, typically representing around 40 per cent of total mining revenue. Goods and materials used in mining operations constitute around one-third of intermediate input costs with the remainder being services, such as freight, contractors, rent and repairs. Intermediate input costs grew quickly after the onset of the mining boom, rising at an annual average rate of 15 per cent, or 3 per cent of GDP over the decade.

Input-output tables available from the ABS provide an indication of the types of industries in the economy that have been supported by the rise in intermediate input demand for mining operations, although the latest data are only available to 2006/07. The data suggest that of the *goods* used in mining operations, many were commodities provided by the industry itself (such as coal and ores). While purchases of petroleum and chemical products (such as fuel and explosives) were substantial, a high share of these purchases is imported by the companies providing these goods to the mining industry (Table 7). Metal products purchased from local companies are a smaller share of total mining intermediate inputs, and direct imports by mining companies constitute around 10 per cent of total mining intermediate inputs (which are primarily goods).[17]

17 More recent data suggest the import share for inputs used in mining operations in Western Australia was around 8 per cent in 2009 and 4 per cent in 2010; see Department of State Development and Department of Commerce (2011).

Table 7: Inputs into Mining Operations by Industry
Per cent of total, gross values

	1998/99	2006/07
Goods and materials	**35**	**34**
Mining products	5	9
Manufactured products	18	15
Petroleum, coal and chemicals	*6*	*8*
Metal products and machinery	*9*	*6*
Direct imports[(a)]	12	10
Services including contractors	**65**	**66**
Mining support services	15	18
Finance, insurance, property and business	15	18
Finance and insurance	*4*	*5*
Property and business	*11*	*13*
Construction[(a)]	5	8
Transport and storage	12	6
Wholesale and retail trade	9	6
Electricity, gas, water and waste services	5	4
Accommodation, cultural and personal	2	4

Note: (a) May include a mix of goods and materials as well as services

Source: ABS

In contrast, purchases of *services* by mining companies for their operations – which constitute two-thirds of mining intermediate inputs – are more commonly provided locally, with, for instance, mining companies often contracting Australian businesses to undertake their ongoing service and maintenance due to their locational advantage. Around one-quarter of these purchases are support services provided by the mining industry itself, such as drilling, draining and plumbing. Another one-quarter are finance, insurance, property and business services, which includes a wide range of services such as engineering consulting, employment placement, legal, accounting, computer system design, marketing, rental and hiring of equipment, and mine support staff provided by service operators (e.g. cooks, cleaners and bus drivers). The rest of the intermediate service inputs covers activities such as transport and storage, distribution, accommodation and services provided by utilities companies.[18]

Not all of the increase in intermediate input costs over the past decade has reflected an increase in the quantity of goods and services supplied to the industry. Along with the increase in fuel prices, global competition for mining equipment has led to rapid growth in the prices of mining intermediate inputs. Reflecting this trend, the price index for materials and services used in coal mining for instance – such as prices for extraction, washing, preparation and transportation – grew at an average annual

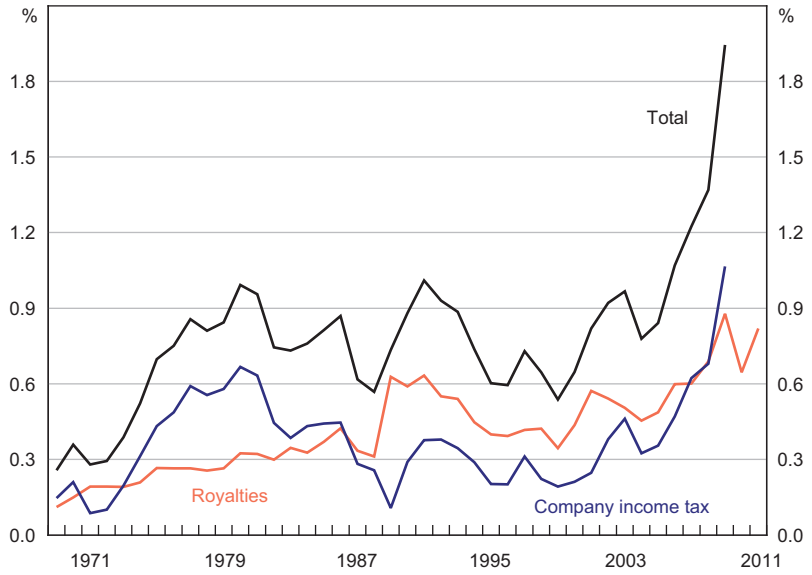
18 Note that accommodation, cultural and personal services include some non-wage expenses provided to mining industry workers. Also, the input-output data show construction supplies only around 8 per cent of total mining inputs. However, this figure does not include the substantial amount of mining investment that takes place within the construction industry itself (see section below).

rate of 6 per cent from the mid 2000s, twice the pace of price growth in the broader domestic economy, after having grown in line with domestic prices over the preceding decade.

4.2.3 Tax and royalty payments

The mining companies pay royalties and taxes to various levels of government in Australia. Royalties and company income taxes paid by the mining industry increased from around ½ per cent of GDP at the start of the decade to around 2 per cent in 2008/09 (the latest available data) – their highest share of GDP since at least the late 1960s. As a share of annual mining receipts, these payments increased from around 10 per cent to almost 15 per cent over the decade. The rise in royalties and taxes was driven by the significant increases in global prices and to a lesser extent export volumes for bulk commodities, while the share of the oil and gas industry in payments to governments fell over the period, reflecting the gradual depletion of Australia's oil fields. Most of this increase was driven by mining income taxes; company income tax is levied on taxable profits, while mining royalties are generally levied on production and are less sensitive to movements in commodity prices (Figure 19).[19] The rise in tax and royalty payments to governments coincided with cuts in personal income taxes from the mid 2000s and a more recent rise in infrastructure investment (including under Western Australia's 'Royalties for Regions' program).

Figure 19: Mining Royalties and Company Income Tax
Per cent of nominal GDP, financial years



Sources: ABS; Australian Taxation Office; RBA; Australian and state government budget papers

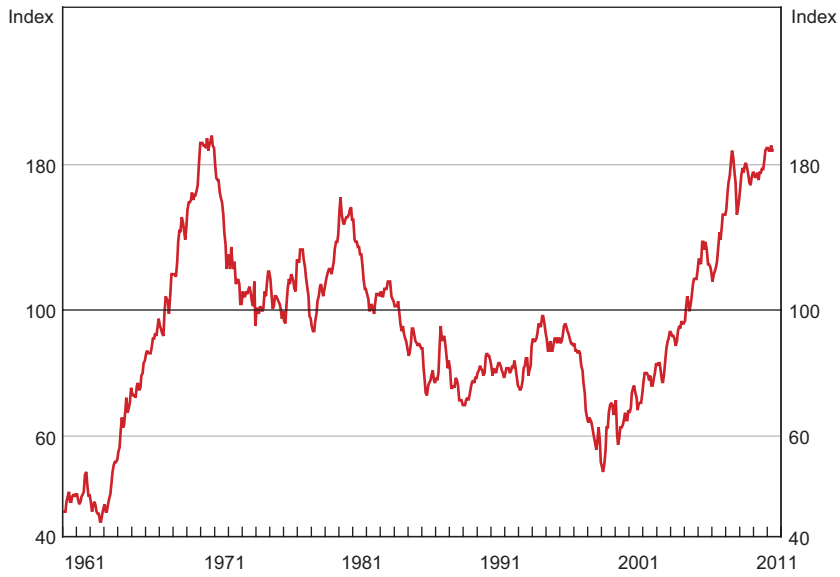
19 The main exceptions are the Petroleum Resource Rent Tax (PRRT) and royalties collected in the Northern Territory, which are levied on measures of profits. The large increase in royalties in the late 1980s was associated with the introduction of the PRRT. In 2010 there was a national debate when the Government proposed replacing the existing system of mining royalties with a broad-based resource rent tax. The proposal was subsequently scaled back to only apply to iron ore and coal production, with the application of the PRRT broadened to include on-shore coal seam gas projects.

4.2.4 Dividends and retained earnings

The gross operating surplus of the mining industry, after deducting royalties and tax payments, rose from around $15 billion in 1999/2000 (2.2 per cent of GDP) to around $65 billion in 2008/09 (5.2 per cent). Earnings (after tax, interest and depreciation) are distributed to shareholders as dividends or retained within the company. Since the mining industry in Australia is majority foreign-owned, most dividends and retained earnings do not add to national income.

The foreign ownership share of the mining industry is difficult to determine for several reasons: many publicly listed equities are held in the name of nominee companies; holdings of companies listed on the ASX that are less than 5 per cent of total equity do not need to be disclosed; and the degree of foreign ownership varies by industry and even by specific mine. Overall, based on published data by the iron ore, coal and LNG producers, effective foreign ownership of the current mining operations in Australia could be around four-fifths, with the share for iron ore producers a little lower and coal and LNG producers a little higher. Part of the earnings to Australians is distributed by mining companies as dividends, with the balance retained by the companies and reflected in rising share valuations. Indeed, mining equity prices increased by 180 per cent relative to the broader market over the 2000s, providing a significant boost to the wealth of Australian residents over the decade (Figure 20).

Figure 20: Mining Share Prices
Relative to broader market, log scale



Notes: Resource share price index divided by market index (ASX 200); average since 1960 = 100
Sources: Bloomberg; RBA; Thomson Reuters

4.2.5 Investment

Thus far this analysis has focused on the direct distribution of the mining sales receipts over the decade and its impact on activity and incomes within the broader economy. The mining industry

also boosted spending in the Australian economy through its investment activity, which rose from $10 billion (1.4 per cent of GDP) at the start of the decade to around $58 billion (4.2 per cent) more recently.[20] This spending covers payments for construction workers and purchases of non-labour inputs for mining investment. It has been financed by a combination of foreign inflows from multinational energy companies – especially for many of the LNG project investments – and retained earnings from existing operators in Australia, such as those producing iron ore and coal.

In regard to the labour used during construction, large mining companies typically engage the services of engineering, procurement and construction management (EPCM) firms to oversee their investment projects. Part of the responsibilities of an EPCM firm is to procure the necessary labour, which can be supplied from its own staff or through subcontracting workers from more specialised construction firms. There is little information available on the total number of construction workers employed on mining projects at any one time, and the Bank's liaison indicates that contractors try where possible to shift labour from one project to the next as different stages of the projects advance. Modelling by the National Resources Sector Employment Taskforce (2010) suggested that the total number of mining-related construction workers employed is fairly small, at around 30 000 in 2010 (¼ per cent of national employment), although this is expected to rise in coming years.

A large part of the inputs used for mining investment is imported rather than sourced from the domestic economy. The share of total investment that is contracted domestically varies significantly depending on the technology used in the project, whether the equipment is assembled locally or imported wholly assembled, and the scale, specification and cost of the steel products used. In addition, the local content share varies from year to year depending on the stages the projects are in. For instance, while some of the labour employed in LNG investment occurs at the front-end when earth and civil works and port dredging is undertaken, more occurs at the back-end of the project after the large LNG modules arrive from offshore and need to be secured in place. Local spending also varies among the different iron ore and coals projects.[21]

Reports by the companies concerned and from official sources suggest in broad terms that over the life of a project the domestically contracted share of mining investment averages around 70–80 per cent for iron ore projects (which are comparatively labour intensive) and around 40–60 per cent for LNG projects (which are not as labour intensive). There is less information available in regard to the domestic spending share in the coal industry, but it may be broadly

20 This estimate reflects the costs of machinery and equipment, buildings and structures, exploration and software and R&D investment specifically related to mining on-site operations and support activities by contractors (including exploration). It does not include investment in infrastructure used to transport (e.g. rail, roads, pipes) and export (e.g. ports) mining products, or for the processing of minerals. These types of investments have also increased in recent years and are expected to continue to do so.

21 For instance, magnetite iron ore projects require labour for on-site processing and assembly of processing and crushing modules as well as for the earth and civil works that are also used in the development of hematite mines. Machinery and equipment (car dumpers, stackers and reclaimers) are usually imported; rolling stock has traditionally been sourced domestically, but an increasing share is imported. As well as mine development, magnetite production requires a magnetite concentrator for processing the ore and key infrastructure to facilitate the production process, such as water and energy utilities. For coal investments, local content shares vary depending in part on whether new mines are underground or open-cut (with the latter having a larger local labour content).

similar to that for iron ore.[22] However, all these estimates overstate to some extent the actual degree of local spending: the reported 'domestic spend' share is the amount contracted from locally based firms, part of which is subsequently sourced from abroad (e.g. for parts). Australian-based firms have indicated that much of the machinery and materials needed cannot be provided from local sources due to limited domestic capability to deliver the scale and specifications required. Adjusting for this effect, perhaps half of the total cost of mining investment in recent years has been domestically spent. This share may fall somewhat in coming years given the intensity of LNG investment and its lower domestic content compared with other mining activities.

Putting all this together, the increase in mining revenues in the 2000s made a significant direct contribution to economic activity and incomes of Australian residents. The main channels identified were through direct labour costs (around 10 per cent of total mining operational revenue), the mining industry's demand for domestically sourced intermediate inputs especially services (perhaps around 25 per cent of total revenue), tax and royalty payments (close to 15 per cent of total revenue in recent years), and the share of the after-tax profits owned by Australian residents (around 5–10 per cent of total revenue). While it is difficult to be exact, these estimates suggest that overall, Australian residents accrued a little over half of the total receipts earned from current mining operations. In addition, perhaps half of the total costs of mining investment was spent acquiring domestically supplied labour and other inputs, which generated further activity in the Australian economy.

4.3 Indirect effects of the mining industry on the national economy

As outlined in the Kearns and Lowe paper in this volume, the rise in global commodity prices and the associated rise in the terms of trade boosted the level of Australia's income during the decade.[23] Given the strong growth of income, demand growth outpaced that of output over the entire mining boom period, with the exception of a short period during the North Atlantic financial crisis. In line with the predictions of the theory outlined earlier, in response to this spending the pace of non-tradables inflation picked up after the onset of the mining boom, running at around 4 per cent a year compared with 3 per cent in the preceding years, while inflation in tradables (excluding fuel) averaged around 1 per cent a year. Consistent with this, measures of the real exchange rate appreciated, rising by around 35 per cent over the mining boom period.

There is also evidence that this large rise in the real exchange rate over the decade has been associated with a shift in spending from non-tradables to tradables. The pace of import volumes growth over the decade has picked up noticeably, especially for capital imports for businesses and foreign travel by residents. Similarly, the pace of growth of exports has slowed for a range of manufactured goods and tourism services.[24] Within the domestic economy, demand conditions

22 However, as noted, the variation around these industry-average spending estimates is considerable; for instance, Department of State Development and Department of Commerce (2011) estimates that around 85 per cent of the work undertaken in 2010 on the iron ore expansions of Rio Tinto and BHP Billiton in Western Australia was contracted locally compared with around 40 per cent for the Gorgon LNG project in 2010. The WA Government also estimates the share of locally contracted investment spending for companies operating under state agreements at 65 per cent in 2009 and 69 per cent in 2010.

23 See also Stevens (2010a, 2011) for discussion of the macroeconomic effects of the current mining boom.

24 Exports of education continued to grow, before slowing more recently, partly in response to changes in visa policies.

varied considerably, even within the same industry or state. For instance, activity at hotels servicing capital cities and fly-in/fly-out air services has been strong, while hotel bookings and flight reservations to resort areas – even within the same states – have softened considerably. There has also been large variation in the pace of output growth within different parts of the manufacturing and construction industries, partly depending on whether their products and activities are used by the mining industry. This intra-industry variability could be one reason why the structural change index noted earlier suggested that to date the overall pace of change of the real output shares and employment between industries has not changed significantly from that prevailing since the mid 1990s. Nonetheless, to the extent the real exchange rate appreciation reflects a highly persistent change in fundamentals, the changes in the structure of domestic demand and industry output are likely to grow over time.

4.4 Effects of the mining boom on the states

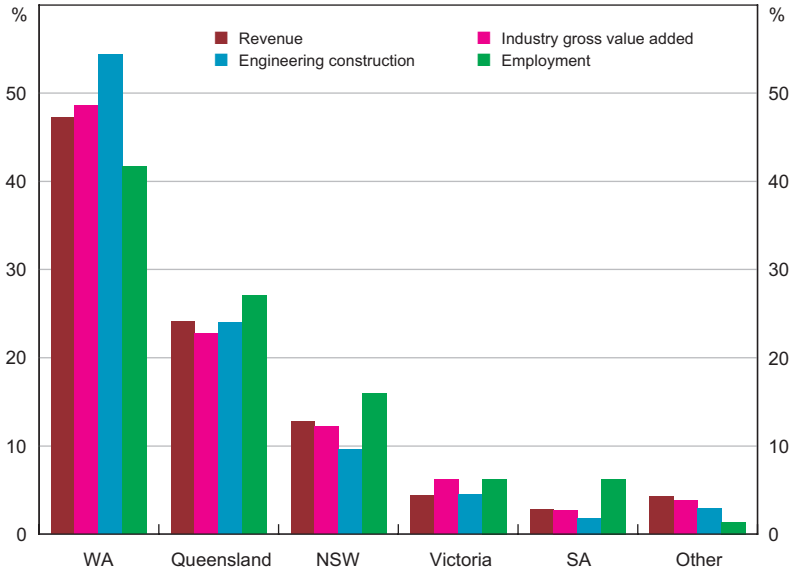
Resources are spread unevenly across the country, with Western Australia, Queensland and the Northern Territory having the highest concentration of known reserves (Table 8). Almost all iron ore mining occurs in Western Australia, while two-thirds of black coal mining is in Queensland (the remaining one-third is in New South Wales). In the case of natural gas, the bulk of current production is from Western Australia, although Queensland is likely to also become a major supplier of CSG-LNG in coming years. The varying concentrations of resource deposits are reflected in the structure of the state economies, with Western Australia and Queensland accounting for about one-half and one-quarter, respectively, of the mining industry's revenue, employment and engineering investment (Figure 21).

Table 8: Resource Endowments by State
2009/10

State/Territory	Share of mining in state output Per cent	Main resource deposits
Western Australia	27	Iron ore, bauxite, nickel, gold, silver, copper, lead, zinc, diamonds, mineral sands, oil and natural gas
Northern Territory	21	Bauxite, gold, silver, lead, uranium, zinc and natural gas
Queensland	10	Black coal, bauxite, gold, silver, copper, nickel, lead, zinc and coal seam gas
South Australia	4	Uranium, gold, silver, copper and iron ore
New South Wales	3	Black coal, gold, silver, copper, lead, mineral sands and zinc
Victoria	2	Brown coal, gold, mineral sands, oil and natural gas
Tasmania	2	Gold, silver, lead, tin and zinc

Sources: ABARES; ABS; Geoscience Australia

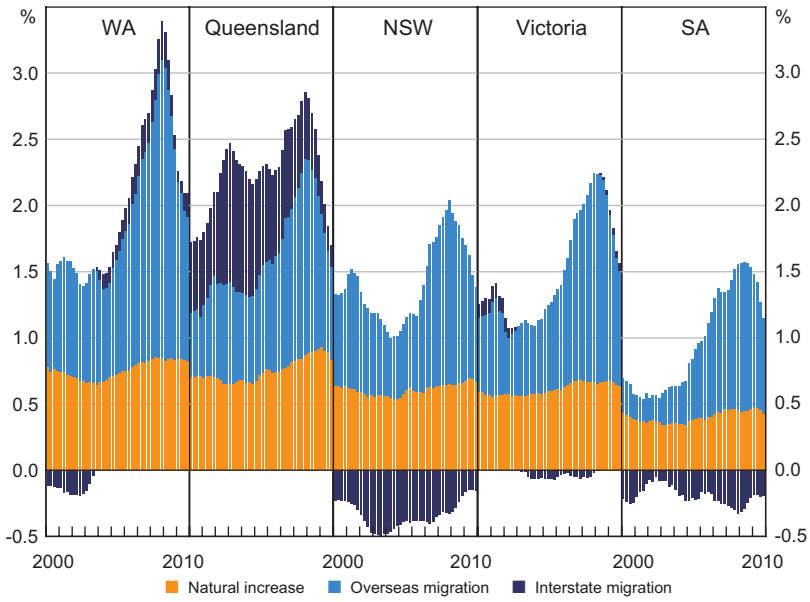
Figure 21: Share of Australian Mining Industry
2009/10



Source: ABS

In addition to the rapid rise in investment in the resource-rich states, the structural change index noted earlier suggests there has been an increase in state variation in other economic indicators. As well as solid output growth, the resource-rich states have had the highest population growth. In part this reflected a high level of overseas migration to these states – especially in the case of Western Australia – and also interstate movements in Queensland, although in the case of Queensland this trend predates the mining boom (Figure 22). For both of these states, the population growth from these sources has slowed significantly in the past year or so.

Figure 22: State Population Growth
Contributions to year-ended state population growth



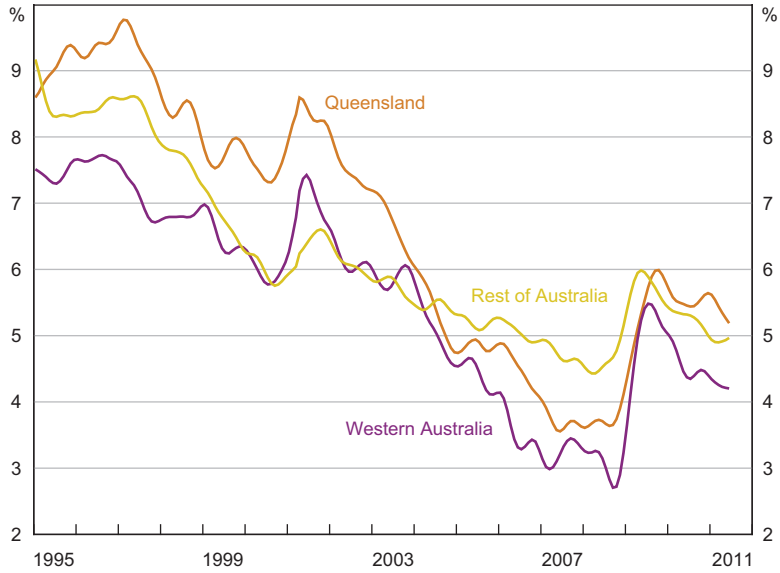
Source: ABS

While the growth of mining industry output, population and investment varies between states, over recent years growth in overall demand and output across the states has become more similar. While the level of mining operations and investment is clearly concentrated in the resource-rich states, the distribution of the mining receipts is more dispersed across the country. The particular channels, as noted earlier, include the purchase of intermediate inputs from other parts of the country to service mining activities,[25] Australian equity holders are widely dispersed, and tax payments to the Australian Government are spent across the country.[26] This could be one reason why unemployment rates have been low in all states since the onset of the mining boom, although lowest in Western Australia and, until recently, in Queensland (Figure 23). Indeed, while final demand in the resource-rich states expanded rapidly between 2003 and 2007, rising at an average annual rate of around 8 per cent, since that time final demand in the resource-rich states has slowed significantly and broadly tracked the pace of growth seen in the rest of the economy, though this partly reflects state-specific reasons as well (Figure 24).

25 Data for Western Australia suggest around 10 per cent of the value of the contracts awarded within Australia for mining operation and mining investment projects located in Western Australia were to companies based outside of that state; see Department of State Development and Department of Commerce (2011).

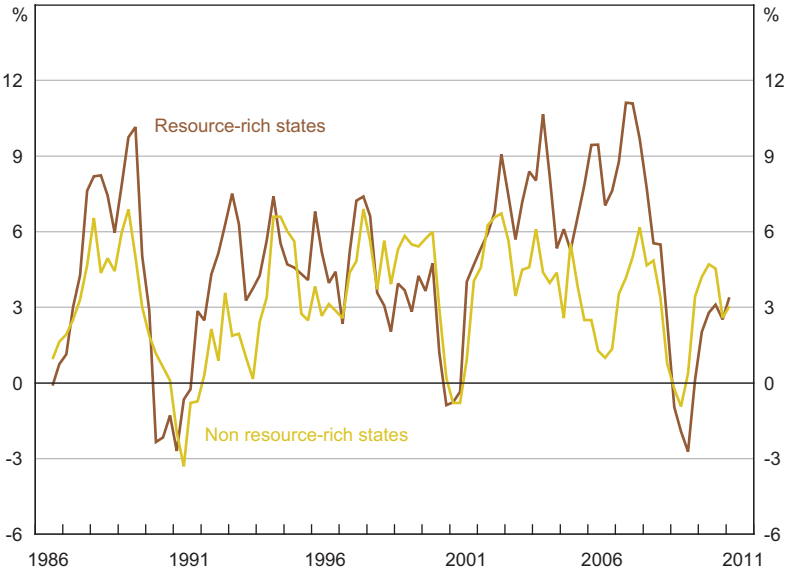
26 For further discussion on state economic disparities and regional transfers, see Stevens (2010b).

Figure 23: State Unemployment Rates
Trend



Source: ABS

Figure 24: State Final Demand
Year-ended percentage change



Source: ABS

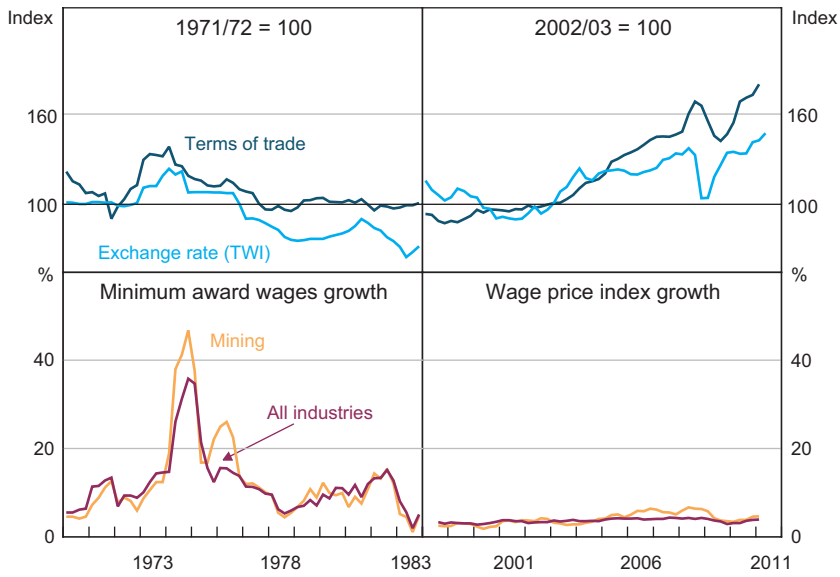
5. Comparisons with Past Mining Booms

Mining booms are not new to Australia. Focusing on the post-WWII period, there were a number of booms between the late 1960s and the early 1980s, due to new discoveries and surges in global commodity prices. In the late 1960s, increased Japanese demand for steelmaking materials and the development of bulk carriers opened up the seaborne trade in coal and iron ore, and there were discoveries of oil, bauxite and nickel. This resulted in a surge in mining investment and culminated in the Poseidon stock market bubble in 1969/70. Then in 1973 and 1974, energy prices increased dramatically due to the OPEC oil embargo, while mineral commodity prices also rose strongly, resulting in a 30 per cent increase in Australia's terms of trade before they fell back as the world entered recession in 1974/75. The second surge in commodity prices from 1978 to 1981 led to another period of great optimism, with expectations that Australia would become a much larger exporter of energy and processed metals. However, this turned out to be short-lived – although commodity prices rose by 40 per cent over the period, import prices were also rising strongly, largely offsetting the boost to national income, and commodity prices subsequently began their long decline with the 1982 global recession.[27] These booms were associated with periods of very poor macroeconomic outcomes, with high unemployment and inflation. In comparison, although Australia has experienced a larger mining boom in the 2000s, the macroeconomy has been much more stable, partly due to improvements in the institutional framework with the adoption of a floating exchange rate, decentralised wage bargaining, an inflation-targeting regime and product market flexibility.

Australia's freely floating exchange rate has allowed a real appreciation to occur in response to the 2000s mining boom without the adjustment coming through high inflation, as occurred under the less flexible exchange rate regimes of the 1970s and early 1980s. The surge in mining export receipts in the late 1960s and early 1970s generated strong domestic demand and placed upward pressure on the exchange rate. The Government kept the exchange rate fixed, building foreign reserves and allowing the domestic money supply to grow at an annual rate of over 20 per cent in the early 1970s (Figure 25). When the Government finally revalued the exchange rate in late 1972 and 1973, it was too late to restrain inflation, which had drifted up from around 3 per cent in the late 1960s to 7 per cent in 1971. In contrast, during the 2000s, the floating exchange rate began appreciating as the global economy recovered from the 2001 recession, and appreciated further over the remainder of the decade as the terms of trade continued to rise. Furthermore, when commodity prices moved sharply in 2008/09, the exchange rate adjusted to cushion the shock to the economy. Overall, the higher exchange rate has helped to offset the expansionary effect of the increase in mining export receipts and investment.

27 For more detail on these mining booms, see Sykes (1978), Pagan (1987), Blainey (2003), Gruen (2006) and Battellino (2010).

Figure 25: Mining Booms and the Macroeconomy



Note: The terms of trade and exchange rate are log scale

Sources: ABS; RBA

The consequences of the mining booms in the 1970s and early 1980s for inflation were magnified by the wage-fixing system, which tended to transmit demand pressures in one sector to wages across the economy through the principle of comparative wage justice. In early 1974, at the height of the terms of trade boom, miners secured a 20 per cent increase in minimum award wages, which was followed soon after by a similar increase in award wages for all industries. When combined with the surge in energy prices, the wages explosion resulted in inflation peaking at over 17 per cent in early 1975. This episode significantly increased real wages across the economy, contributing to a structural increase in unemployment over subsequent years. The (short-lived) resources boom of the early 1980s led the metals manufacturing industry to agree to a 24 per cent rise in hourly wages in 1982, which then set a precedent for other industries, resulting in a 16 per cent rise in wages across the workforce (Kelly 1992). This explosion in wages was followed by inflation of over 12 per cent and the 1982/83 recession, during which employment in metals manufacturing fell by a fifth and the unemployment rate rose to 10 per cent. In contrast, the replacement of the centralised wage system with more deregulated wage structures has enabled a rise in mining industry wages in the 2000s to be contained from the wage structure across the economy.

Other changes in government policy have also contributed to better macroeconomic outcomes during the 2000s. The current boom has occurred after a strengthening of institutions, including the introduction of a clear inflation-targeting framework and operational independence for the RBA, with inflation and aggregate wage growth remaining much more contained during the 2000s than in the 1970s and early 1980s. In addition, the economic reforms undertaken by Australian Governments since the 1970s to deregulate product markets have improved the ability

of the economy to flexibly respond to mining booms and changes in relative prices more broadly. As an example, trade barriers have been wound back progressively, with the Productivity Commission (2011) estimating that the effective rate of assistance to manufacturing has fallen from around 35 per cent in the early 1970s to around 5 per cent in the 2000s. The lower trade barriers have given households and businesses greater access to global markets to satisfy the extra demand generated by the mining boom, reducing the inflationary pressure in the domestic economy.

6. Conclusion

The rapid growth in Asia – especially China – is having a significant effect on the structure of the global economy, and on the Australian economy in particular. The strong global demand for energy and other commodities has led to rapid growth in the mining industry, both in the value of commodity exports and the level of mining investment, especially for iron ore, coal and LNG. At the same time, oil and metals processing exports have contracted, as Australia's oil fields have been depleted and Australia's comparative advantage has shifted towards the export of basic commodities.

The rapid growth in mining receipts has also had an impact on the directly affected industries and regional areas, as well as the rest of the economy. Activity within the mining industry has spilled over into domestic activity through its demand for labour, intermediate inputs (especially services) and investment, its payment of taxes and royalties, and the boost to Australian incomes through the ownership of mining equities. Overall, the available data suggest a little over half of the total receipts from current mining operations accrued to Australian residents, with around half the value of mining investment also spent within Australia.

Although the associated rise in spending has been a benefit to the Australian economy, it has also led to pressure on the price of non-tradables, and a large increase in the real exchange rate. While this has clearly had an impact on some activities – especially those affected by the exchange rate appreciation – overall the structural changes in the 2000s were more noticeable in investment patterns in the national and state economies rather than on unusually large changes in the industry composition of employment and real output. Nonetheless, there is evidence of changes *within* different industries, such as manufacturing, construction and accommodation.

Looking ahead, the increase in mining investment still in prospect is likely to see the mining industry having a larger effect on the economy, both in terms of the availability of the factors of production for the non-mining sector and its income effects. The economy is now closer to full employment and hence additional demands for labour and other inputs from the domestic economy and the distribution of mining revenues have the potential to spill over into further changes in input and non-tradable prices.

This is likely to be a challenging environment for policy as it attempts to ensure continued containment of overall demand and inflation pressures. In this regard, examination of past mining booms with the current one shows the benefits that have been derived from flexibility in both relative prices and allocative efficiency to help smooth these changes to input usage and domestic spending patterns.

References

ABARE (Australian Bureau of Agricultural and Resource Economics) (2002), *Australian Commodities*, 9(1).

ABARES (Australian Bureau of Agricultural and Resource Economics and Sciences) (2011), *Australian Commodities*, 18(2).

Andrews D (2009), 'Australia and the Global Market for Bulk Commodities', RBA *Bulletin*, January, pp 1–6.

AFR (Australian Financial Review) (2011), 'ASX Top 300 Companies', *Australian Financial Review*, 25 July, p 26.

Angevine G and M Cervantes (2011), *Fraser Institute Global Petroleum Survey 2011*, The Fraser Institute, Vancouver.

Banks G (2011), 'Australia's Mining Boom: What's the Problem?', Paper presented to the Melbourne Institute and *The Australian* Economic and Social Outlook Conference 2011 'Growth Challenge: Riding the Resources Boom to Lasting Prosperity', Melbourne, 30 June–1 July.

Battellino R (2010), 'Mining Booms and the Australian Economy', RBA *Bulletin*, March, pp 63–69.

Blainey G (2003), *The Rush that Never Ended: A History of Australian Mining*, 5th edn, Melbourne University Press, Melbourne.

BRW (Business Review Weekly) (2000), 'Top 500', *Business Review Weekly*, 22(16), pp 98–108.

Cagliarini A and M Baker (2010), 'Economic Change in India', RBA *Bulletin*, September, pp 19–24.

Christie V, B Mitchell, D Orsmond and M van Zyl (2011), 'The Iron Ore, Coal and Gas Sectors', RBA *Bulletin*, March, pp 1–7.

Connolly E and C Lewis (2010), 'Structural Change in the Australian Economy', RBA *Bulletin*, September, pp 1–9.

Cook LH and E Sieper (1984), 'Minerals Sector Growth and Structural Change', in LH Cook and MG Porter (eds), *The Minerals Sector and the Australian Economy*, Special Study No 6, George Allen & Unwin Australia in association with Centre of Policy Studies, Monash University, Sydney, pp 85–127.

Coombs M (2000), 'Developments in the Mining Sector', RBA *Bulletin*, July, pp 1–5.

Corden WM (1982), 'Exchange Rate Policy and the Resources Boom', *Economic Record,* 58(1), pp 18–31.

Corden WM (1984), 'Booming Sector and Dutch Disease Economics: Survey and Consolidation', *Oxford Economic Papers*, 36(3), pp 359–380.

Corden WM and JP Neary (1982), 'Booming Sector and De-industrialisation in a Small Open Economy', *The Economic Journal*, 92(368), pp 825–848.

Department of State Development and Department of Commerce (2011), 'Local Content Report', Government of Western Australia, May.

Donovan JB (1981), 'Social Accounting Measures of Regional Growth', in RL Matthews (ed), *Regional Disparities and Economic Development*, Centre for Research on Federal Financial Relations, Australian National University, Canberra, pp 221–254.

Fainstein M, J Harman and A Dickson (2002), *Australian Gas Supply and Demand Balance to 2019–20*, ABARE report for the Commonwealth Department of Industry, Tourism and Resources, Australian Bureau of Agricultural and Resource Economics, Canberra, August.

Geoscience Australia (2007), *Australia's Identified Mineral Resources 2007*, Geoscience Australia, Canberra.

Geoscience Australia (2010), *Australia's Identified Mineral Resources 2010*, Geoscience Australia, Canberra.

Gillitzer C and J Kearns (2005), 'Long-Term Patterns in Australia's Terms of Trade', RBA Research Discussion Paper 2005-01.

Gregory RG (1976), 'Some Implications of the Growth of the Mineral Sector', *The Australian Journal of Agricultural Economics*, 20(2), pp 71–91.

Gruen D (2006), 'A Tale of Two Terms-of-Trade Booms', Address to Australian Industry Group's Economy 2006 Forum, Melbourne, 1 March.

Gruen D and S Kennedy (2006), 'Reflections on the Global Economy and the Australian Mining Boom', *Economic Roundup*, Spring, pp 45–65.

Henry K (2008), 'Revisiting the Policy Requirements of the Terms-of-Trade Boom', Address to the Australian Business Economists, Sydney, 20 May.

Hogan L, J Harman, A Maritz, S Thorpe, A Simms, P Berry and A Copeland (2002), 'Mineral Exploration in Australia: Trends, Economic Impacts and Policy Issues', *Australian Commodities*, 9(4), pp 601–607.

Holloway J, I Roberts and A Rush (2010), 'China's Steel Industry', RBA *Bulletin*, December, pp 19–25.

IEA (International Energy Agency) (2010), *World Energy Outlook 2010*, OECD/IEA, Paris.

Johnston L and SH Williamson (2010), 'What Was the U.S. GDP Then?', MeasuringWorth. Available at <http://measuringworth.com/usgdp/>.

Kelly P (1992), *The End of Certainty: The Story of the 1980s*, Allen & Unwin Pty Ltd, St Leonards.

Macfarlane IJ (2002), 'The Australian Economy: Past, Present and Future', RBA *Bulletin*, April, pp 6–11.

Maddison A (2009), 'Statistics on World Population, GDP and Per Capita GDP, 1-2008 AD'. Available at <http://www.ggdc.net/MADDISON/Historical_Statistics/horizontal-file_02-2010.xls>.

Maurer A, T Wells, R Curtotti, T Johnson and I Haine (2004), 'China's Mineral Sector: Strong Growth Providing Opportunities for Australia', *Australian Commodities*, 11(2), pp 306–318.

McKissack A, J Chang, R Ewing and J Rahman (2008), 'Structural Effects of a Sustained Rise in the Terms of Trade', Treasury Working Paper 2008–01.

Mélanie J, R Curtotti, M Saunders, K Schneider, L Fairhead and Y Qiang (2002), *Global Coal Markets: Prospects to 2010*, ABARE Research Report 02.2, Australian Bureau of Agricultural Resource Economics, Canberra.

Metals Economics Group (2011), 'World Exploration Trends 2011', A Special Report from Metals Economics Group for the PDAC International Convention. Available at <http://www.metalseconomics.com/sites/default/files/uploads/PDFs/wet2011english.pdf>.

Mudd GM (2010), 'The Environmental Sustainability of Mining in Australia: Key Mega-Trends and Looming Constraints', *Resources Policy*, 35(2), pp 98–115.

National Resources Sector Employment Taskforce (2010), *Resourcing the Future: National Resources Sector Employment Taskforce Report*, Final Report, Department of Education, Employment and Workplace Relations, Canberra.

New R, A Ball, A Copeland *et al* (2011), *Minerals and Energy, Major Development Projects – April 2011 Listing*, Australian Bureau of Agricultural and Resource Economics and Sciences, Canberra, May.

OECD (Organisation for Economic Co-operation and Development) (2001), *Developments in Steelmaking Capacity of Non-OECD Countries*, OECD Publishing, Paris.

OECD (2002), 'High-Level Meeting on Steel, 18-19 April 2002', OECD document PAC/COM/NEWS(2002)52, 19 April. Available at <http://www.oecd.org/officialdocuments/displaydocumentpdf/?cote=PAC/COM/NEWS(2002)52&doclanguage=en>.

Pagan AR (1987), 'The End of the Long Boom', in R Maddock and IW McLean (eds), *The Australian Economy in the Long Run*, Cambridge University Press, Cambridge, pp 106–130.

Productivity Commission (1998), *Aspects of Structural Change in Australia*, Research Paper, AusInfo, Canberra.

Productivity Commission (2011), *Trade & Assistance Review 2009-10*, Annual Report Series, Productivity Commission, Canberra.

RBA (Reserve Bank of Australia) (2005), 'Commodity Prices and the Terms of Trade', RBA *Bulletin*, April, pp 1–7.

Roberts I and A Rush (2010), 'Sources of Chinese Demand for Resource Commodities', RBA Research Discussion Paper No 2010-08.

Schneider K (2004), 'China's Energy Sector: Recent Developments and Outlook', *Australian Commodities*, 11(2), pp 299–305.

Stevens G (2010a), 'The Challenge of Prosperity', RBA *Bulletin*, December, pp 69–75.

Stevens G (2010b), 'Monetary Policy and the Regions', RBA *Bulletin*, December, pp 83–90.

Stevens G (2011), 'The Resources Boom', RBA *Bulletin*, March, pp 67–71.

Sykes T (1978), *The Money Miners: Australia's Mining Boom 1969-1970*, Wildcat Press, Sydney.

Topp V, L Soames, D Parham and H Bloch (2008), 'Productivity in the Mining Industry: Measurement and Interpretation', Productivity Commission Staff Working Paper, December.

United Nations (2009), 'World Urbanization Prospects: The 2009 Revision Population Database', Department of Economic and Social Affairs, Population Division. Available at <http://esa.un.org/wup2009/unup/index.asp>.

Withers G, T Endres and L Perry (1985), 'Australian Historical Statistics: Labour Statistics', Australian National University Source Papers in Economic History No 7.