

Mineral Economics — An Introduction

Philip Maxwell

Definitions of Economics and the Economic Way of Thinking

Economics and Mineral Economics

The Focus of Mineral Economics

Some Key Questions in Mineral Economics

The Structure of this Volume

DEFINITIONS OF ECONOMICS AND THE ECONOMIC WAY OF THINKING

Economics, and the economic way of thinking, have had an important influence on business and government affairs for at least the last two centuries. The Scottish author Adam Smith espoused the foundations of modern economic thought in 1776 (Smith, 1976 [1776]). His famous volume – *The Wealth of Nations*¹ – ushered in a revolution in economic thinking. His ideas formed the basis of the new academic field of political economy, which writers such as William Stanley Jevons renamed as **economics** some 100 years later.

In the early pages of his book, *The Worldly Philosophers*, Heilbroner (1972) traces the rise of economics to the **emergence of the market system** in the wake of the Industrial Revolution, which began in the middle of the 18th century. Prior to that time, the organisation and survival of society had largely depended on **tradition and authoritarian rule**.

The discipline of economics developed strongly during the 20th century, with economists applying its principles to many areas and industries. One of these industries was mining. For at least the last 50 years, undergraduate students in mining engineering programs around the world have taken one or more courses in mineral economics or engineering economics as part of their curriculum. Graduate coursework programs in mineral economics have also developed in a number of well-known universities.

As one might expect, **mineral economics** is ‘**the application of economics in the study of all aspects of the mineral sector**’ (MacKenzie, 1987, p 2). To understand its focus more clearly, however, it is necessary briefly to consider the definition of economics, and its evolution.

One of the most widely used early definitions of economics was that of Alfred Marshall, in his influential volume, *The Principles of Economics*. Marshall (1890, p 1) notes that:

POLITICAL ECONOMY or ECONOMICS is the study of man in the ordinary business of life; it

examines that part of individual and social action which is most closely connected with the attainment and with the use of the material requisites of wellbeing.

Thus it is on the one side a study of wealth; and on the other, and more important side, a part of the study of man.

This is a broad definition and, as such, it attracted debate. In seeking to clarify the nature of economics, Robbins (1932, p 16) offered a different perspective with his so-called ‘scarcity’ definition as opposed to Marshall’s ‘materialist’ definition. This was that:

Economics is the science which studies human behaviour as a relationship between ends and scarce means which have alternative uses.

Most writers of modern principles economics textbooks have embraced this scarcity definition. Without scarcity, there would be no need for markets. Everything would be free and uncontested. It provides a reference point for new students to consider and digest the subsequent theories and models of classical and neoclassical economics, the two major schools of thought. They present it in a slightly extended version such as:

Economics is the study of how people and society choose to employ scarce productive resources to produce goods and services and distribute them among various groups in society (Waud et al, 1996, p 6).

This is, however, not the last word. Non-traditional economists, such as John Kenneth Galbraith take an even broader view. In his volume *The New Industrial State*, Galbraith (1978, p 417) notes that:

In economics:

- *Economic theory – the study which deals with the way prices, output and incomes of individuals, firms and the economy at large are decided – is one area of specialisation.*
- *The corporation is another.*

1. Its full title is *An Inquiry into the Nature and Causes of the Wealth of Nations* (Smith, 1976 [1776]).

- *Decision theory – how decisions are reached in complex organisations – is yet another and more modern field.*

Writers in the field of mineral economics such as MacKenzie (1987), and practitioners more generally, have tended to embrace a broader definition in the Galbraithian mould. Why and how this has happened is considered in the third section of this chapter. Before doing so, consideration is given to the place of mineral economics in the broader context of the study of economics more generally.

ECONOMICS AND MINERAL ECONOMICS

The rise of economics during the 20th century has occurred in several dimensions. At one level there has been division of the discipline between microeconomics and macroeconomics.

Microeconomics is the study of economic decision-making by consumers, households, firms and government, and the way in which these relate to the operation of markets. Its focus has been on areas such as supply and demand, on the organisation of markets and on industry regulation.

Macroeconomics, by contrast, is concerned with the operations of national economies and the world economy. Its focus has been on measures of economic performance such as Gross Domestic Product, inflation, investment, saving, economic growth, the balance of payments and the distribution of income and wealth. It is concerned as well with the formulation of fiscal, monetary and other areas of national economic policy to manage these variables.

There has also been strong interest in areas such as international trade and finance, economic development, financial markets and institutions, public finance, labour markets, economic systems, urban and regional economics, natural resource economics, environmental economics, economic history, law and economics, and the history of economic thought. Many economists make their careers by specialising in one of these fields².

In a rather different way, there has also been a growing interest in the economics of many major industries. Fields such as agricultural economics, transport economics, health economics, communication economics, tourism economics, cultural economics, and **mineral economics** also are now distinct sub-disciplines.

The study of these areas has emerged because of:

- the overall size of these industries;
- their importance to specific economies and regions; and
- different specific characteristics which make them worthy of separate analysis.

The minerals sector currently accounts for around US\$ 700 billion of world production. This is a little more than two per cent of the world's estimated gross product. Perhaps more importantly, international minerals trade has consistently accounted for more than ten per cent of the value of world merchandise trade since 1960. Mineral production and trade is of great significance in as many as 50 nations, and it is the dominant industry in many sub-national regions around the world. Some indication of this importance for selected economies can be seen in Table 1.1.

A difference between minerals and many other commodities is that they are factor inputs rather than final consumer goods. With one or two notable exceptions, manufacturers demand them because of the particular attributes they possess – qualities such as strength, ductility, heat conductivity, and resistance to corrosion to produce final consumer and producer goods.

2. It can also be noted that the broader discipline of finance has become an area of applied microeconomics in the past three decades.

TABLE 1.1

The size of the minerals sector in selected economies and the extent of international minerals trade – 2001. Source: World Bank (2004), various.

Country	Minerals GDP (US\$ B)	Total GDP (US\$ B)	Minerals GDP/Total GDP	Mineral exports/Total exports
USA	150	9780.8	0.015	0.04
Japan	81.4	4523.3	0.018	negligible
Germany	40.2	1939.6	0.021	0.007
China	45	1131.2	0.04	0.04
India	14.5	477.4	0.03	0.09
Australia	17.2	410.0	0.042	0.36
Brazil	7.6	508.9	0.015	0.21
Canada	25.2	681.6	0.037	0.18
South Africa	8.6	121.9	0.081	0.274
Chile	10.5	66.5	0.158	0.42
Peru	4.1	53.0	0.077	0.46
Papua New Guinea	0.8	3.0	0.250	0.80
Botswana	1.9	5.3	0.360	0.59
Namibia	1.4	3.5	0.200	0.62
Ghana	0.9	5.7	0.250	0.49
Zambia	0.7	3.3	0.200	0.74
Indonesia	13.0	144.7	0.090	0.29
Nigeria	6.7	37.1	0.180	1.00
Saudi Arabia	56.1	181.1	0.310	0.95

Minerals differ widely in their characteristics. The standard classification of **metals**, **non-metals** and **energy minerals** provides one pointer to these differences. An appreciation of the diversity of minerals produced and consumed is possible by reviewing relevant web pages of the United States Geological Survey or Natural Resources Canada. The list in Table 1.2 (derived from United States Geological Survey web pages) shows that there are at least 50 metals, 50 non-metals and seven or eight major energy minerals that are mined or drilled on a regular basis around the world. They vary widely in value with oil being worth several hundred billion dollars annually, while some of the smaller minerals would be worth perhaps as little as US\$ 10 million each year.

MacKenzie (1987, p 6) argues that the main special characteristic of the minerals sector that justifies its study as a separate sub-branch of economics relates to the issue of **geological endowment**. The implications of a fixed endowment for economic analysis relate to patterns of optimal use, the optimal timing of this use, increasing scarcity and conservation. He notes in particular that mineral deposits are:

- initially unknown (they must be discovered);
- fixed in size (they are non-renewable);
- variable in quality (they often must be extracted using new technologies); and
- fixed in location (they may be discovered in remote locations and need to be moved to intermediate and end-use markets).

An associated supply-side matter of interest is **recycling**. While most energy minerals can be consumed only once, metals and some non-metals can be profitably recycled using old-scrap and new-scrap sources. Recycling may also be more environmentally friendly.

TABLE 1.2

A classification of mineral resources – metals, non-metals and energy. Source: United States Geological Survey (2006).

Metals	Non-metals	Energy
Aluminium	Abrasives	Black coal
Antimony	Aggregates	Brown coal
Arsenic	Bromine	Crude oil
Asbestos	Cement	LNG
Bauxite and alumina	Clays	LPG
Barite	Corundum	Uranium
Beryllium	Crushed stone	
Bismuth	Diamond	
Cadmium	Dimension stone	
Cesium	Feldspar	
Chromium	Fluorspar	
Cobalt	Garnet	
Copper	Gemstones	
Gallium	Graphite	
Germanium	Gypsum	
Gold	Helium	
Indium	Iodine	
Iron	Lime	
Lead	Limestone	
Lithium	Mica	
Magnesium	Peat	
Manganese	Perlite	
Mercury	Phosphate rock	
Molybdenum	Potash	
Nickel	Pumice	
Niobium	Quartz crystal	
Platinum group metals (6)	Salt	
Rare earths (14)	Sand and gravel	
Rhenium	Sandstone	
Silver	Scoria	
Tantalum	Selenium	
Thallium	Silica	
Thorium	Slate	
Tin	Sodium sulfate	
Titanium	Sulfur	
Vanadium	Talc	
Zinc	Tungsten	
Zirconium	Vermiculite	

Garnaut (1995) adds a further perspective on the special nature of minerals when he describes five characteristics of mines that make them a special focus of government policy and administration. These are:

1. they can generate economic rent³;
2. they are often established most efficiently on a very large scale;
3. their development is often highly capital intensive;

3. Chapter 13 later shows that this 'is a surplus in excess of the minimum profit required by shareholders in a company or firm to stay in business'. Mineral rents receive further attention also in Chapter 15.

4. they have unusually large local environmental, social and economic impacts; and
5. their national economic impact varies greatly over relatively short periods of time.

THE FOCUS OF MINERAL ECONOMICS

While one can justify the study of mineral economics in terms of the rise of the economics discipline, the emergence of mineral economics has also been influenced by the development of parallel sub-disciplines such as engineering economics. In their preface to a successful US text in the area, Riggs, Bedworth and Randhawa (1996, p xv) note that:

The curriculums of most professional schools (of engineering) include a course in applied economics under such titles as engineering economy, financial management, managerial economics and economic decision-making.

These courses typically appear in the latter part of the undergraduate curriculum. In mining schools, they were initially often called **mining economics**. Their emphasis was typically on decision-making at the operational level, usually with a focus on minimising or optimising costs in the context of investment decisions. Students completing these courses often then expect that subsequent study of **mineral economics** will largely be focused on issues or project evaluation and related areas of applied financial analysis.

While this emphasis from the operations side has been an important influence on the development of **mineral economics**, Schanz (1990) points to a broader emerging interest in the economics of the mineral industry in the United States in the early 1930s. The Brookings Institute commissioned lectures in the area in 1931 and faculty members at universities such as Penn State and Columbia began offering courses in the late 1930s. The origins of the formal study of mineral economics appear to have come from concerns over the implications of the fixed geological endowment for strategic mineral supply in the United States during the Cold War. In 1946 the College of Mineral Industries at Penn State formed a separate small department to offer the first degrees in mineral economics.

Several other mineral economics programs have emerged over the past half-century (and some of these have disappeared). As this volume is written there are six or seven active programs spread around the world. They are at institutions such as the Colorado School of Mines, Curtin University of Technology, the University of the Witwatersrand, Michigan Tech, the University of Chile, the Luleå University of Technology and the Pontificia Catholic University of Chile.

Post-professional programs in mineral economics tend to contain a strong emphasis on financial analysis. They combine this with study of mainstream economic issues, which arise from the special nature of mineral markets, and the other features that the geological endowment constraint places on the study of the discipline. One view is that the key contribution of mineral economics has been systematically to analyse the benefits and costs at project level, for the firm and for society.

Many professionals, who take mineral economics courses, are seeking to move into more senior managerial roles. It seems desirable therefore, that any comprehensive treatment of the area should address the strategic, operational and human resource management issues that relate specifically to resource sector companies, as well as providing a suitable overview of the legal environment in which these firms operate. These elements relate quite neatly to Galbraith's broader definition of economics, with its focus on economic theory, the corporation and decision-making.

It is instructive to complete this introductory discussion by making one further important point. MacKenzie (1987, p 8) identifies two main requirements for the practice of mineral economics. They are:

- knowledge of the principles of economics and associated analysis techniques; and
- understanding of the technical characteristics of the mineral sector that are of significance from an economic viewpoint.

The focus of discussion in this chapter has been on the first of these issues. However, the second point is also important. It is often necessary to appreciate the technical issues relating to a mining or energy project to apply economic and other principles to its analysis. Business, law and economics graduates will find it difficult to undertake the depth of analysis necessary to analyse minerals sector issues unless they extend their technical knowledge in areas such as geology, mining methods and mineral processing.

A well-trained mineral economist will apply economic principles, in combination with suitable technical knowledge, to analyse resources available in a fixed endowment. He or she will consider issues such as how to use minerals, when to use them, how to mine them, when to recycle them and how to regulate them.

SOME KEY QUESTIONS IN MINERAL ECONOMICS

This short section is something of an aside. It seemed a good idea to pose some of the questions that we are seeking to address in this volume. The aim is to whet your appetite for the journey ahead. Here they are!

Does an abundance of mineral resources make a country rich?

What effects do mineral-based resource booms have on different economies?

What factors influence the discovery and exploitation of minerals around the world?

What did the discovery of gold do to the Australian economy?

Why has the resources sector been important to economies such as Australia, Canada and Chile in the recent past?

What factors determine the contribution of mineral production to sustainable economic wellbeing?

What influence has greater environmental regulation had on the supply of minerals?

What forces have been driving change in mining's interaction with local communities?

How important is international trade in minerals and energy?

What role has major changes in transport costs played in international minerals trade?

How does recent growth in mineral and energy trade compare with growth in other areas of international trade?

What are the sources of competitive advantage of the Australian minerals sector?

What are the key factors that influence the demand for different minerals?

How important are joint production issues in the analysis of mineral supply?

How has recycling affected the supply of major metals in the recent past?

THE STRUCTURE OF THIS VOLUME

In compiling this monograph, our aim is to provide a balanced and up to date view of the approaches and techniques which mineral economists use to appreciate the resources sector. While the bias of this volume is towards the Australian mineral and energy sector, the discussion often takes a broader perspective. We live in a 'global village' and if this volume is to provide value to its readers, it must be internationally relevant.

The 17 chapters that follow this introduction are organised in four main sections:

- Minerals and the World Economy (three chapters);
- Minerals: Consumption, Production and Markets (four chapters);
- Mineral Finance and Investment (four chapters); and
- Minerals and Public Policy (six chapters).

Philip Maxwell has played the coordinating role with the first, second and fourth sections. **Pietro Guj** is responsible for the Mineral Finance and Investment section. Each of us contributes on an ongoing basis to the Graduate Coursework program in Mineral Economics in the Western Australian School of Mines.

One of the features that has assisted the quality of our program offerings over the past decade has been the contributions from colleagues from other institutions, both in Australia and overseas. It is particularly appropriate, therefore, that several of these visiting faculty, together with other selected colleagues, are also contributing to this volume. Others have acted as reviewers. Their insights enhance the quality of the pages ahead. We thank them for their contributions.

REFERENCES

- Galbraith, J K, 1978. *The New Industrial State*, third revised edition, (Houghton Mifflin: Boston).
- Garnaut, R, 1995. Dilemmas of governance, in *Mining and Mineral Resource Policy in Asia-Pacific: Prospects for the 21st Century* (eds: D Denoon, C Ballard, G Banks and P Hancock) pp 61-66 (Australian National University: Canberra).
- Heilbroner, R, 1972. *The Worldly Philosophers*, fourth edition (Simon and Schuster: New York).
- MacKenzie, B, 1987. *Mineral Economics: Decision-Making Methods in the Mineral Industry* (Australian Mineral Foundation: Adelaide).
- Marshall, A, 1890. *The Principles of Economics*.
- Riggs, J L, Bedworth, D B and Ranhawa, S U, 1996. *Engineering Economics*, fourth edition (McGraw-Hill: New York).
- Robbins, L, 1932. *An Essay on the Nature and Significance of Economic Science* (Macmillan: London).
- Schanz, J J Jr, 1990. Mineral economics and mineral economists – Origins of the species, Working Paper 90-13, Department of Mineral Economics, Colorado School of Mines, 41 p.
- Smith, A, 1976 [1776]. *An Enquiry into the Nature and Causes of the Wealth of Nations* (eds: R H Campbell, A S Skinner and W B Todd) (Oxford University Press: Oxford).
- United States Geological Survey, 2006. Commodity statistics and information [online]. Available from: <<http://minerals.usgs.gov/minerals/pubs/commodity>>. Date accessed: 8 May 2006.
- Waud, R, Maxwell, P, Hocking, A, Bonnici, J and Waud, I, 1996. *Economics*, third Australian edition (Longman: Melbourne).
- World Bank, 2004. *World Development Indicators* (Oxford University Press: New York).