Minerals, Growth and Development

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SOME FOUNDATIONS – MINERAL EXPLOITATION, PRODUCTION, DISTRIBUTION, CONSUMPTION, TRADE AND RELATED ECONOMIC CONCEPTS

Several processes always occurring within any economy determine the economic wellbeing of its citizens. They include **production, distribution, consumption and trade**. The focus of this volume is how minerals and energy impinge on these processes.

It is typical, initially at least, to think of the ways in which people use minerals and energy in the process of producing goods and services. The distribution of the proceeds of resource wealth and the consumption of mineral and energy resources are very important as well. Furthermore, the sale and purchase of minerals and energy through interregional and international trade plays an important role in increasing people's welfare.

Let us begin by taking a **production** view of things. Over any given period, what an individual, firm, region, nation or the world produces in terms of a production function in which the output generated is a function of the economic resources used as inputs. Economists have typically denoted these resources as land, labour and capital. The state of technology may also be added as an additional factor but in the short term at least this may be reflected in the nature of the capital stock and the quality of the labour force. More recently it has also become common to include the environment (or environmental services) among this group of inputs.

Hence it may be hypothesised that:

> Economic output = f (Land, Labour, Capital, Environment)

But what do economists mean by land, labour and capital? ***Land*** refers to all of the natural resources used in production. As well as the land itself it includes water, forests, fisheries, **oil, gas** and **mineral deposits**. ***Labour*** refers to the skills and capabilities used by humans in the production process. ***Capital*** describes all of the manufactured aids used in the process of production[1].

The environment reflects the quality of the natural world around us. It is responsible for quality of the air that we breathe, the water that we drink and the way that we utilise it affects the food that we eat and the materials that we use to build shelter for ourselves. The services that the environment provides are an input to production. It is also a 'sink' for our wastes and if this aspect is overused, the environment can adversely affect our ability to produce.

Critics might argue that most mining and oil companies neglected their surrounding environment until quite recently[2]. Companies did so because their main focus was on profits and dividends to shareholders, and governments did not actively regulate pollution. They were not alone in their practices. Many manufacturing firms did little to treat wastes, discharging them into the nearby atmosphere, or into rivers, lakes or the ocean with minimal treatment. Also, in many parts of Australia, past farming practices have resulted in erosion and reduced soil fertility.

The following statement by McDivitt and Jeffrey (1976, p 16) reflects an interesting additional economic perspective about the impact of mining on production:

> *mineral development can contribute to the three major factors of production – land, through bringing into action otherwise dormant resources in the country; capital, both through attracting*

1. It has become increasingly common practice to identify *land* as natural capital, *labour* as human capital and *capital* as physical capital.
2. This criticism continues to apply to the activities of most small-scale and artisanal miners in developing nations.

> *outside investment capital to the country and through providing new money some of which can be used for local investment; and labor, through upgrading local skills and implanting concepts of entrepreneurship.*

That is, mining uses machines, labour, and ore to produce metals that produce further capital (buildings, bridges). Through the process, worker skills are upgraded, enhancing the labour pool for mining's own use or for use in other sectors. If they were rewriting this passage today, the two authors may also have included a reference to environmental quality issues.

In any economy, the issue of **distribution** is also important – the way in which different individuals or groups share production. Issues relating to the fairness or equity in the distribution of income and wealth generate controversy. This happens within families, regions and also between nations on the world stage. Governments use the proceeds of taxation and royalty collection to redistribute this income and wealth.

The discovery and exploitation of minerals often brings major new activity to mining regions. Issues quickly arise as to how much of the windfall should be retained by local residents, how much distributed to the investors (often from other places) who have taken risks and incurred large past expenditures to develop new oil wells or mines, and how much redistributed by government to citizens in other regions or states. These controversies are often the source of continuing disquiet. Where resolved in a satisfactory fashion, major new mineral and energy production has the potential to be shared widely for the benefit of many people in the state where a mining region is located, and in the nation more generally[3].

Hence one might argue that the great mineral wealth of the Pilbara, Eastern Goldfields and other mining regions of Western Australia have been distributed effectively over more than a century. It has enhanced the income and general fortunes of the average citizen of the mining regions. A large royalty stream, together with payroll tax receipts, has assisted the finances of the Western Australian government. Greater individual and company income taxes, as well as resource rent royalties, have also contributed to the welfare of Australians more generally.

Even without the hand of government to redistribute income and wealth through the fiscal system, many past mineral discoveries have brought a more even distribution of income. This was the case with the Victorian, New South Wales and Western Australian gold rushes in the 19th century. Blainey (2003, p 62) notes that:

> *Gold checked, and for a time, reversed Australia's tendency to become a land that favoured the big man. Whereas Australia's first natural asset, the sheeplands, was grasped by a few thousand men, its second rich natural asset, the goldlands was divided among hundreds of thousands of men.*

Where mineral windfalls involve labour-intensive mining activity there is increased opportunity to share income and wealth more equally[4]. But as minerals then become less amenable to labour-intensive mining and require greater amounts of capital, there is potentially the reverse tendency for the distribution of income and wealth to become more unequal.

A continuing issue regarding our future concerns the way in which production and **consumption** relate to one another. Consumption involves individuals and households (the private sector) and also government using up goods and services.

If a society *consumes less than it produces* (ie spends less than its income) in any given time period, its members (both the private and public sector) can save the residual and invest it to ensure production continuing in the future. **Saving** and **investment** are important additional concepts in the economist's lexicon. Saving refers to the amount generated from abstaining from consumption in any given period, while investment is spending on capital formation, both physical and human.

New investment that increases a nation's or region's physical and human capital typically provides the basis for further economic growth and development. If citizens consume what they produce, or *more than they produce* by borrowing against future expected production, their capital stock will fall and so will production, if other things are equal. It is typical to be impressed by 'economic miracle' nations whose strong growth and development is attributable to saving, followed by wise investment in new physical and human capital. The economic performance of Japan, Korea, Taiwan, Singapore, Hong Kong and now China in the latter part of the 20th century have drawn great praise from most commentators.

Where nations have large mineral and energy resource endowments, much of which may have only recently been discovered, there also seems considerable potential to invest the profits from its exploitation. Such endowments form part of a **natural capital** base. Some natural capital is renewable, while some is not. It is normal to think of agricultural land, forests, fisheries and solar, wind and tidal energy as **renewable resources**, and to classify minerals and many other energy sources as **non-renewable resources**. Despite their finite nature, and as noted earlier, it is possible to recycle many minerals in a financially viable way.

If minerals are produced, and consumed, and they cannot be recycled, their stock will decline[5]. How the citizens of a country or region allocate the proceeds of mineral exploitation to current consumption and investment is an issue that has been of interest to many people. Such debate is typically heard in discussions about minerals and sustainable development.

The final key concept in this section is **trade**. Trade takes place because it makes individuals, companies and nations better off. By specialising in the things they can do best, these groups can exchange part of their production for a variety of goods and services that will enable them to reach a higher standard of living than without trade. Trade takes place within regions, between regions and between nations. Trade in minerals and energy is important. The nature and location of mineral deposits means that not all nations or regions can be self-sufficient in minerals, even if they want to be. With the exception of mineral production by firms that are vertically integrated[6], most minerals and energy produced is traded either domestically or internationally.

As will be discussed later, exports of minerals and energy play an important part in increasing the economic and social welfare of perhaps one quarter of all nations. Their importance to Australia was particularly significant from the early 1840s until the beginning of World War I. Though subsiding dramatically after 1914, mineral export trade rose again dramatically from the 1960s onwards. Sustained international competitiveness in many sectors of the industry has underpinned Australia's strong economic performance in the last part of the 20th century and at the beginning of the new millennium.

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3. An important associated point here relates to the intertemporal flow of resources. A mine that is generating lots of production/profit in 2005 may not be generating enough to pay off the debt incurred in building the mine. Yet the profits are often seen as a windfall.
4. Elements of this argument apply widely to labour-intensive small-scale mining activities in developing nations.
5. Technology will of course make it more possible to access lower grade deposits over time.
6. Vertical integration describes a situation in which 'a firm participates in more than one successive stage of the production or distribution of goods and services'.

TABLE 2.1

Key production and growth indicators for selected economies. (Source: World Bank, 2005.)

Nation	GDP in 2001 (US$ billion)	GDP per capita in 2001 (US$)	GDP per capita at PPP in 2001 (US$)	Real GDP growth 1990 - 2001 (per cent)
Major developed economies				
United States of America	10 416	35 060	35 060	3.7
Japan	3978	33 550	24 076	2.3
Germany	1976	22 670	24 288	2.4
United Kingdom	1552	25 250	24 467	3.4
France	1409	22 010	22 716	2.0
Italy	1181	20 397	25 809	1.8
Korea	448	9471	15 087	5.6
Major developing economies				
China	1237	940	4177	8.9
India	515	480	2929	7.9
Russia	346	2390	9385	-0.2
Indonesia	172	710	2900	5.6
Major mineral exporters				
Canada	715	22 300	26 992	2.9
Brazil	452	2850	6569	2.9
Australia	410	19 740	24 451	4.3
South Africa	104	2600	10 067	2.7
Chile	64	4260	8206	6.2
Peru	57	2050	4634	3.7
Developing mineral economies				
Papua New Guinea	2.8	530	2297	1.4
Ghana	6	270	2037	5.5
Tanzania	9.4	280	1321	3.0
Botswana	5.2	2980	7309	8.1
Zambia	3.7	310	752	2.8
Dem Rep of Congo	5.7	90	707	-10.9
Major oil producers				
Saudi Arabia	187	8460	13 267	
Venezuela	108	1710	6025	3.5
Iran	109	1680	5940	3.4
Nigeria	37	285	784	2.9

ECONOMIC GROWTH AND DEVELOPMENT

When commentators discuss the **economic growth** of a nation, a region, or the world, they usually are referring to the percentage rate of growth in total production over a given period such as a year (or a quarter).

On some occasions, however, they may mean:

- the percentage rate of growth in *per capita* production of the average citizen over a given time period; and
- more recently, the rate of growth of productivity, or output per worker.

Following the widespread adoption and use of national accounting frameworks throughout the world since 1950, it has become standard practice to measure economic growth by computing percentage changes in real *Gross Domestic Product* – commonly known as GDP. The term 'real' is used to indicate that the measure has been adjusted for changes in the rate of inflation.

Gross Domestic Product is a measure of the market value of final goods and services produced in an economy during a given period[7].

Each nation's central statistical agency typically has the role to compute official estimates of GDP. In the case of Australia, this organisation is the Australian Bureau of Statistics. Australia's officially estimated GDP in the 2002-03 financial year was around A$ 735 billion (or US$ 450 billion). This meant that GDP per capita for each of Australia's 19.7 million inhabitants was a little more than A$ 37 000. Australia's rate of real GDP growth during this period was 3.8 per cent.

Some comparisons between the level of Australia's GDP in 2001 and those of selected other nations, together with actual GDP per capita, and GDP per capita at **Purchasing Power Parity** (PPP) appear in Table 2.1.

The PPP adjustment in GDP per capita allows for cost of living differences. The benchmark for the PPP measure is the cost of living in the USA. GDP per capita in the US was US$ 35 060 in 2001. Its GDP per capita at PPP was, of course, also US$ 35 060.

7. The GDP measure differs conceptually from Gross National Product, which refers to the estimated value of final goods and services produced in a given period by a country's citizens. International agencies such as the World Bank have recently commenced using another measure (Gross National Income (GNI)) in making international comparisons of economic size and growth between nations.

Compare this with the situation in Japan. Over the past two decades, most would judge that the cost of living in Japan has been high. While GDP per capita in Japan, at US$ 33 550, was close to that in the US, that nation's GDP per capita at PPP was only US$ 24 076. The cost of living in the United States was about 30 per cent less than in Japan.

Think now about the average Australian, whose estimated GDP per capita in 2002 was US$ 19 740. The purchasing power of an Australian income earner was almost 24 per cent higher than his or her counterpart in the United States. Australia's estimated GDP per capita at PPP in 2002 was US$ 24 451.

These estimates are important for mining companies and consultants in estimating the relative average living standards of citizens, and potential operating costs, in nations in which they may wish to invest or otherwise do business. In Chile, for example, per capita GDP was only US$ 4206 in 2002. But, because the cost of living was only about a half of that in the United States, estimated GDP per capita at PPP was US$ 8206, almost double this amount.

The GDP measure has several notable limitations. Importantly it does not include adjustments for capital consumption, depreciation of natural capital, or environmental degradation. It fails to include estimates of the value of non-market goods such as work at home. Hence the contributions to production of women and men who devote their lives to being homemakers and raising families are not included. Also excluded is the work of volunteers who contribute generously to the functioning of many community organisations. In a 1987 study, the Australian Bureau of Statistics estimated that Australians devoted just over 250 million hours each week to paid work, and a further 303 million hours to unpaid work.

Notwithstanding the significant contributions to overall production of these latter groups in a country such as Australia, the size of these latter parts of the informal economy are of considerably greater relative importance in developing nations. Hence, even adjusting for Purchasing Power Parity, it is still likely that any comparison of living standards using GDP per capita at PPP between an affluent developed nation, such as Australia, and a poor developing mineral economy in Africa will overstate the difference between them. While it is clear, therefore, that the average citizen of a nation such as Tanzania is very poor, his or her production will in reality exceed the estimate of $1321 in Table 2.1 by a higher percentage than it does for the average Australian citizen. GDP per capita at Purchasing Power Parity comparisons between nations are at best only an approximate indicator of differences.

These limitations have stimulated a number of alternative approaches and adjustments to reflect a country's economic size and stage of development in a more effective manner. But this statement itself begs the question of what development really means.

Todaro (1989, pp 86-87) points to traditional views that **development** or **economic development** takes place over an extended period (of say ten years or more) when an economy:

- is able, following a period of mediocre economic performance, to bring about annual rates of growth exceeding five per cent; or
- generates consistent growth in its real GDP per capita.

Hence, according to the estimates reported in Table 2.1, it may be argued that between 1990 and 2001 nations such as South Korea, China, India, Indonesia, as well as the two mineral rich nations of Botswana and Chile experienced economic development.

But the Todaro view also seems implicitly to assume that the structure of such an economy will change, with the emergence of major new and competitive industry sectors (eg manufacturing, services, etc). The achievements over a longer period of Japan and the Asian Tigers and China, which have transformed their economies, are examples of significant economic development taking place. Historically, it would also seem that nations such as the United States, Britain, Germany, France, Canada and Australia have experienced economic development surges in this way.

During the 1970s, a broader view emerged concerning the dimensions of the concept of economic development. Writers began to consider economic development in terms of reducing poverty, income inequality and unemployment when an economy was experiencing consistently strong real GDP growth over an extended period.

In his extended definition, Todaro (1989, p 88) argues that:

> *Development must… be conceived as a multi-dimensional process involving major changes in social structures, popular attitudes and national institutions, as well as the acceleration of economic growth, the reduction of inequality, and the eradication of absolute poverty.*

Associated with this interest in a broader definition of economic development, several economists have proposed the use of broader socioeconomic indicators to measure development. These began in the United Nations in the late 1960s. One of the notable measures has been Morris's Physical Quality of Life Index (based on life expectancy at age one, infant mortality and literacy). Following in this tradition, the United Nations Development Programme (UNDP) publishes its Human Development Index (HDI) in its annual *Human Development Report*[8]. The HDI measure is based equally on **life expectancy**, **education levels** and the **average standard of living** (UNDP, 2003, p 340). The UNDP classifies countries as follows:

Level of human development	HDI value
High	0.8 or above
Medium	Between 0.5 and 0.8
Low	Less than 0.5

Estimates of the HDI for 2000 appear in Table 2.2 for the same selection of countries as in Table 2.1. The UNDP ranked 173 nations in its 2000 list. It classified 55 nations as exhibiting high human development, 83 with medium human development and 37 with low human development[9]. A complementary classification of developed and developing nations also appears in the Appendix of this chapter.

Most of the major developed economies (with Canada and Australia also on this list) have Human Development Index values greater than 0.9[10]. These values had increased by approximately 0.1 between 1975 and 2000. Among the four major developing nations, China and Russia had Human Development Index levels above 0.7. While HDI levels had consistently risen in China since 1975, they had fallen in Russia from 0.824 in 1990 to 0.781 a decade later. Both India and Indonesia experienced rises of around 200 points in their HDI levels between 1975 and 2000[11].

8. As this manuscript is written, the *Human Development Report* is readily available in downloadable form from the UNDP web site: http://www.undp.org.

9. Through its promotion of the Millennium Development Goals the United Nations has focused attention over the past five years on 'an expanded vision of development… that vigorously promoted human development as the key to sustaining social and economic progress'.

10. Norway and Sweden (not listed in Table 2.2) were the top ranked nations in 2000 with HDI values of 0.942 and 0.941 respectively.

11. It is important to acknowledge that because the goalposts are renormed every year that intertemporal comparisons of HDI values should be interpreted with caution.

TABLE 2.2

Estimates of human development indices for selected economies in 2000. (Source: United Nations Development Programme, 2003.)

Nation	Life expectancy	Education	GDP at PPP	HDI	GDP per capita minus HDI rank
Major developed economies					
United States of America	0.87	0.98	0.97	0.939	-4
Japan	0.93	0.93	0.93	0.933	2
Germany	0.88	0.97	0.92	0.925	-2
United Kingdom	0.88	0.99	0.91	0.928	7
France	0.89	0.97	0.92	0.928	6
Italy	0.89	0.94	0.91	0.913	-1
Korea	0.83	0.95	0.86	0.882	1
Major developing economies					
China	0.76	0.80	0.61	0.726	0
India	0.64	0.57	0.53	0.577	-1
Russia	0.68	0.92	0.74	0.781	-2
Indonesia	0.69	0.79	0.57	0.684	1
Major mineral exporters					
Canada	0.90	0.98	0.94	0.940	4
Brazil	0.71	0.83	0.72	0.757	-13
Australia	0.90	0.99	0.93	0.939	7
South Africa	0.45	0.88	0.76	0.695	-56
Chile	0.84	0.90	0.76	0.831	12
Peru	0.73	0.87	0.65	0.747	6
Developing mineral economies					
Papua New Guinea	0.53	0.55	0.52	0.535	-9
Ghana	0.53	0.62	0.50	0.548	1
Tanzania	0.43	0.61	0.28	0.440	21
Botswana	0.25	0.75	0.71	0.572	-62
Zambia	0.27	0.68	0.34	0.433	12
Dem Rep of Congo	0.44	0.51	0.34	0.431	11
Major oil producers					
Saudi Arabia	0.78	0.71	0.79	0.759	-26
Venezuela	0.80	0.83	0.68	0.770	10
Iran	0.73	0.75	0.68	0.721	-22
Nigeria	0.44	0.58	0.37	0.462	9

Among the somewhat diverse major mineral exporting country group, all except South Africa had experienced continuing increases in their HDI levels. While rising from 0.714 in 1990 to 0.724 in 1995, South Africa's level dropped to 0.695 by 2000. Perusal of Table 2.2 suggests that the low value of 0.45 for the life expectancy component of the HDI was largely responsible for this. There were similarly low levels for other African mineral economies such as Botswana, Zambia, Tanzania and the Democratic Republic of the Congo. This is a reflection of their health crises arising from the HIV/AIDS epidemic.

The final column of Table 2.2 provides a summary analytical tool in comparing perceived development as reflected in HDI ranking, with the narrower production-based GDP per capita at Purchasing Power Parity. Positive entries indicate that the GDP-based measure may understate a country's stage of development. Nations such as the United Kingdom, France, Australia, Chile and Venezuela might all be somewhat more developed according to this metric. Brazil, South Africa, Botswana, Papua New Guinea, Saudi Arabia and Iran are apparently less developed. While this summary measure provides a novel development indicator, the impact of the health crisis in sub-Saharan Africa seems to undermine its value for anything more than a first pass appraisal by a mining company of the stage of development of any potential new investment destination.

Other things being equal, it should be more attractive to invest in a more developed nation, but making a judgment about development should involve assessing several other issues. Consistent with the Todaro definition above, such things as social and institutional stability and honesty, income and wealth distribution trends, and poverty levels interact with the status of mineral policy and the extent of a country's mineral endowment in doing this in an effective and professional way.

PERIODS OF HISTORY AND MINERALS

Minerals and energy have had a major role in the history of the world. This is apparent simply by noting that so many periods have been characterised by material or energy names. Reflecting the role of changing technology (apparent in the production function) the use of key minerals as a principal ingredient of tools, or power, in periods bearing their names brought improvement in terms of human well-being, as measured by population growth and other indicators.

TABLE 2.3

Different periods in history. (Source: Derived from Wilson, 1994.)

Period	Dates
Homo Erectus	500 000 years ago
Homo Sapiens	200 000 years ago
Stone Age	30 000 to 4000 BC
Neolithic (New **Stone** Age)	SW Asia 9000 to 6000 BC Europe to 4000 BC
Chalcolithic (**copper-stone**) period	4000 to 3000 BC
Copper Age	Began 3000 BC
Bronze Age	Began 2500 BC
Iron Age	Began 1000 BC
Coal Age	Began AD 1600
Industrial Revolution (based on **coal**, **iron** and **steam**)	AD 1750 to 1850
Oil Age	Began AD 1875
Atomic Age	Began AD 1945
Information Age	Began AD 1960

This shows up clearly in Table 2.3, a summary table adapted from Wilson (1994). Wilson (1994, p xiii) also argues that:

> *The history of metals is the history of civilisation. The two are inseparable; each depends on the other for its development; when one stumbles the other falters. Ever since Neolithic man learned the secret of winning metals from ore-bearing rock, metals have dominated the world's political, social and economic evolution. For 5000 years they have been the major factor in the flowering of a people's culture, the key to their industrial power and their influence in world affairs.*

There seems much to this argument, though modern oil and gas producers would also associate themselves with these views.

A brief review of ancient history illustrates how members of the prominent civilisations effectively used new technologies in processing metals such as copper, iron, gold, silver and tin as a basis for enhancing both the quality of life of their citizens, as well as their military strength. The emphasis on the latter area seems to have been of central importance in the domination of surrounding populations. This applied in varying ways to the Sumerian, Babylonian, Assyrian, Persian, Greek, Carthaginian, Roman and Chinese civilisations. With the fall of the Roman Empire around 450 AD, the use of metals dwindled as the world of Europe and the Middle East descended into the 'Dark Ages' period.

Though new uses of minerals and energy began slowly emerging after 1500, it was the emergence of the Industrial Revolution in the United Kingdom from about 1750 that heralded the widespread modern uses on minerals and energy. The emergence of heavy industry, the widespread use of coal and more recently oil and gas as its major energy sources, and the rise of materials such as steel, aluminium and a range of more exotic metals, have all been part of this picture. The Industrial Revolution has led to consumer societies in which minerals and energy are used in ways and at levels that were previously unimaginable. Associated with this have been major technological advances in exploration, mining and particularly mineral processing. Advances in transport technology have also created a global minerals economy, and as will be seen in the next chapter, have hastened the economic development of nations such as Australia in a dramatic way.

ECONOMIC DEVELOPMENT AND MINERAL RESOURCES – THE TRADITIONAL VIEW

A generally accepted view is that the presence of minerals should assist the economic fortunes of a nation or region. The greater the quantity of reserves available, up to some point, the more economic growth should be generated and conversely, as reserves are used up, economic growth will be constrained. The discussion then moves to sustainability issues. Wise investment of the proceeds of mineral exploitation should ensure a different but potentially sustainable economy after the lode has run out.

Tilton (1992, p 1) notes that:

> *…the returns from mineral exploitation can be used to build airports and highways, stores and factories, schools and hospitals, and homes and parks. They can enhance political stability by addressing regional and tribal grievances and in various ways bolster economic growth.*
>
> *Mining and mineral processing can also generate jobs, provide opportunities for the development of domestic skills, encourage the creation of associated industries, and provide other beneficial side effects or linkages for the local economy.*

He goes on to observe that:

> *History documents that mineral resources can indeed facilitate economic development. The Industrial Revolution began in England and quickly spread to Germany and the United States partly because these countries were well endowed with coal and other natural resources. Saudi Arabia and other Middle East oil-producing countries are more recent examples of the positive role mineral wealth can have in economic development.*

A major mineral windfall has the potential, if properly managed, to stimulate economic growth, raise incomes and allow investment in human and physical capital, which will ensure a nation's longer term economic and social success.

THE AUSTRALIAN EXPERIENCE

Australia's experience with minerals and energy seems to fit in well with this traditional view. The impact of major mineral discoveries, and their subsequent exploitation, on Australia's economic performance during more than two centuries of European settlement is an interesting case study. Perceived in terms of the perspective of economic production and the factors in the production function, described in the McDivitt and Jeffrey quotation at the beginning of this chapter, the discovery and exploitation of minerals transformed Australia. It moved from undeveloped to developed status over a relatively short period of time.[12] The further development of the resources sector underpinned development of the Australian economy for much of the second half of the 20th century. This contribution is set to continue in the 21st century.

The major impact of mineral development did not emerge until the 1840s, some 50 years after European settlement. The discovery of copper in South Australia provided a strong stimulus for the fledgling new colony there. But it was the gold rushes in New South Wales and Victoria, only a decade later, that dramatically transformed the Australian colonies from struggling

12. Several economic historians have written authoritatively about the topic. Notable among them have been Blainey (1966, 2003), Sinclair (1976) and Shaw (1966).

TABLE 2.4

Mining and Australian population growth 1788 - 2001.

Year	Total population (M)†	M/F	Main event in preceding period
1788	0.001	na	Convict settlement
1800	0.005	2.63	Convict settlement
1820	0.034	2.44	Dominance of whaling, emergence of agriculture
1840	0.190	2.02	Decline of whaling, agriculture strong, new colonies (Victoria, South Australia, Western Australia)
1850	0.405	1.43	New colonies emerge, Irish famine, **copper mines** in South Australia
1860	1.146	1.40	**Gold rushes** (Bathurst, Ballarat, Bendigo, etc)
1870	1.648	1.21	Mining strong, emergence of railways, faster ships
1880	2.231	1.17	Continuation of above trends, emergence of **Tasmanian mines**, telegraph service
1890	3.151	1.16	**Broken Hill** rush, new gold finds, railway boom
1900	3.765	1.11	Major national recession, bank failures, **Western Australia gold rush**
1911	4.455	1.08	Federation, continued strength of mining
1921	5.435	1.03	First World War, **copper boom**
1933	6.629	1.03	Stock boom of 1920s, decline of mining towns, beginning of Depression.
1947	7.579	1.004	Effects of Depression, Second World War
1954	8.986	1.032	Post war boom, major new migration, promotion of manufacturing, **uranium** mines
1961	10.548	1.022	Strong economic growth, migration, manufacturing, major **bauxite** finds
1971	13.067	1.022	Continuation of above trends, new finds of **iron ore**, off-shore **petroleum, nickel, coal**
1981	14.932	1.005	Mining boom, stagflation, major rises in **oil prices**
1991	17.085	0.99	Deep recessions at beginning and end of decade, boom in middle, **strong performance of mining, gold, iron ore, coal, nickel, copper**, etc
2001	19.5	0.975	**Mining retains strong role** with new discoveries continuing, Australian mining companies invest offshore

† Aboriginal population not included until 1971.

economic backwaters into much more desirable migration and investment destinations. Some of the factors that held back the discovery and exploitation of minerals in Australia were poor roads, the lack of a railway system, unnavigable rivers and distance from major markets.

Yet it was an unlikely and short-lived geographical advantage – the proximity of ports like Sydney to California – that acted as a catalyst for the Australian gold rushes. The discovery of gold near San Francisco in 1848 led to the California gold rushes. Although more than 10 000 km away on the other side of the Pacific, the ten-week journey by ship from Sydney to San Francisco was less than the 13-week journey around Cape Horn from New York[13]. For a brief period Sydney became a significant supply port for California. The Australians, who flocked across the Pacific to join the rush, noticed the similarity of the terrain with that in New South Wales. Returning to Sydney in early 1851, the entrepreneurial Edward Hargraves travelled to Hill End where he showed local shepherds how to search for gold. They soon discovered the yellow metal and on 3 April, Hargraves announced to the Colonial Secretary in Sydney that he had discovered gold.

The following quote by Shaw (1966, p 65) captures the atmosphere in a colourful way:

> *On 3 April 1851, occurred an event which radically changed the character of the Australian colonies and tremendously hastened their development. Edward Hammond Hargreaves officially notified the Colonial Secretary of New South Wales that he had discovered gold near Bathurst.*
>
> *It was a memorable day. Its effects were tremendous. There was an immediate rush to New South Wales from the other colonies; to stop this, a committee of Victorian businessmen on 9 June offered a reward of £200 for the discovery of gold within 200 miles of Melbourne. It was claimed next day. By the end of the year (1851) rich fields near Ballarat and Bendigo and other minor discoveries made Victoria, not New South Wales, the magnet for the diggers.*

The summary information in Table 2.4 provides some insight into the effect of major mining discoveries and subsequent mineral exploitation on Australia's population growth. This impact has been associated with sustained economic growth and associated economic development.

Even though the British government established six colonies (in what were to become Australia's six states at Federation) during the first 50 years of European settlement, the European population grew slowly until 1840, when it stood at 190 000. This growth related particularly to Australia's status as a convict destination, the rise and fall of whaling and the development of agriculture. Even though the population more than doubled to 405 000 by 1850, partly due to the stimulus of the discovery of copper in South Australia, it was gold that brought dramatic change.

Sinclair (1976, p 79) notes:

> *…the discovery of alluvial gold must be regarded as a major discontinuity. The significance of this for the course of Australian economic development was heightened by the rapidity with which gold was extracted from the ground.*

Australia became the world's leading gold producer as production rose from zero in 1851 to more than 90 tonnes in 1856, then declined gradually around 50 tonnes per annum in 1865.

13. There were no roads or railways across the United States at that time. The Panama Canal was not completed until several decades later.

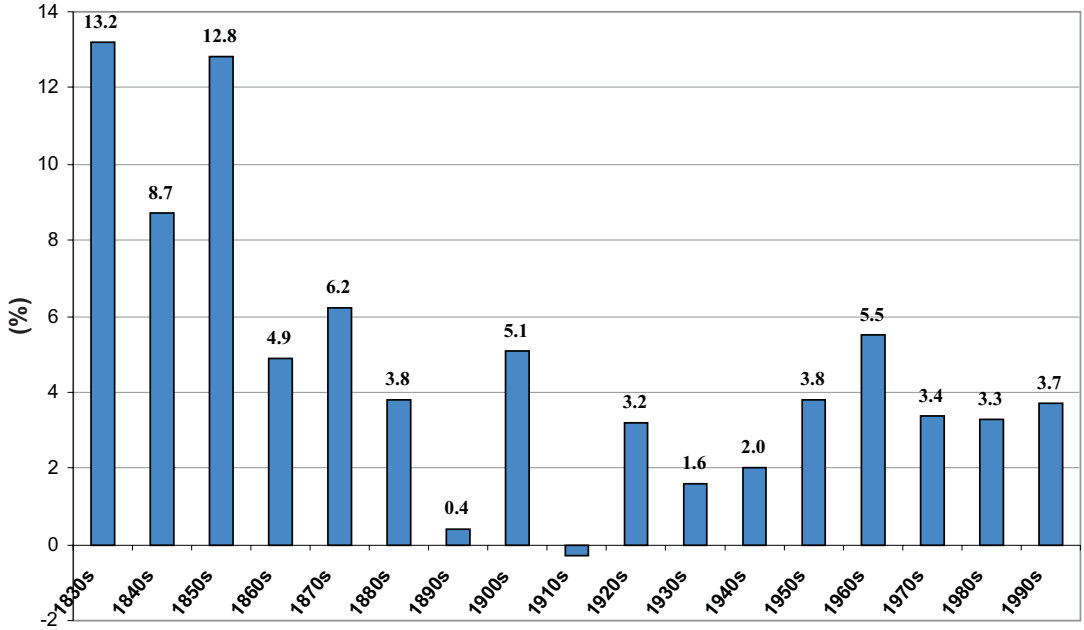

FIG 2.1 - Estimated percentage average real GDP growth in the Australian economy on a decade by decade basis – 1830 to 2000.

Blainey (2003, p 62) notes:

> *Possibly no other country in the world has been so quickly transformed by metals; the normal growth and achievement of several decades were crammed into one. Australia ceased to be a land of exile in British eyes and became a respectable field of migration and [beginning with capital-intensive underground mining in 1886] investment… The swift growth of population widened the market for Australian manufactures and foodstuffs. It stimulated farms and factories and workshops and cities. Gold drew population into the interior and attracted railways from the ports. Bendigo and Ballarat in 1862 got the continent's first upcountry railways, and cheap transport stimulated farming…*

This shows up in an interesting way in the estimates of average annual real GDP growth, and GDP per capita growth, that appear respectively in Figures 2.1 and 2.2. The Australian government began producing the national accounts in a formal way during the 1950s. The earlier estimates are derived from Butlin (1962) and McLean (2004). They cover ten-year periods and hence do not reflect considerable annual variations in the rate of growth.

In addition to stimulating the development of key industry sectors such as agriculture, manufacturing, construction and transport, the gold rushes of the 1850s inspired other major mineral discoveries. These new finds included gold in many areas of Queensland from the late 1860s, tin in northern New South Wales during the 1870s, copper, gold and tin in Tasmania between the 1870s and 1890s, gold in the Northern Territory in the 1870s, and gold in Western Australia from the early 1880s. By 1900, in the wake of the WA gold rushes, gold production had risen to close to 100 tonnes per annum.

One recently used criterion (by Davis (1995) and others) is that a country has a strong mineral economy if the ratio of the value added by its mineral production to total GDP exceeds eight per cent. The Australian colonies satisfied this measure during the period between 1851 and 1914.

Not only did Australia's Gross Domestic Product increase dramatically during the 1850s. It grew strongly during every succeeding decade (except the 1890s) until the beginning of World War I. The per capita incomes of Australian residents also rose strongly. Maddison (1995) estimates that they were the highest in the world by 1870 and that they remained in that position for the next 30 years.

The fortunes of the mining industry, and of the Australian economy, subsided during the first half of the new century. The exceptions were the development of copper and other metals at Mount Isa, and of iron ore deposits around Iron Knob to supply BHP's newly emerging steel mills – first in Newcastle and later in Port Kembla. But there were no other new major mineral finds. Furthermore, international trade in minerals was disrupted by the two World Wars and the Depression of the 1930s. Although coal, gold iron ore and base metal mining continued in established areas such as the Hunter Valley, the Illawarra, the Latrobe Valley, Broken Hill and the Eastern Goldfields of Western Australia, mining declined in its relative and absolute importance. By 1960 the minerals and energy sector accounted for little more than one per cent of Gross Domestic Product and only around five per cent of exports. This compared with the situation 100 years earlier in which Butlin (1962) estimated that mineral production had accounted for more than 15 per cent of GDP and perhaps 80 per cent of exports.

Two key events then occurred. In 1961, the British government decided to join the European Economic Community. This had an almost immediate negative effect on the competitiveness of Australian agriculture. But offsetting this negative force was the rise of the Japanese economy, followed by the emergence of the Asian Tiger economies of Korea and Taiwan, which created an opportunity for the Australian minerals and energy sector. There were major discoveries of:

- coal (in New South Wales and Queensland);
- iron ore in Western Australia;
- oil and gas in the Bass Strait, on the North West Shelf of Western Australia and in the Cooper Basin in South Australia;
- bauxite in Western Australia and Queensland;
- nickel in Western Australia and Queensland;
- copper and other base metals in Queensland and several other states;
- diamonds in Western Australia; and
- mineral sands in Western Australia.

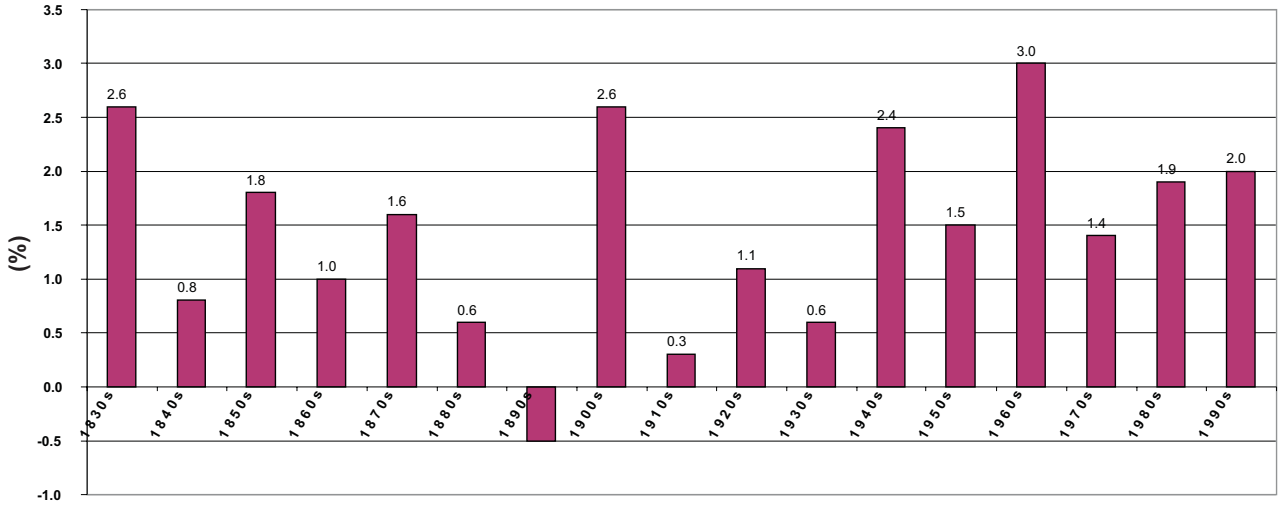

FIG 2.2 - Estimated percentage average real GDP per capita growth in the Australian economy on a decade by decade basis – 1830 to 2000.

Australia emerged as a world-class producer and exporter in many of these areas. This was particularly the case for iron ore, bauxite and alumina, and mineral sands, where it soon ranked as either first or second in production. While Australia was not the largest coal producer, the high quality of the hard coal in the East Coast mines made it the leading exporter of this market. Even in the field of oil and gas, the significant finds in the Bass Strait and then off the North West Shelf gave Australia a greater level of self-sufficiency in petroleum, and made it a significant exporter of natural gas.

As part of the Bretton Woods gold exchange standard that governed the international exchange rate system in the 1950s and 1960s, gold had a fixed price of US$ 35 per ounce. Under this regime Australian gold production languished. In the 1950s and early 1960s at just over 30 tonnes per annum, it was less than a third of what it had been in 1900. But worse was to come. The rise of inflation in Australia, combined with a strong Australian dollar in the early 1970s, made gold mining even more marginal. By 1976, Australian gold miners produced only 15 tonnes and in 1980 only 17 tonnes. The twin towns of Kalgoorlie and Boulder, which had stood as the nation's 'gold capital' for more than 80 years, were surviving fortuitously on the newly emerging nickel sector but not because of gold.

But the demise of the Bretton Woods system also led to a change in the status of gold, with citizens of many nations now able to purchase it as a private asset. In the uncertain 1970s, dominated by unexpected events such as the OPEC oil price rises and the Iran hostage crisis, the demand for gold rose, and so did its price. By 1976 it had reached US$ 160 per ounce. By 1979 it was US$ 300 per ounce. In 1980, it peaked at US$ 800 per ounce. Furthermore, by this time, the value of the Australian dollar had also fallen back from its high levels in the mid-1970s.

Even though many of the near surface high-grade deposits had been exploited, the emergence of metallurgical processes such as carbon in pulp leaching, in combination with greater exploration and the development of open cut mining in a major way, brought a dramatic re-emergence of the Australian gold sector. With its price holding at around A$ 500 per ounce for much of the past two decades, Australia emerged again as a major gold producer. In 1990, its miners produced 244 tonnes, more than double the amount of 90 years earlier. At its peak in 1997, Australian mines produced more than 300 tonnes.

Through its Industry Commission, the Australian government published a major study of the minerals and energy sector in 1991. It noted that:

> *An indication of the importance of mining and early-stage minerals processing to the Australian economy is that these industries account for almost a tenth of national output (and an even higher proportion of investment spending) while employing just over two per cent of the workforce.*

During the 1960s, the proportion of mineral resource sector exports started to rise again. In 1974 they passed 30 per cent for the first time since the period immediately prior to World War I. They have remained at this level for the past 30 years.

Not only has mining emerged domestically, Australian-based mining companies began investing internationally in a major fashion in the 1990s. In 1999, Australian-based companies were active in about 80 nations – see for example Maponga and Maxwell (2000). The mining services sector has also emerged as an area of international competitiveness, with Australian mining professionals now travelling throughout the world to provide their services.

Wright and Czelusta (2003) have recently argued that:

> *Minerals constitute a high-tech knowledge industry in many countries. Investment in such knowledge should be seen as a legitimate component of a forward-looking economic development program.*

This situation seems clearly to have applied to Australia for much of the past century and a half.

COMPLICATING FACTORS WITH MINERAL PRODUCTION AND CONSUMPTION

A variety of factors make the study of mineral production, mineral consumption and mineral economics generally more complex but also more interesting. As has been noted already in this chapter, one of these is the non-renewable nature of minerals and energy resources. Others include:

- the fixed locations of deposits (often in remote areas);
- the economic rent that they generate;
- the impact of technological change on both the supply and demand side;
- the competitive behaviour of mineral producers and purchasers;
- effects of mineral development on indigenous populations; and finally
- the environmental impact of mining and its mitigation.

The relevance of each of these issues is discussed in the coming chapters – often on more than one occasion. The following table provides a brief guide, should it be required.

Issues	Chapters
Locations of deposits and their implications	4 (trade), 6 (supply), 8 (workforces)
Mineral rent	3 (developing nations), 13 (mineral policy), 15 (taxes and royalties)
Impact of technology	5 (demand), 6 (supply)
Nature of competition	7 (markets)
Indigenous populations	17
Sustainable development	16
Smaller regions	18

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APPENDIX – A CLASSIFICATION OF DEVELOPED AND DEVELOPING NATIONS

Determining which nations are developed or developing is, in many respects, an arbitrary decision. Our approach has been to identify *those nations with Human Development Index values of 0.850 or above* as developed. There were 33 nations in this group in 2001. Ranked in descending HDI order (with Norway as the most developed nation and Australia fourth), these nations were mostly located in Western Europe, North America and Oceania, though five Asian nations (including Hong Kong) were also in the group.

The remaining 142 nations in Table 3.1 with *HDI values less that 0.850* are developing nations. They include all of Africa and South America, and most of Asia. The 22 nations closest to developed in this group include the most affluent countries of Latin America and the Caribbean, Eastern European nations, and some of the oil rich nations of the Middle East. The least developed are mainly in Africa and their HDI values show they have a long way to go before reaching the 'developed' status.

TABLE A2.1

A classification of developed and developing nations using the United Nations Development Program HDI Index for 2001. (Source: United Nations Development Program, 2003.)

Value of HDI	No of countries	Countries
Developed nations		
≥0.900	22	Norway, Iceland, Sweden, Australia, Netherlands, Belgium, United States, Canada, Japan, Switzerland, Denmark, Ireland, United Kingdom, Finland, Luxembourg, Austria, France, Germany, Spain, New Zealand, Italy, Israel
0.850-0.899	11	Portugal, Greece, Cyprus, Hong Kong, Barbados, Singapore, Slovenia, South Korea, Brunei, Czech Republic, Malta
Developing nations		
0.800-0.849	22	Argentina, Poland, Seychelles, Bahrain, Hungary, Slovakia, Uruguay, Estonia, Costa Rica, Chile, Qatar, Lithuania, Kuwait, United Arab Emirates, Bahamas, Latvia, Saint Kitts and Nevis, Cuba, Belarus, Trinidad and Tobago, Mexico
0.750-0.799	31	Antigua and Barbuda, Bulgaria, Malaysia, Panama, Macedonia, Libya, Mauritius, Russian Federation, Colombia, Brazil, Bosnia and Herzegovina, Belize, Dominica, Venezuela, Samoa, Saint Lucia, Romania, Saudi Arabia, Thailand, Kazakhstan, Surinam, Jamaica, Oman, St Vincent and the Grenadines, Fiji, Peru, Lebanon, Paraguay, Philippines, Maldives
0.700-0.749	22	Turkmenistan, Georgia, Azerbaijan, Jordan, Tunisia, Guyana, Grenada, Dominican Republic, Albania, Turkey, Ecuador, Palestine, Sri Lanka, Armenia, Uzbekistan, Kyrgyzstan, Cape Verde, China, El Salvador, Iran, Algeria, Moldova
0.600-0.699	18	Vietnam, Syria, South Africa, Indonesia, Tajikistan, Bolivia, Honduras, Equatorial Guinea, Mongolia, Gabon, Guatemala, Egypt, Nicaragua, São Tomé and Principe, Solomon Islands, Namibia, Botswana, Morocco
0.500-0.599	15	India, Vanuatu, Ghana, Cambodia, Myanmar, Papua New Guinea, Swaziland, Comoros, Laos, Bhutan, Lesotho, Bangladesh, Congo, Togo
0.400-0.499	19	Cameroon, Nepal, Pakistan, Zimbabwe, Kenya, Uganda, Yemen, Madagascar, Haiti, Gambia, Nigeria, Djibouti, Mauritania, Eritrea, Senegal, Guinea, Rwanda, Benin, Tanzania
<0.400	15	Côte d'Ivoire, Malawi, Zambia, Angola, Chad, Guinea-Bissau, Democratic Republic of Congo, Central African Republic, Ethiopia, Mozambique, Burundi, Mali, Burkina Faso, Niger, Sierra Leone
Total nations	175	