



# **Expanding Queensland's Mining Exploration Capacity**

Economic Impact Analysis  
Final Report

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## Executive Summary

Synergies was engaged by the Queensland Resources Council (QRC) to analyse the potential benefits to the Queensland economy of increased mineral and petroleum and gas exploration. There are at least two streams of benefits related to exploration in Queensland; (a) direct benefits from greater exploration activity and (b) benefits from seeking to service more of this activity from Queensland based companies.

The aims of the study are to:

- understand the economic linkages between a well-developed mining exploration sector and the rest of an economy. This aim will be achieved by measuring the direct and indirect benefits to the Western Australian economy from its mining exploration sector. This will provide insights into the extent to which the mining exploration sector contributes directly to Gross State Product (GSP) and the strength of its linkages to other sectors in the economy;
- quantify a strategy for reducing reliance on mining exploration services sourced from outside of Queensland to the point where a greater share of these services are sourced from Queensland-based firms; and
- quantify scenarios for the expansion of exploration activity and outsourcing reduction in Queensland.

The level of spending on mining exploration in Queensland (as a ratio of the value of mining output in the State) is relatively low given the importance of the mining industry to the Queensland economy. Queensland currently spends approximately \$16 per \$1000 of mining output on mining exploration compared to an average spend in Australia, Western Australia and Canada of \$25, \$37 and \$89 respectively. The report examines the potential impact on the Queensland economy of increasing spending on mining exploration to approximate the average spend in these other economies.

The modelling approach adopted is to model the impact of several 'what-if' scenarios on the Queensland economy:

- what if more mining exploration was sourced from Queensland based firms rather than purchased externally? (Scenario 1);
- what if the ratio of exploration spending to mining production in Queensland was increased to the level observed in other locations? (Scenario 2); and

- what if both scenarios 1 and 2 were applied simultaneously? (Scenario 3).

It is important to note that the current report is not an examination of the rationale for these scenarios only the quantification of their potential impact on the Queensland economy.

Even in this more modest task the economic estimation procedures involved were considerable.

First, to consider the comparative importance of mining exploration in the Western Australian and Queensland economies, a 12 sector Western Australian Input Output table (IO) had to be constructed from primary sources, including the Australian National IO table. The constructed IO table enabled the economic linkages between mining exploration and the rest of the economy in Western Australia (which was seen as the best practice case) to be estimated and compared with those in Queensland.

Second, within existing IO tables no specific mining exploration sector existed and an estimate of the sector had to be constructed from the services to mining sector. The methodology used and the assumptions to affect the decomposition are outlined in the report.

Third, an appropriate tool for estimating potential benefits to the Queensland economy from implementing scenarios (1, 2 and 3) had to be found. This report uses the Queensland Non-Linear Model (QNLN) developed at the University of Queensland. The principle advantages of this model is that it is designed to remove some of the major criticisms of traditional IO models while, at the same time, retaining the ease of manipulation and relatively light data needs. However, it is acknowledged that other methods and techniques of estimation could have been applied, but with a far greater need for primary data than appeared to be available for this project.

Finally, the report needed a consistent measure for demonstrating economic impact. This report chose final demand Gross State Product (GSP) flow-on measure. GSP is the value of new production in an economy over a specified time period. GSP flow-on measures the net impact to the rest of the economy from the changes in the mining exploration sector. It should be noted that the estimates only consider the impact of the mining exploration expenditure. In addition there would be additional economic impacts related to the discovery of mineral deposits. However, valuing additional discoveries is not within the scope of this project.

The report made a number of important findings. In terms of a comparison of the economy wide economic linkages with mining exploration for Western Australia and Queensland respectively, it was found that, despite the widespread belief that industry in Western Australia is more developed; structural differences between Western

Australia and Queensland were not that large. The mining exploration sector in Western Australia is currently more integrated into its local economy. The ability of the mining exploration sector to add value to its main customers (the mining industry) is currently greater in Western Australia than in Queensland.

This is due to two factors;

- the higher intensity of exploration spending in the Western Australian sector;<sup>1</sup> and
- a greater proportion of mining exploration is purchased locally.

Apart from these differences there was little to differentiate between the two industries in terms of economic linkage. The substantive point here is that, if exploration spending increased in Queensland and/or local production of mining exploration services in Queensland increased to levels that approximated the Western Australian situation, the Queensland industry could produce a similar degree of forward linkage (or sales to other sectors in the economy) as the Western Australian industry.

The report found that currently about 32% (in value) of mining exploration in Queensland is sourced outside of Queensland compared to about 8% in Western Australia. To examine the economic impact of reducing mining exploration services from outside Queensland we allowed the level of non-Queensland supply to fall to the Western Australian level (which was regarded as the base level achievable). The modelling used three time periods for achieving the reduction (immediate, 4 years and 10 years). Here we report the results for the four year period (which we think is likely to be the most likely of the three timeframes for achieving the reduction). The results for the other periods are reported in the body of the report. The additional annual GSP flow-on impact to the Queensland economy from this staged reduction in external sourcing of mining services was:

- \$32.4 million (in year 1);
- \$49.4 million (in year 2);
- \$81.64 million (in year 3); and
- \$125.95 million (in year 4 and each additional year from then on)

The total gain in GSP flow-on after 4 years was \$260.00 million to which need be added a continuing annual benefit of \$125.95 million in the 5<sup>th</sup> and subsequent years.

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<sup>1</sup> It could be that exploration is more costly in Western Australia and there may be a narrower difference in outcomes. However data to investigate this further was not available.

For Scenario 2, the ratio of spending on exploration to mining production in Queensland was raised to approximate that in Australia as a whole, Western Australia and Canada (as a proxy for international levels). The full set of results is shown in the body of the report. Here we report the results from applying the Western Australian ratio, as we feel this is the level of exploration spending relative to mining output to which Queensland could reasonably aspire. The report considered Scenario 2 and 3 simultaneously by running scenario 2 without greater proportions of local production (Scenario 2 in isolation) and with higher levels of local production (Scenarios 2 and 3 jointly) the results were:

- Scenario 2 (in isolation) - a \$191 million per annum increase in GSP flow-on; and
- Scenario 2 and 3 - a \$275 million per annum increase in GSP flow-on.

Some caution needs to be attached to the results for Scenario 2 and 3 combined as there may be some interaction between increased spending on exploration and the level of outsourcing which means that the policies of increased exploration spending and reduced outsourcing are not independent.

Overall, we find the potential economic results of structural change in Queensland mining exploration spending to be significant in terms of the current size of the Queensland sector but modest in terms of its overall relative impact on the Queensland economy. The results provided are both conservative and plausible given the current size of the mining exploration sector relative to the Queensland economy.

Synergies note that the underlying economic rationale supporting such an expansion has still to be investigated.

## Glossary

Backward Linkage	A backward linkage measures the economic activity between a sector and other sectors supplying inputs either directly to the sector in question, or indirectly by supplying inputs to another supplier.
Elasticity	The relative response of one variable to changes in another variable. The phrase "relative response" is best interpreted as the percentage change.
Factor income	Compensation of employees by, and operating surplus of, producers
Forward Linkage	A forward linkage measures the relative importance of the sector as supplier to the other sectors in the economy.
Gross State Product (GSP)	The total market value of all goods and services produced within a State in a given period of time.
GSP Flow-on	GSP flow-on measures the change in value of economic output from a modelled change to the economy.
Input Output Table	An input output table provides a snapshot of the purchases and sales between industries and households in an economy at a moment in time.
Present Value	The amount of money today that, after interest is added, would have the same value as an amount some time in the future.
Value Added	The increase in the value of a good at each of the production process.

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## 1 Introduction

Synergies was engaged by the Queensland Resources Council (QRC) to analyse the potential benefits to the Queensland economy of increased mineral and petroleum and gas exploration. There are at least two streams of benefits related to exploration in Queensland; (a) direct benefits from greater exploration activity and (b) benefits from seeking to service more of this activity from Queensland based companies.

This project is commissioned as one of several projects being undertaken under the QRC's *Exploration Agenda* which aims to achieve a whole-of-Government approach to fostering exploration and maximising the benefits of exploration activity for Queensland. It falls under the fourth agenda item:

Finance and Investment - establishing a financial environment conducive to further investment in exploration activity in Queensland. Queensland needs to emulate Western Australia's culture and supporting environment which provides the backing for the mining exploration resources sector in that state.

The aims of the study are to:

- understand the quantitative linkages between a well-developed mining exploration sector and the rest of an economy. This aim will be achieved by measuring the direct and indirect benefits to the Western Australian economy from its mining exploration sector. This will provide insights into the extent to which the mining exploration sector contributes directly to Gross State Product and the strength of its linkages to other sectors in the economy;
- quantify an outsourcing (import) replacement scenario for Queensland's mining exploration sector to the point that is all exploration related services are sourced by Queensland firms; and
- quantify scenarios for the expansion of exploration activity and a reduction in externally sourced mining services in Queensland.

This report is structured as follows:

- section 2 provides information on exploration activity;
- section 3 reports on the linkages between exploration activity and the rest of the economy for Western Australia and Queensland;
- section 4 describes the structure of the QNLM model used to undertake the analysis and the modelling scenarios;

QRC

- section 5 reports the results for the modelling scenarios; and
- section 6 summarises the key findings and caveats on interpreting the results.

## 2 Exploration Activity

*Exploration* refers to the search for, and appraisal of economic concentrations or deposits of naturally occurring solid, liquid (excluding water) or gaseous materials on or below the surface of the earth. It includes activities to identify, delineate and assess these concentrations or deposits. Such activities could include:

- geological, geophysical, and geochemical techniques and analysis involving satellite, airborne and land-based activities;
- drilling of boreholes, stratigraphic, wildcat, appraisal and field extension wells;
- bulk sampling from a pit, shaft or adit sunk for appraisal purposes;
- management of tenements and other land access matters;
- resource and reserve calculations; and
- commercial feasibility studies of extraction.

Exploration excludes *development*, which refers to activities to prepare a deposit or an extension of one for production. Such activities could include removal of overburden, sinking of shafts, drives and winzes, drilling and completion of production wells, and construction of facilities required for mining and early stage processing activities.

*Mining* refers to extraction of materials defined through exploration. It includes underground or open cut earth-moving activities, dredging, operation of wells, and early stage processing activities customarily performed at mine sites, such as crushing, screening, dressing, washing, floatation, leaching, roasting, and gold bullion production.

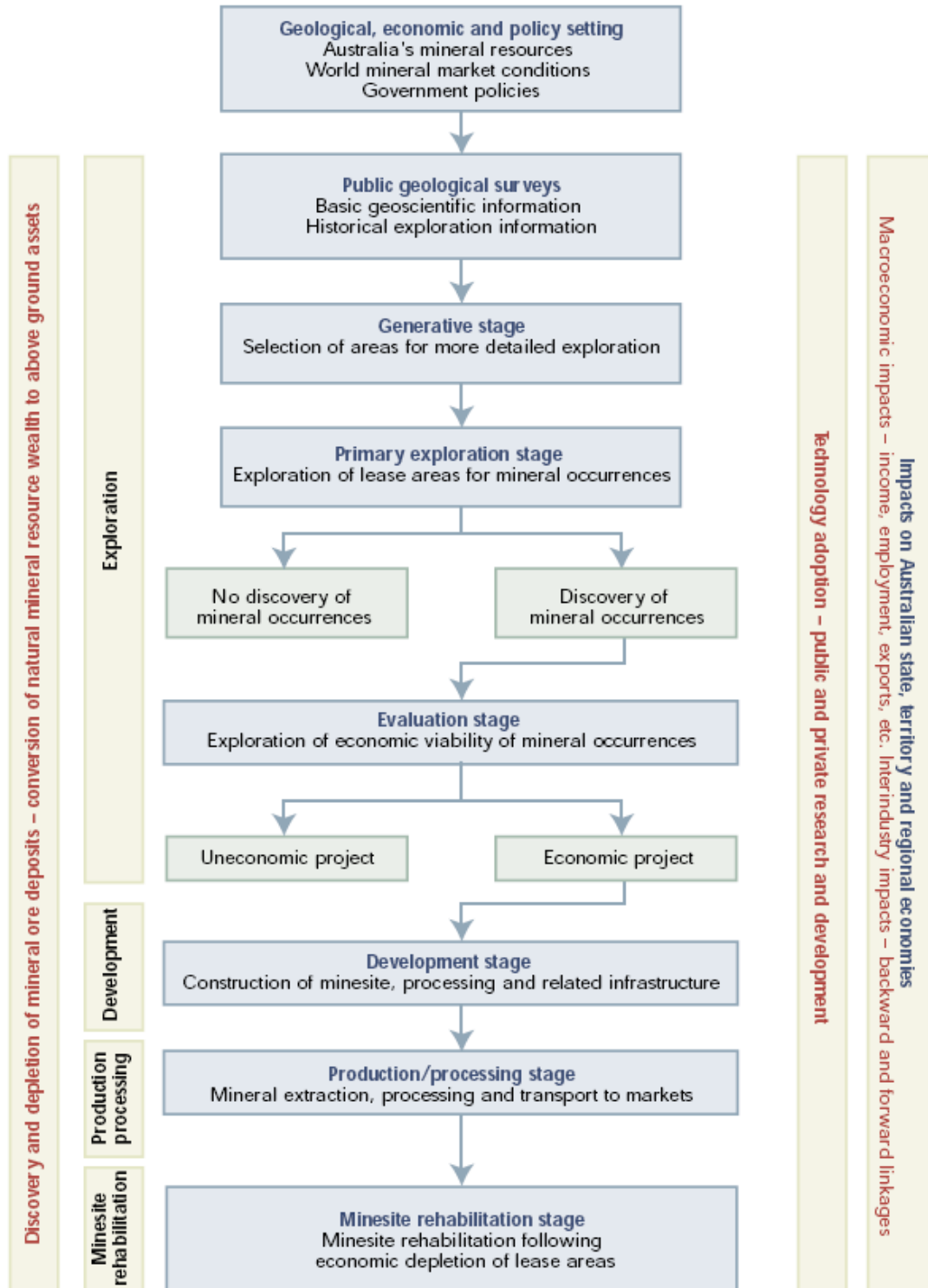
These definitions of exploration, development and mining are consistent with those used by the Australian Bureau of Statistics (ABS) in collecting, classifying and presenting statistical information.<sup>2</sup>

Figure 1 depicts the exploration, development, mining and rehabilitation phases of exploitation of deposits. It also identifies key influences on and economic effects of those activities.

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<sup>2</sup> See Australian Bureau of Statistics (2007), *Mineral and Petroleum Exploration*, Cat no. 8412.0; Australian Bureau of Statistics, *Mining Operations*, Cat. No. 8415.0, 2005-06, Australian Bureau of Statistics (2006), *Australian and New Zealand Standard Industrial Classification* Cat. No.1292.0.

**Figure 1 Phases of, Influences on and Effects of Exploitation of Deposits**



Source: ABARE (2002), *Mining exploration in Australia: Trends, Economic Impacts and Policy Issues*, Canberra

Exploration is an investment in knowledge about the location, size and quality of petroleum and mineral deposits. According to Australian Bureau of Agricultural and Resource Economics (ABARE), the ability of Australia's minerals and energy sector to sustain its recent strong growth and expand its contribution to national economic performance in the medium and longer term depends on the amount of investment in minerals exploration.<sup>3</sup>

## 2.1 Exploration industry structure

On the basis of information obtained from the Minmet database and the Minerals Council of Australia, ABARE observed that in Australia, in 2002, numbers of exploration and mining companies were as follows:<sup>4</sup>

- up to 204 independent mining exploration companies were engaged in mining exploration or exploration and production and had market capitalisations under \$200 million;
- at least 106 mining exploration/production companies were owned or controlled by mid-size or major production companies;
- 15 mid-size mineral production companies also engaged in some exploration with market capitalisations between \$200 million and \$1000 million;
- 10 major production companies (majors) with market capitalisations in excess of \$1000 million.

There is limited information on the contribution of the mining exploration sector to exploration activity. In 2002, Geoscience Australia provided ABARE with information on the contribution of mining exploration companies to mineral discoveries, rediscoveries and renewals since the 1960s. Mining exploration companies accounted for around 60 per cent of exploration successes for gold and base metals. In the case of gold, they contributed nearly two-thirds and for base metals their contribution was about 50 per cent.<sup>5</sup> Unfortunately, similar information is not available for iron ore, coal, and petroleum.

Major mining companies tend to target discovery of large deposits, applying integrated, multidisciplinary, advanced interpretative and survey techniques. Mining exploration tends to focus on smaller, easier to find, easier to develop targets amenable

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<sup>3</sup> ABARE (2007), *Australian Commodities*, Vol 14, June quarter, p 357.

<sup>4</sup> ABARE (2002), *op cit*, p. 22.

<sup>5</sup> ABARE (2002), *op cit*, pp. 82-83.

to economic exploitation on a relatively small scale. Of course, majors may find small deposits and mining exploration companies may make large finds.

The Metals Economics Group's recent report on world exploration trends made the following pertinent observations:

- Exploration companies suffer the steepest exploration budget declines during bad times and enjoy the most dramatic increases during the booms;
- During the 1997 peak in exploration spending, mining exploration companies accounted for just under 40 per cent of worldwide exploration, but in the 2001 trough, their share of worldwide exploration expenditure declined to 25 per cent;
- During the 1997 to 2001 period, the majors' share of worldwide exploration increased from just over 40 per cent to 60 per cent;
- Since the 2001 trough in exploration expenditure, junior spending has increased by 600 per cent;
- From 2001 to 2006, the majors' share of rising worldwide exploration expenditure decreased from 60 per cent to 30 per cent, while the juniors' share increased from 25 per cent to more than 50 per cent;
- Mid-sized mining companies' share was relatively stable, being just under 20 per cent in boom times and between 12 and 15 per cent during downswings and upswings; and
- The share of exploration in regions traditionally perceived to have a higher political risk has been increasing in the current strong upswing in the exploration expenditure cycle. <sup>6</sup>

QRC has pointed out that Western Australia dominates the junior exploration sector. It noted that in the last three years, more than one third of new listings on the Australian Securities Exchange had been Perth-based, and only 8 per cent had been Brisbane-based. Also, three quarters of the new Perth based companies were exploration related, but only 30 per cent of the Brisbane-based companies were targeting exploration. This means Perth hosts 10 times the number of new exploration company listings hosted by Brisbane (25 per cent compared to 2.5 per cent).

Some possible explanations of this phenomenon are as follows:

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<sup>6</sup> Metals Economics Group, *World Exploration Trends*, Special Report for PDAC International Convention, 2007.

- Western Australia's geology favoured establishment of a substantial junior exploration sector during the nickel boom of the late 1960s and early 1970s, the gold boom of the 1980s and the smaller mid-1990s revival;
- there is now an established junior exploration culture in Western Australia; and
- the nickel and gold booms led to the development of investment banking, other financial and legal expertise specific to a junior exploration in Perth.

## 2.2 Exploration expenditure in Australia

Expenditure on minerals and energy exploration in Australia is estimated to total over \$4 billion in 2006-07, an increase of over 56 per cent on exploration expenditure in 2005-06. In real terms (2006-07 dollars), 2006-07 exploration expenditure will be the highest on record and around 72 per cent higher than the average annual expenditure on exploration over the past 25 years.<sup>7</sup> Over half of this expenditure was on petroleum expenditure (\$2.14 billion). Other major areas of exploration are base metals (\$560m), gold (\$400m) and iron-ore (\$320m).

In the first half of this decade, exploration expenditure in Australia, in real terms, was well below the annual average of the past 25 years. According to ABS data, exploration output (as measured by metres drilled) increased significantly in 2006-07.<sup>8</sup> The ABS data also shows that expenditure increased more than drilling activity in 2006-07. This fact is consistent with media reports of drilling gear and labour shortages throughout the Australian resources sector.

Exploration activity is a small component of mining activity (including petroleum extraction). Figure 2 shows that exploration expenditures are small in comparison to the value of mining output. However, it also shows that the ratio of exploration expenditure to the value of mining output is well below the Australia average or the ratio in Western Australia.

Obtaining and selecting an international benchmark to compare Australian exploration effort is a complex exercise given the number of variables that have to be controlled for to obtain a reasonable comparator. We considered using a global average but decided this would not provide a meaningful benchmark given the wide range of mining exploration activities undertaken across vastly different countries. We obtained data for Canada because it has an economy with a similar economic and institutional

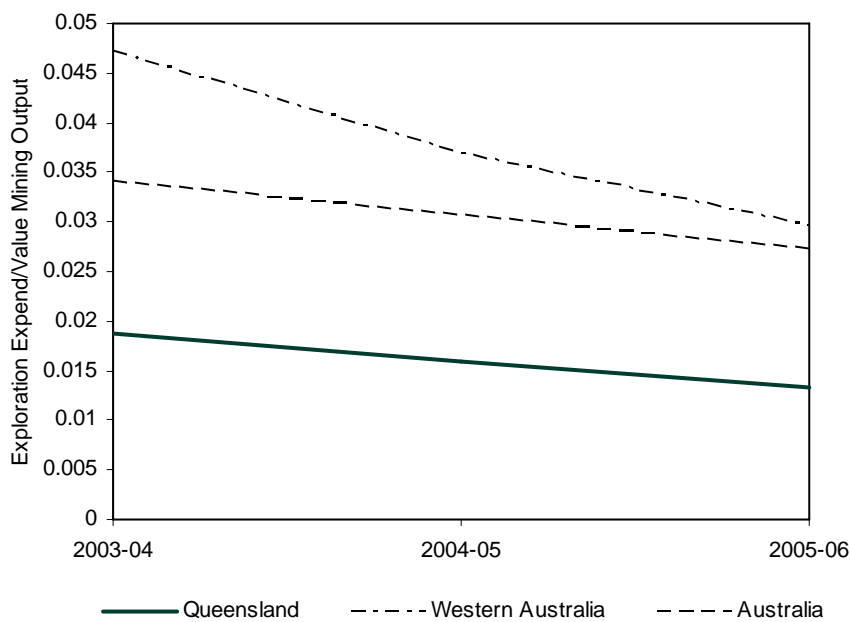
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<sup>7</sup> ABARE (2007), *op cit*, p 357.

<sup>8</sup> ABS (2007), *Mineral and Petroleum Exploration*, Cat no. 8412.0.

structure to Australia. Although not shown in Figure 2, the ratio for Canada in 2005 was 0.09, much higher than Australia (0.03) or Western Australia (0.037). However, it should be noted that Canadian exploration expenditure in that year was dominated by petroleum exploration expenditures (for every dollar spent on mining exploration \$9 were spent on petroleum exploration). In Queensland, almost twice as much is spent on mining exploration as petroleum exploration.

**Figure 2 Ratio of exploration expenditure to the value of mining output**



Data source: ABS Cat no 8412.0, Mineral and Petroleum Exploration, ABS Cat no 8415.0 Mining Operations, Australia, Statistics Canada, Oil and Gas Exploration, Natural Resources Canada, Mineral and Resource Development Statistics..

### 3 Economic Linkages with the Economy

To investigate the backward and forward linkages between mining exploration activity and other sectors in an economy, a 12 sector Input-Output (IO) table (with mining exploration included as one of these sectors) was created for the Western Australian and the Queensland economy. An IO table provides a snapshot of the purchases and sales between industries and households of an economy at a moment in time.

The ABS, in its sectoral break up for the Australian National Accounts, does not define a specific mining exploration sector. State Governments and the ABS publish data on total annual expenditure on mining exploration but these data are aggregate expenditures and do not identify the components of the expenditure (eg labour, inputs from other industries).

The ABS does delineate a 'services to mining' sector from which it is possible to approximate a 'mining exploration' sector.

The ABS IO tables for Australia list the direct purchases by the services to mining sector from 107 industries. The direct input coefficients, which measure the relative importance of each industry as a supplier, are shown in Appendix A. For example, scientific research, technical and computer services are the most significant input suppliers.

The purchases can be aggregated into four main types:

- Wholesale and Retail Services (31% of inputs) - Industries which supply these inputs include Wholesale trade, Wholesale Mechanical repairs, Other Wholesale, Retail Trade, Retail Mechanical Repairs, Accommodation, Cafes and Restaurants, and Utilities and Transport;
- Construction and Infrastructure Services (15% of inputs) - These inputs include construction and building services and purchases of equipment;
- Scientific Research/Technical and Computer Services (40% of inputs) - These inputs include geotechnical services, photographic and scientific equipment services, electronic equipment, communication services, research and computing services, library services, printing and services to printing; and
- Financial/Legal and Business Services (14% of inputs) - These inputs include banking, non-bank finance, insurance, services to finance, investment and insurance, legal, accounting, marketing and business management services and Government administration (including Community Services).

To delineate a mining exploration sector it could be assumed that the purchasing structure for services to mining mirrored that of mining exploration. However, there are likely to be some significant areas of difference between the inputs purchased by the mining exploration sector and the services to mining sector. For example, the mining exploration sector is likely to purchase considerably less from construction and infrastructure services than the services to mining sector. Also, a number of the subcategories of retail and wholesale trade purchased by the services to mining sector are unlikely to be relevant to mining exploration.

On the other hand there is likely to be a higher percentage of inputs originating from financial/legal and business services and scientific research technical and computer services.

To account for these differences adjustments were made based on an assessment of the relevance of an input to exploration activity. To some extent this involved an element of subjectivity, but the process of favouring some sectors such as financial/legal and business services, scientific, research, technical and computer services and those complementary wholesale and retail expenditures allowed the core of the mining exploration activities to be decomposed from the general services to mining sector. The resulting purchasing profile is used to approximate a mining exploration sector for Western Australia.

The input purchases profile consisted of:

- Wholesale and Retail Services, including purchases from manufacturing and utilities (25%);
- Construction and Infrastructure Services (5%);
- Scientific Research/ Technical and Computer Services (45%);
- Financial/Legal and Business Services (25%).

Compared to the services to mining sector, the derived mining exploration sector has a much higher proportion of inputs of financial/legal and business services and less from construction and infrastructure services.

The specific industry sectors included in the purchases of the mining exploration sector were:

- Wholesale Trade;
- Retail Trade;
- Direct sales of manufactures;

- Purchases of Buildings and equipment;
- Scientific Research;
- Technical Services;
- Computer services;
- Geotechnical services;
- IT Services;
- Library Services;
- Communication Services;
- Financial Services (Bank) and Non-Bank;
- Legal Services;
- Investment and Insurance;
- Business Services (accounting and marketing); and
- Government Services.

The procedure we have used to derive a mining exploration sector is subjective. However, we consider that the above list is likely to encompass the breath of input suppliers to a mining exploration sector.

The Western Australian Department of Industry and Resources estimate of the total size of the mining exploration sector provides a final control total for our derived sector. In other words, our modification of the services to mining sector was initially judged on its ability to produce an aggregate output estimate approximately equal to the independent estimate provided by the Western Australian Government. The aggregate output of our derived sector was within 10% of the Western Australian control total. The derived input table was then adjusted to exactly match the aggregate exploration expenditure published by the Western Australian Government.<sup>9</sup>

After specifying the input side of the mining exploration sector it is then necessary to specify an output side. Once again the parent sector used to specify outputs was the services to mining sector. Sales from the services to mining sector are to:

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<sup>9</sup> The RAS method (Rationalised Algorithm Strategy) was used to adjust the table. It is a bi-proportional method for adjusting the coefficients in an IO sector or table. For a full description of the technique, see Jackson, R and Murray, A (2003) "Alternate Input-Output Updating Formulations" Research paper no.6, Regional Research Center University of West Virginia.

- within-sector activities (sales between firms in the same industry, for example where a smaller firm is used as a sub-contractor to a larger firm);
- the mining industry (subdivided in intensity between the main subcategories of mining);
- exports; and
- finance/legal and business services.

Sales from the services to mining are more concentrated than purchases. In the absence of specific data, we assumed that the sales from the mining exploration sector mirrored that of that of the services to mining sector. The greater concentration of sales indicates that most linkages between the service to mining sector and the rest of the economy are backward linkages.

### 3.1 Constructing a WA Input-Output table

We were unable to access a recent IO table for Western Australia. As a result, there was a need to construct a table using ABS National and State data on the Western Australian economy.

The method used was a bi-proportional Generated Regional Input-output Table (GRIT) method, in which location quotients are used to weight the coefficients of the national table to approximate the State coefficients.<sup>10</sup>

Estimates of the GSP per sector and the total size of the Western Australian economy<sup>11</sup> allow the table to be balanced and constrained in such a way to present a reliable approximation of the Western Australian economy.<sup>12</sup> GSP is the value of new production in an economy over a specified time period, net of inputs and imports.

The constructed table performed well in terms of producing sensible results for total and disaggregated multipliers and conforming well to the picture of the Western Australian economy developed earlier by Qiang.<sup>13</sup>

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<sup>10</sup> Location quotients are defined as the ratio  $LQ_i = (e_i/e) / (E_i/E)$  where  $e_i$  is regional employment in industry  $i$ ,  $e$  is total employment in region  $i$ ,  $E_i$  is total employment in the base economy (Queensland) and  $E_i$  is total employment industry  $i$

<sup>11</sup> See, Year Book of Australia 2006, ABS Catalogue 1301.0 Canberra.

<sup>12</sup> See, for example, Panizza, R and Benvenuti (2002) *A Multi-Regional Input-Output Model for Italy; Methodology and First Results*, Paper presented to the 14<sup>th</sup> IO Association Conference, Montreal October for a discussion of the bi-proportional technique

<sup>13</sup> See, Qiang, V.E. (1996) "The Nature of the West Australian Economy", Economic Research Centre Research Monograph, University of Western Perth

Most importantly the results from the table conformed closely to the aggregate data available from the ABS. For example, the GSP estimate from the table for 2004-05 of \$93.5 billion compared very closely to the actual GSP total estimated by the ABS of \$94.02 billion. Our constructed mining exploration sector accounts for a relatively small proportion of GSP (0.6 per cent or \$0.625 billion) but this total equals the estimates of the Western Australian Department of Industry and Resources. Moreover, it is double the size of the estimated Queensland mining exploration sector (\$0.269 billion).

### 3.2 Analysis of backward and forward linkages

IO tables are often used to identify relationships between sectors within an economy through the use of backward and forward linkages. This analysis was first used by Rasmussen (1956) and Hirschman (1958)<sup>14</sup> and has since been widely used.<sup>15</sup>

A backward linkage measures the economic activity between a sector and other sectors supplying inputs either directly to the sector in question, or indirectly by supplying inputs to another supplier. For example, an increase in output of exploration services will require additional inputs such as fuel, accommodation. A forward linkage measures the relative importance of the sector as supplier to the other sectors in the economy. Linkages are reported as an index value commencing at 0. A linkage  $>1$  is considered strong, a linkage  $> 0.5$  is considered average and a linkage  $< 0.5$  is considered small. There are two broad dimensions to “backward” effects. Backward linkage examines the *intensity or strength* of the relationship between a sector and its suppliers and backward spread examines the *coverage* of suppliers throughout the economy, for example how many of the other sectors form part of the supply chain. Forward relationships work in the same way but measure the strength and coverage of sales from a sector to other parts of the economy.

Linkage indices have been used to identify key sectors of the economy. Key sectors are typically defined as industries which have both strong forward and backward linkages with other industries in the economy. Changes in the output of sectors with strong backward and forward linkages will have the greatest relative impact on the rest of the economy. Sectors that have strong forward linkages are affected to a greater extent by changes in the general level of local economic activity.

The constructed IO table was used to generate backward and forward linkages for the mining exploration sector in Western Australia. These results were then compared

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<sup>14</sup> See, Rasmussen P (1956) *Studies in Intersectoral Relations*, Amsterdam, North Holland and Hirschman A (1958) *The Study of Economic Development*, Yale University Press

<sup>15</sup> Andersso-O’Callaghan, B and Yue (2003) , *Op cit*, p.7

with linkages from the constructed sector in the Queensland economy. The analysis shows that the Western Australian mining exploration sector exerts a considerably larger influence on the Western Australian economy in comparison to the influence of the Queensland exploration sector has on the Queensland economy.

**Table 1 Backward and Forward Linkages - WA mining exploration sector**

	Output	Value Added	Factor Income	Employment
Backward Linkage	0.50	0.59	0.57	0.44
Backward Spread	1.07	1.06	1.02	0.96
Forward Linkage	1.64	1.90	1.43	0.63
Forward Spread	0.11	0.13	0.27	0.69

**Source:** Synergies estimates

Linkages are reported for four economic measures; output, value-added, factor income and employment. The results for each category run down the column. For example, for the Western Australian output has strong backward spread (1.07) and forward linkage (1.64) but is less strong (average) in backward linkage (0.50) and weak in forward spread (0.11). The weak forward spread simply reflects the fact that the output by the mining exploration sector is used as an input by the mining sector and not by other sectors in the economy.

In essence this indicates an industry that draws inputs from a range of industries (high backward spread) and that feeds value into only a small number of sectors as final demand. In this case the mining exploration industry is providing strong input into its main forward link sector, the mining industry proper, but little to other sectors.

Analysis of the IO table indicates that the only other significant destination for services from the mining exploration sector is in exports outside of Western Australia. Overall the picture is of an integrated sector on the input side and a specialised provider of final demand services, exactly what would be expected in a specialised industry sector.<sup>16</sup> Of particular significance is that mining exploration sector has a very strong value adding effect of 1.90. Off-setting that is a relatively weak employment effect, caused by the high capital intensity of the industry.

The backward and forward linkage effects from the mining exploration sector in Queensland are shown in Table 2.

<sup>16</sup> The supply chain is simply the list of industry that sells to the mining exploration sector.

**Table 2 Backward and Forward Linkages- Queensland mining exploration sector**

	Output	Value Added	Factor Income	Employment
Backward Linkage	1.12	1.04	0.74	0.57
Backward Spread	1.04	1.03	0.95	0.87
Forward Linkage	1.50	0.76	0.89	0.29
Forward Spread	0.30	0.05	0.06	0.29

Source: Synergies Estimates

Despite the fact that the mining exploration sector in Queensland is a smaller sector than its counterpart in Western Australia, both in absolute and relative terms, the data in Table 2 suggests that it has the potential to be just as influential (or more so) if it could be expanded.

In terms of linkages it currently has stronger backward linkages (for output and value adding) than Western Australia but smaller forward linkage value adding (0.76 compared to 1.90 for Western Australia) and a smaller forward linkage spread. This suggests that the current exploration industry in Queensland is less significant, as a supplier of services to the mining sector than the comparable sector in Western Australia, most likely because of the greater reliance in Queensland on imported exploration services.

The smaller forward linkage is particularly significant in the context of this report because it indicates that the strength or intensity of the connection between the mining exploration sector and the mining sector as a whole is currently less strong in Queensland than in Western Australia.

However the stronger backward linkages in Queensland relative to Western Australia indicate that, if Queensland's forward linkage were stronger, for example, by expanding the delivery of Queensland based mining explorations services to the mining industry in Queensland, the exploration industry in Queensland would have a stronger impact on the economy than is currently the case for the Western Australian industry on its economy. These results provide support for the view that the Queensland mining exploration sector is currently less integrated into other sectors in the economy than Western Australia.

To provide a base case for the impact scenarios the total value-added flow-on of the Western Australian mining exploration sector (to its State economy) is calculated and compared to the sector's current value added.

**Table 3 GSP contribution of mining exploration sector- 2004-05 \$M**

	Western Australia	Queensland
Direct spending	625	269.0
GSP flow-on	434.73	139

Source: Synergies estimate

Table 3 shows that the Western Australian exploration industry has a greater value adding potential than the Queensland exploration industry. In Western Australian an additional dollar of expenditure on mining exploration services results in an additional \$0.70 in GSP. Table 3 shows that in 2004-05 (the latest available year) \$625 M in expenditure on mining exploration resulted in an additional \$435 M of GSP. In Queensland the GSP flow-on from direct expenditure on mining exploration services is lower at around 50 percent of direct expenditure (\$269 M in direct expenditure resulted in \$139 M in GSP flow-on).

## 4 Modelling Approach

### 4.1 Description of the model

This study employs an econometric input-output model, the Queensland Non-Linear Model (QNLN). The model contains 12 sectors which conform to the aggregated sectoral distribution of the fuller version of the QNLN model and are based on the latest publicly available Queensland input-output tables.<sup>17</sup> Notable features of the IOW suite of software are its ability to vary income and employment elasticities and to incorporate price and supply effects.<sup>18</sup>

The model contains a number of default values that enable projects to be modelled on the basis of limited or incomplete information. This is particularly true of the assigned elasticities in final demand and consumption.

Some key advantages of the model include:

- it is able to model impacts through marginal effects rather than average effects;
- it uses published Queensland Government data; and
- the model disaggregates the economy into 12 sectors, which is sufficient to model the impacts of expanding both the level of mining exploration and increasing the proportion of services sourced from Queensland based firms.

The model contained 5 primary input sectors:

- compensation of employees;
- gross operating surplus & mixed income;
- taxes, less subsidies on products;
- taxes less subsidies on production; and
- complementary imports and competing imports.

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<sup>17</sup> See, [www.oesr.qld.gov.au](http://www.oesr.qld.gov.au) for a listing of the sectors used. The basis IO structure itself is downloadable from this site. The tables on this site refer to 1996/97. Some updating has been done in the QNLN to approximate 2004/05, using ABS data.

The IO table was assembled with the IO8 and IOW software devised by the Centre for Economic Policy Modelling at the University of West Virginia.

<sup>18</sup> Elasticities are introduced into the model on the basis of external estimates.

Final demand sectors are represented in the model as:

- final consumption (Household and Government);
- gross fixed capital expenditure (by Government, Government Enterprise and Private);
- change in inventories; and
- exports.

The model measures impacts on a State rather than regional spatial basis, which is appropriate for this exercise as the purpose of the study is to assess impacts at the State level.

In terms of currently available modelling techniques, there exist a number of different forms of modelling that might have been used ranging from traditional input-output, through to computable general equilibrium models (CGE) and econometric/IO models. Most disagreements over modelling technique surface over the allocation of flow-on or indirect benefits and the relative importance of marginal as opposed to average effects.

The advantage of the model chosen is that, while retaining the convenience and relative simplicity of input-output modelling, it overcomes a major weakness of that form of modelling by being able to model through marginal coefficients rather than average coefficients. That is, in standard input-output models output changes are driven by the average relationships, whereas in economic transactions it is marginal effects that generally determine demand and supply changes. In the QNLM elasticities in the model are drawn from published sources or assigned values.<sup>19</sup> The advantages of this type of model include:

- its non-linear structure. Economic relationships are rarely linear. For example, exploration activity can increase without the need to increase inputs (particularly labour) in proportion (which would be the case if a linear model was used);
- avoids overstating employment and income estimates of economic impact; and
- elasticity parameters embedded in non-linear models allow explicit consideration of supply constraints, and in this way more closely resemble the outcome of a CGE model, while at the same time avoiding the onerous data considerations and economic convergence in CGE models.

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<sup>19</sup> Work is continuing on producing a full econometric IO model which allows for elasticities to be generated within the model, but such a process requires much greater intra-sectoral information than is currently available.

## 4.2 Modelling scenarios

The QRC has asked Synergies to model three scenarios:

- Scenario 1: quantify a scenario whereby the supply of mining services from outside the State was reduced to the point that a greater share of exploration related services are supplied by Queensland-based firms (replacing non-Queensland supply);
- Scenario 2: quantify the impact of an expansion of exploration activity (expansion); and
- Scenario 3: quantify scenarios for the expansion of exploration activity and a reduction in external supply in Queensland (replacing non-Queensland supply and expansion).

The derivation of an exploration sector from the services to mining sector in the IO table presents a problem because we are not able to identify competing external supply (that is mining exploration services that could be replaced by feasible Queensland supply) and non-competing external supply, mining exploration services which cannot (at least in the short run) be replaced. To overcome this, some assumptions, detailed later in the report, are made concerning the competing/non-competing non-Queensland supply ratios in assumed efficient industries such as in Western Australia.

The QNLM is a comparative static model which means it compares changes in the economy after the change has been fully absorbed into the economy. This means that the results do not measure the dynamics of a change. To provide some insight into how “replacing non-Queensland supply” might impact on the economy where the change occurs at different speeds we have modelled three scenarios with different rates of change; instantaneous change, change applied over 4 years and change applied over 10 years.

To simulate change over time, the value of output in mining exploration was increased at by 2% per annum in each year of the 4 year and 10 year)adjustment paths.<sup>20</sup> In other words, some change is allowed within the mining exploration sector, but not in its relationship with other sectors. For the 4 year scenario this should not be a problem, but over 10 years structural change to the other sectors in the economy is likely to

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<sup>20</sup> The modelling in this report is comparative static, but there needs to be some recognition of the time dimensions of the problem and the fact that the industry would tend to grow across time independently of reduced non-Queensland supply or greater proportionate exploration spending. For this reason a modest, additional growth factor of 2% per annum was applied. This level was seen as a conservative but acceptable approximation of the long term residual growth rate

occur, which would ideally be incorporated in the model.<sup>21</sup> However, in the absence of reliable information on likely structural change we have assumed the relative shares of sectors in our model are constant. Overall, this assumption should not be overly problematic because mining exploration has well defined inter-industry relationships (in terms of inputs and sales) and these are unlikely to change significantly.

We have also been asked to model the impact of an expansion of exploration activity in Queensland. As noted in section 2, the ratio of exploration activity to the value of mining output is below the ratio achieved for Australia and Western Australia. We have modelled the expansion of exploration activity to be consistent with achieving the Australian and Western Australian ratios. We also modelled the impact of achieving the Canadian ratio. However, as stated in section 2, we do not think Canada provides an appropriate benchmark ratio.

**Table 4 Scenarios**

Scenario
1.Reduction in the extent of external supply (replacing non-Queensland supply)
- Modelled through exploration linkages (ie Qld same as WA)
- Model three adjustment paths
o Immediate
o 4 years
o 10 years
2. Exploration Expansion (expansion)
- Ratio of Exploration/Mining
o WA average (increase from X to Y)
o Australian average (increase from X to Y)
o International average (increase from X to Y)
3. Replacing non-Queensland supply and Exploration Expansion (ie scenario 1 & 2 combined)

We have assumed it is valid to compare the structure of the mining industry in Queensland and Western Australia. While mining is important to both states, it is considerably more important in Western Australia in terms of its net percentage contribution to GSP. This size dominance has flowed through to the mining exploration sector in Western Australia.

Currently, the Western Australian industry in terms of value of production is approximately 2.3 times that of Queensland but it serves a different mining base than that of Queensland. As a result we are seeking to compare different forms of mining,

<sup>21</sup> For a further discussion of simulating dynamic change within a static model see, Mangan, J (1994), 'The Gladstone Industrial Project: An Application of Input-Output Analysis Over Time', Australian Journal of Regional Studies, Vol. 8, No. 2 pp. 1-23, 1994.

with Queensland being heavily dependent upon coal and Western Australia on iron-ore and other metals.

We also have assumed that more mining exploration is better than less and the report focuses on the absolute level of exploration expenditure. In such circumstances the high level of expenditure on exploration in Western Australia is assumed to be a desirable goal for Queensland to achieve.

However, there are other outcomes that could be benchmarked such as the success rate of exploration or the rate of return per dollar invested in exploration<sup>22</sup>. Benchmarking such data may lead to a different interpretation both of the results and of the original research questions. For example, it may show that the Queensland industry is smaller but more targeted and has a higher success rate per dollar of expenditure than in other States. However, within this paper, we seek to examine the economic impacts of the Queensland sector of moving closer to the significance and size of the Western Australian sector, which is seen as the default standard.

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<sup>22</sup> The ABS also reports meters drilled. This might provide an alternative measure of efficiency however our model requires a monetary value of exploration effort.

## 5 Modelling Results

Section 3 of this report examined the linkages between mining exploration and the rest of the economy. This analysis indicates that an increase in local (Queensland) exploration activity is likely to result in a positive impact on the rest of the economy because of the strength of existing economic linkages.

In this section we model scenarios which relate to less reliance on mining exploration services sourced from outside Queensland. To do this we have re-assigned the value of the services formerly sourced from outside of Queensland to local purchases, wages and consumption. We also simulated structural change by increasing the mining exploration/mining ratio in Queensland to the ratios operating at the Australian level, the Western Australian level and the international level. Finally we simulated the joint occurrence of both higher percentage of locally based mining exploration services and increased exploration/mining ratios.

### 5.1 Reduction in non-Queensland supply

The Queensland Non-Linear Input Output Model built for this analysis shows that the current level of mining services sourced from outside of the State is approximately 32% of the total value of mining exploration services in Queensland.

A key issue for the modelling of this scenario is to determine the level to which non-Queensland supply should be reduced. There will always be some non-Queensland supply. We have assumed that non-Queensland supply can be reduced to a minimum level which represents mining exploration services for which there will be no Queensland substitute. We refer to such services as non-competing non-Queensland supply.

To estimate the level of non-competing non-Queensland supply we examined the level of exploration services produced outside Western Australia on the assumption that the industry in this State represents the benchmark level. The Western Australian Non-Linear Model sets this level at 8%. On this basis the level of non-Queensland supply potentially achievable by Queensland is 8%.

Table 5 provides a baseline for the non-Queensland supply reduction simulation. The flow-on impacts of the current level of exploration activity is \$139M. The largest flow-on impact is to the finance and business sector. Significant flow-on impacts also occur to the mining sector and mining exploration sector which are the normal intra-industry flows that occur in economic modelling, because some of the outputs from an industry

are re-used as inputs and because firms within an industry often conduct a lot of intra-industry trade.

**Table 5 Base case 2004-05 \$M**

Sector	Final Demand	Value-added	Consumption	Total	Percent	Gross Flow-on	Percent
Ag/For/Fish	0.00	0.91	1.69	2.60	1.31	2.60	0.00
Mining	0.00	17.92	1.16	19.08	9.64	19.08	0.00
Mining Exploration	58.95	10.01	0.00	68.96	34.83	10.01	58.95
Manufacturing	0.00	3.01	3.56	6.57	3.32	6.57	0.00
Utilities	0.00	8.83	1.53	10.37	5.24	10.37	7.46
Building Construction	0.00	0.47	0.24	0.71	0.36	0.71	0.51
Trade/Accommodation	0.00	5.32	11.12	16.44	8.30	16.44	11.82
Transport& Communications	0.00	8.91	3.36	12.27	6.20	12.27	8.83
Finance & Business	0.00	34.89	17.00	51.89	26.21	51.89	37.32
Public Administration & Defence	0.00	0.56	0.44	1.01	0.51	1.01	0.72
Community Services	0.00	0.86	4.39	5.25	2.65	5.25	3.77
Recreation & Personal Services	0.00	0.49	2.37	2.86	1.44	2.86	2.06
Total	58.95	92.19	46.85	197.99	100.00	139.04	100.00

a. Tables 3 and 5 measure the baseline flow on GSP from different perspectives, although both achieve the same flow –on GSP amount of \$139 million. Table 3 looks at gross spending in the mining exploration sector (\$269 million), while table 5 has, as its starting point, net spending (\$197 million) - total spending net of input costs. Table 5 shows the net value adding process in the industry and its break up into industry led and consumption led components.

**Source:** Synergies estimate

Table 6 shows the results of achieving an immediate reduction of external supply from 32% to 8%. Impacts are measured in GSP flow-on, which measures the net impact to the rest of the economy. The GSP flow-on measure closely approximates the welfare measures used in studies using Computable General Equilibrium (CGE) models.<sup>23</sup>

<sup>23</sup> The net change in welfare derived in CGE models takes into account the value added achieved by the expansion of an industry but offsets against this any displacement or loss that one industry might suffer as a result of the expansion of that industry.

**Table 6 Replacing non-Queensland supply scenario 1(a) – immediate adjustment 2004-05 \$M**

Sector	Final Demand	Value-added	Consumption	Total	Percent	Gross Flow-on	Net Flow-on	Percent
Ag/For/Fish	0	0.928	4.303	5.231	1.52	5.231		2.33
Mining	0	18.302	2.951	21.253	6.16	21.253		9.48
Mining Exploration	120.68	20.924	0.016	141.62	41.06	20.94		9.34
Manufacturing	0	3.077	9.063	12.14	3.52	12.14		5.41
Utilities	0	9.022	3.905	12.928	3.75	12.928		5.77
Building Construction	0	0.48	0.601	1.081	0.31	1.081		0.48
Trade/Accommodation	0	5.434	28.322	33.756	9.79	33.756		15.05
Transport& Communications	0	9.104	8.561	17.664	5.12	17.664		7.88
Finance & Business	0	35.64	43.297	78.937	22.89	78.937		35.2
Public Administration & Defence	0	0.576	1.127	1.703	0.49	1.703		0.76
Community Services	0	0.878	11.181	12.058	3.5	12.058		5.38
Recreation & Personal Services	0	0.503	6.032	6.535	1.89	6.535		2.91
<b>Total</b>	<b>120.68</b>	<b>104.868</b>	<b>119.358</b>	<b>344.906</b>	<b>100</b>	<b>224.226</b>	<b>85.2</b>	<b>100</b>

Source: Estimated from QNLM (2005)

The GSP flow-on measures the expansion in output value after allowing for input costs of the industry concerned but does not consider the potential impact on other industries. In the case of mining exploration services the two are likely to be similar because this industry has few if any substitutes for its products. Therefore within a growing economy the expansion of the exploration sector’s output is unlikely to impact negatively on other sectors. In an economy which is resource constrained, such as the current Australian economy, industries are competing for resources and there is the possibility of displacement, where an industry can only expand at the cost of others. However, the report has examined strategies of growing the industry over a 4 and 10 year period. Such a staged introduction should eliminate any serious displacement problems and in 4-10 years time the boost to mining that will occur from an expansion of mining exploration may be needed to sustain the economy at current levels.

The table also shows the impact on value-added in other sectors (value-added) and consumption, which sum to the gross impact on GSP flow-on. In comparing the various scenarios it should be remembered that the baseline GSP flow-on for the Queensland Industry is \$139.04 M. This amount needs to be subtracted from the GSP

flow-on of \$224 M report in Table 6 to derive the incremental impact on external supply.<sup>24</sup>

An immediate shift from 32% to 8% of externally sourced exploration services results in an annual impact of \$85.2 M (or 0.05% of GSP).

The QNLM is a comparative static model which means that it models a change in an economic variable, in this case non-Queensland supply, and measures the changes in economic aggregates assuming there are no other further changes in the economy. The change is measured from an initial equilibrium state to a new equilibrium state (that is, after the economy has fully adjusted to the modelled change).

A comparative static model does not explicitly model the period of time the adjustment takes. The above results assume the change could be achieved immediately. We think this assumption is unlikely to be achieved in a real economy as it would require perfect resource mobility and perfect information.

We modelled two further scenarios which assume that reduction in non-Queensland supply will be achieved over time. In our view the results in Table 6 are best interpreted as the maximum economic impact after competition non-Queensland supply has been replaced by Queensland production.

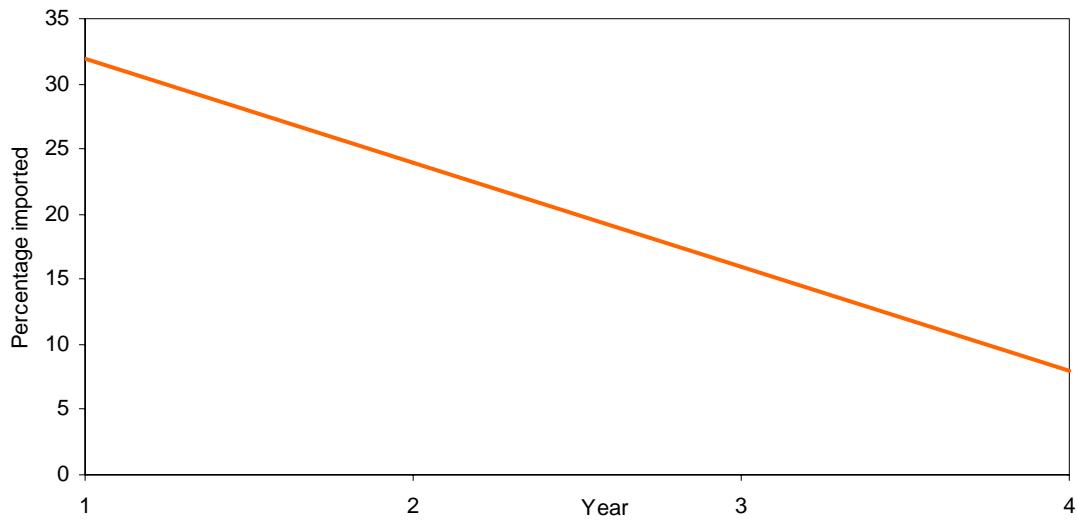
### **5.1.1 Non-Queensland supply replacement –reduction over a four year period**

Figure 3 indicates the adjustment assumptions for scenario 1(b) where the reduction in services supplied from outside of Queensland is achieved over a four year period. The reduction period is an assumption as there is no information on the time period it might take to displace non-Queensland mining exploration services. The adjustment path shown in figure 4 assumes that the speed of reduction will be evenly spread over 4 years from 32% (year 1) to 8% (year 4).

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<sup>24</sup> The baseline table is contained in appendix 1. Comparison with table 5 will allow calculation of the net gain.

**Figure 3 Adjustment path – scenario 1(b) – even paced adjustment**



The gains in GSP flow-on per year over the 4 year period are shown in Table 7.

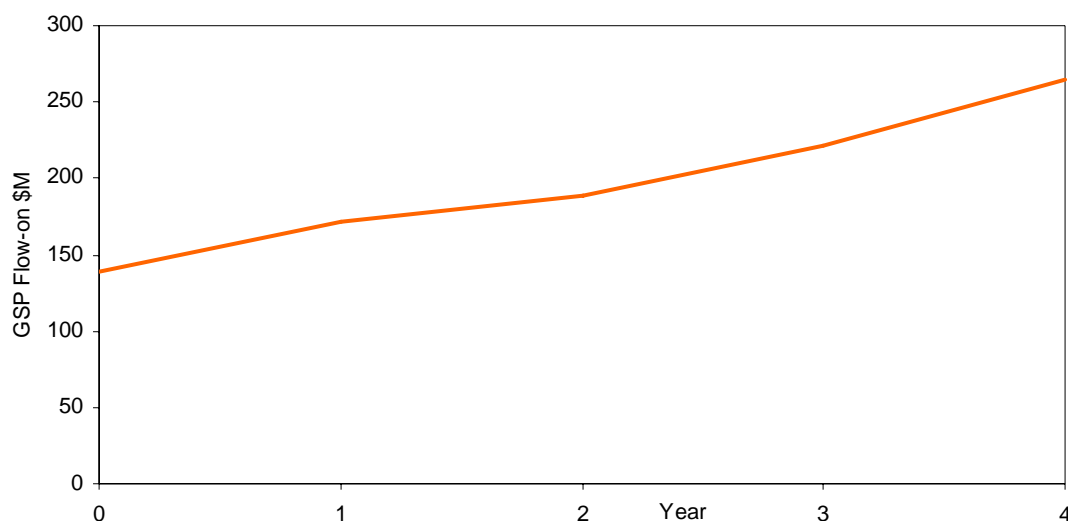
**Table 7 Annual GSP flow-on impacts from a 4 year reduction strategy, \$M**

Year	GSP flow-on
1	32.4
2	49.23
3	81.64
4	125.95

**Source:** Estimated from QNLM (2005)

It is notable that the 4 year strategy produces greater annual impacts at the end of the 4<sup>th</sup> year than was achieved by going immediately to the 8% target. Part of this is explained by the assumption of growth in the value of mining exploration services over time and part is explained by the stimulatory effects each successive year has on the economy.

**Figure 4 Gross GSP flow-on impact– 4 year outsource reduction strategy - \$M**



Data source: Synergies

Similarly Figure 4 indicates that the total effect in terms of GSP flow-on is again larger under this scenario compared to the previous scenario (approximately \$260 M compared to \$224 M).

**5.1.2 Non-Queensland supply replacement - reduction over a 10 year period.**

In this scenario the adjustment path is smoothed over 10 years and results in slightly higher annual GSP flow-on by the 10<sup>th</sup> year (\$126.78) compared to year 4 under the more rapid scenario. This is due to the assumed baseline 2% growth rate of the mining exploration sector (see Table 8).

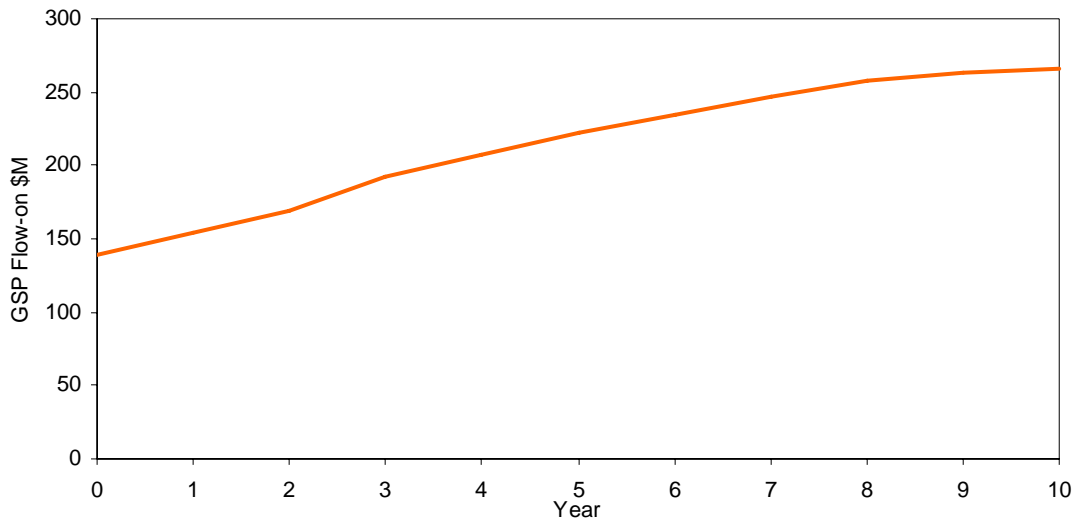
**Table 8 Annual GSP flow-on impacts from a 10 year reduction in the level of externally sourced mining exploration services, \$M**

Year	GSP flow-on
1	14.97
2	29.573
3	52.67
4	68.2
5	82.46
6	95.37
7	107.45
8	118.92
9	123.4
10	126.782

Source: Estimated from QNLM (2005)

Figure 5 shows the size of annual impacts begins to slow after year 3. This indicates that by the 3<sup>rd</sup> or 4<sup>th</sup> year the largest marginal GSP flow-on increase from reducing non-Queensland supply have been achieved and subsequent increases, though still significant, are smaller. This is in line with the observed pattern in the 4-year scenario and indicates that a faster implementation strategy is to be preferred to a slow implementation strategy.

**Figure 5 Gross GSP flow-on impact– 4 year reduction strategy - \$M**



Data source: Synergies

### 5.1.3 Comparison of the three scenarios

Table 9 compares the impact of the three scenarios over a 10 year period. For scenario 1(a) and 1(b) we have assumed that exploration impacts will expand at 2%, consistent with the assumption of growth used to model impacts under scenario 1(b) and 1(c). Annual impacts and present value (PV) impacts are largest under scenario 1(b) – a four year adjustment path. It is noted that the present value impacts under a slow adjustment path are significantly less than either of the other two scenarios modelled. This is because its full impact is not achieved until year 10, indicating a significant opportunity cost if reducing non-Queensland supply is protracted. This indicates the benefit of removing impediments that affect the ability of the local mining exploration sector to compete with non-Queensland sources of supply.

**Table 9 Annual impact comparisons and Present Value 2004-05 \$M**

Scenario/Year	PV <sup>a</sup>	1	2	3	4	5	6	7	8	9	10
1(a)	714	85	87	88	90	92	94	96	98	100	102
1(b)	767	32	49	82	126	128	131	134	136	139	142
1(c)	557	15	30	53	68	82	95	107	119	123	127

<sup>a</sup> A 6% discount rate was used in the NPV calculations.

Source: Synergies

## 5.2 Expansion and simultaneous reduction in external supply

Scenarios 2 and 3 were modelled jointly. Scenario 2 investigates the impact of raising the ratio of mining exploration expenditure in Queensland to the levels of: (a) the Australian average, (b) the Western Australian average and (c) an international average. Data to establish these ratios were gathered from ABS data on private exploration expenditure and the value of mining output for the years 2004-2006 (at June). Canadian data was used to represent the international average.<sup>25</sup> From these data, the following average exploration expenditure per \$1000 of mining output was derived:

- Queensland \$16.00
- Australian Average \$30.69
- Western Australia \$37.98
- International (Canada) \$ 89.03

<sup>25</sup> Canadian data relates to 2005 and was sourced from Statistics Canada and the Department of Natural Resources.

To simulate the impact of increasing the Queensland exploration/mining ratio to the above benchmarks, the value of output for the mining exploration sector was increased to be consistent with each benchmark and used to adjust the total in the mining exploration sector in the 12 sector QNLM.

To simulate the impact of both increasing exploration ratios and replacing non-Queensland supply, the analysis was run at both current levels of non-Queensland supply and the low level of non-Queensland supply as indicated by the 4-year reduction strategy. The advantage of combining the two scenarios is that it answers the research questions jointly, and also allows consideration of possible interaction effects of running both policy measures; increased exploration spending and reduced non-Queensland supply, simultaneously. Therefore from a modelling perspective it is a very efficient way of considering the research questions.

However, a disadvantage is that it suggests that increased exploration/mining ratios and reduced non-Queensland supply can occur independently of one another. This is unlikely to be the case. For example, raising the level of mining exploration in Queensland may lead to reduced external supply of mining exploration services if the increased spending led to more intensive local operations, which in turn reduced the level of non-Queensland supplied exploration services.

Therefore by modelling both the impacts of exploration ratio expansion and reducing non-Queensland supply, we run the danger of double counting the impact of reducing external supply.

**Figure 6 Scenarios 2 (expansion) and 3 (expansion plus reducing non-Queensland supply) - Additional annual GSP flow-on impact from mining exploration sector**

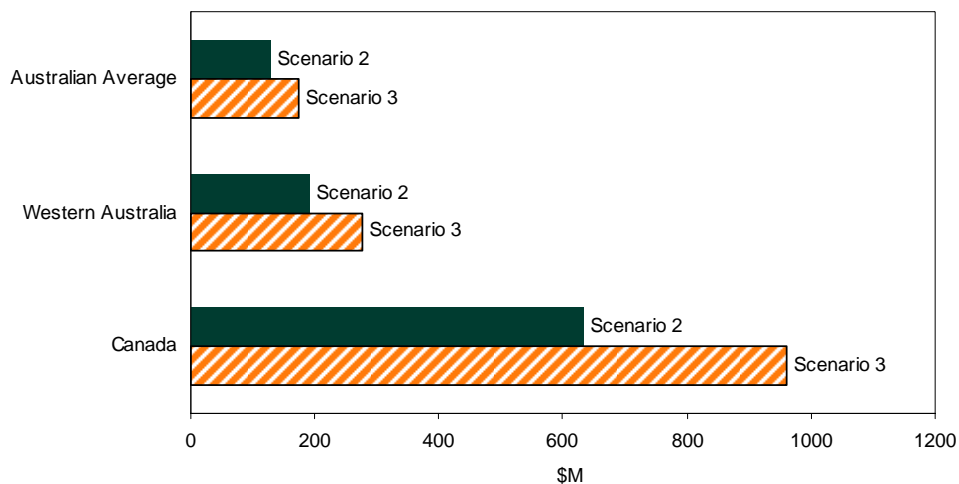


Figure 6 shows that the expansion of exploration activity (no reduction in non-Queensland supply) substantially increases GSP flow-on. However, it is doubtful that the Canadian experience offers a realistic example of what is feasible in Queensland. Much of the Canadian exploration is in petroleum related projects and operates over substantially different mining terrain than occurs in Queensland. As well, Canada is at the high end of mining exploration internationally. It would take a very large increase in spending on exploration in Queensland to approach the Canadian total, which is also operating at a considerably larger ratio than occurs in Western Australia.

As well, the simultaneous reduction in non-Queensland supply significantly increases final demand GSP flow-on. Applying the Australian, Western Australian and International ratios when non-Queensland supply of exploration services is at a minimum increases GSP flow-on by \$172.74 M, \$275.06 M and \$960.96 M respectively.

Table 10 reports the impacts under scenarios 2 and 3 as a proportion of GSP. The impacts on GSP are quite small ranging from 0.08% to 0.58%. As stated previously we think that an expansion consistent with the level of Canadian exploration is unattainable, which narrows the potential annual impact to between 0.08% and 0.17%.

**Table 10 Additional annual GSP flow-on impact from increasing mining exploration and reducing non-Queensland supply of mining exploration 2004-05 \$M**

Scenario	Description	Queensland Current(Baseline)	Australian Average Exploration/Mining ratio	Western Australian Exploration/Mining Ratio	International Exploration/Mining Ratio (Canada)
2	No outsource replacement	139.04	266.7	330.04	773.15
	Net impact	-	127.66	191	634.11
	- Percentage increase in GSP	-	0.08	0.12	0.38
3	With outsource Replacement	260	432.74	535.06	1496.02
	Net impact	-	172.74	275.06	960.96
	- Percentage increase in GSP	-	0.10	0.17	0.58

Source: Synergies

## 6 Conclusions

Throughout the paper the mining exploration sector in Western Australia was put forward as a benchmark for Queensland to emulate, in terms of its size and inter-connectedness to the rest of the economy. In the report we found that:

- the mining exploration sector in Western Australia has average strength backward linkages with a large number of sectors. It has a strong forward linkage with a small number of sectors, principally the mining sector;
- in Queensland the backward linkages are strong and widespread. Similar to Western Australia it has strong forward linkages with a small number of sectors (though not currently as strong as in Western Australia); and
- given the existing backward and forward linkages Queensland has the potential to have a similarly significant exploration industry as Western Australia if the level of spending on exploration and the extent of local production approximated that of Western Australia.

What was lacking in Queensland, in comparison to Western Australia, was a comparable level of spending on exploration relative to the total value of mining output. In our model for 2004-05, exploration spending in Western Australia (\$625M) was almost two and a half times the level of exploration expenditure in Queensland (\$269M).

For Queensland's exploration sector to achieve a similar economic influence as the Western Australian sector an increase in spending on Queensland based mining exploration and/or a reduction in the extent of mining services supplied from outside of Queensland would be necessary. For reasons discussed in the report, the two policies are unlikely to be mutually exclusive.

To restrict any analytical difficulties from these assumptions, economic significance was measured in terms of GSP flow-on, as this was seen as the most comparable measure across all the scenarios and the one best able to indicate the wealth creating potential of the scenarios. Our analysis was capable of producing additional estimates of economic impact, such as employment, but we caution advice against doing so. It must be remembered that the mining exploration sectors were created from larger sectors, and while aggregate data exists to cross check the accuracy of our constructed sectors in terms of output and value added, no such aggregates existed in relation to employment. Moreover, some of the scenarios involved lengthy time periods, for example 10 years. Measuring all the factors that impact on employment, such as

capital/labour substitution over such a long period is beyond the capabilities of most models.

Both the reduction in the proportion of externally sourced mining exploration services, particularly if staged over 4 years, and raising the mining exploration/mining output ratios brought significant economic impacts. The largest impacts were produced by a combination of the two scenarios.

The mining exploration sector in Queensland has the basic structure which would result in reasonably large flow-on economic impacts, although the impacts are small as a percentage of GSP. Overall, we find the potential economic results of structural change in Queensland mining exploration spending to be significant in terms of the current size of the Queensland industry but modest in terms of its overall relative impact on the Queensland economy. The results provided are both conservative and plausible given the current size of the mining exploration sector relative to the Queensland economy.

Synergies note that the underlying economic rationale supporting such an expansion has still to be investigated. The report had as its basis, what-if scenarios. What if non-Queensland supply were reduced? What if exploration/mining output ratios rose? It did not consider if these strategies should be undertaken. In this study we have assumed that the origins of the competitive advantage of the Western Australian mining exploration sector could be emulated in Queensland. Further work is required to confirm that it would be economically efficient to expand production of mining exploration services in Queensland.

## A Direct Supply Requirement

**Table A.1 Direct Supply Requirements – Services to Minerals Sector**

0101	Sheep	-Direct Requirement	2801	Motor vehicles and parts, other transport equipment	0.171099
0102	Grains	-	8101	Government administration	0.135078
0103	Beef cattle	-	2504	Medicinal and pharmaceutical products, pesticides	0.127574
0104	Dairy cattle	-	2509	Plastic products	0.124572
0105	Pigs	-	2808	Other electrical equipment	0.121571
0106	Poultry	-	7401	Insurance	0.12007
0107	Other agriculture	-	9301	Sport, gambling and recreational services	0.118569
0200	Services to agriculture,	-	2302	Other wood products	0.105061
0300	Forestry and logging	-	2304	Paper containers and products	0.102059
0400	Commercial fishing	-	2805	Photographic and scientific equipment	0.102059
2110	Beer and malt	-	2508	Rubber products	0.096056
2203	Knitting mill products	-	2704	Sheet metal products	0.096056
2205	Footwear	-	2106	Bakery products	0.081047
2206	Leather and leather products	-	2402	Publishing, recorded media, etc.	0.078045
2803	Railway equipment	-	9501	Personal services	0.076544
3602	Gas supply	-	3601	Electricity supply	0.064537
5103	Other retail repairs	-	2702	Basic non-ferrous metal and products	0.061536
7701	Ownership of dwellings	-	2903	Other manufacturing	0.049529
8701	Community services	-	2507	Other chemical products	0.043525
7801	Scientific research, technical and computer services	16.97785	2605	Other non-metallic mineral products	0.037522
2501	Petroleum and coal products	2.875668	2113	Wine, spirits and tobacco products (a)	0.036021
6301	Water transport	2.682056	6201	Rail, pipeline and other transport	0.036021
2701	Iron and steel	2.498949	2902	Furniture	0.031518
4501	Wholesale trade	2.257309	9101	Motion picture, radio and television services	0.028517
1500	Services to mining	2.071201	2901	Prefabricated buildings	0.025515
7802	Legal, accounting, marketing and business management services	1.892598	2301	Sawmill products	0.022513
7803	Other business services	1.856577	2202	Textile products	0.021012
4201	Construction trade services	0.963559	2503	Paints	0.01651

4503	Other wholesale repairs	0.939545	2601	Glass and glass products	0.01651
7501	Services to finance, investment and insurance	0.852494	2604	Plaster and other concrete products	0.01651
5701	Accommodation, cafes and restaurants	0.831482	2807	Household appliances	0.01651
7101	Communication services	0.79396	3701	Water supply, sewerage and drainage services	0.01651
4502	Wholesale mechanical repairs	0.754938	9601	Other services	0.01651
2703	Structural metal products	0.652879	2108	Other food products	0.015009
6101	Road transport	0.570331	2505	Soap and detergents	0.015009
2804	Aircraft	0.559825	8601	Health services	0.015009
7301	Banking	0.559825	8201	Defence	0.013508
6401	Air and space transport	0.558324	2103	Fruit and vegetable products	0.012007
5102	Retail mechanical repairs	0.450261	1201	Oil and gas	0.009005
7702	Other property services	0.423245	2204	Clothing	0.009005
6601	Services to transport, storage	0.39623	2101	Meat and meat products	0.007504
2810	Other machinery and equipment	0.364712	2201	Textile fibres, yarns and woven fabrics	0.004503
2303	Pulp, paper and paperboard	0.358708	1101	Coal	0.003002
2809	Agricultural, mining, etc. machinery	0.351204	1301	Iron ores	0.003002
7302	Non-bank finance	0.319685	1400	Other mining	0.003002
2502	Basic chemicals	0.313682	2102	Dairy products	0.003002
2705	Fabricated metal products	0.307678	2602	Ceramic products	0.003002
2806	Electronic equipment	0.303176	2802	Ships and boats	0.003002
9201	Libraries, museums and the arts	0.300174	1302	Non-ferrous metal ores	0.001501
5101	Retail trade	0.297172	2104	Oils and fats	0.001501
8401	Education	0.252146	2105	Flour mill products and cereal foods	0.001501
4102	Other construction	0.235637	2107	Confectionery	0.001501
4101	Residential building	0.192111	2109	Soft drinks, cordials and syrups	0.001501
2401	Printing and services to printing	0.174101	2506	Cosmetics and toiletry preparations	0.001501
2603	Cement, lime and concrete slurry	0.1726			

Source: ABS National Input Output Table 2001