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Economic analysis of the Quarrying and Aggregate Production Industry

Report to the Aggregate & Quarry Association of New Zealand

November 2008

Preface

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Executive Summary

This report estimates the contribution of quarrying and aggregate production to the New Zealand economy.

Direct impacts

The industry produced 45.4 million tonnes of aggregates in 2007, worth an estimated $550 million. Production has been increasing over the current decade due to growth in demand for roads and construction. Over half of output is used for roading, and 21% (a quarter by value) for construction of residential and commercial/industrial buildings.

Associated with this output is:

- employment of 1,890 persons, with average earnings in 2005/06 of over $49,000 per annum, 25% above the national average
- value added of $240 million (the equivalent of the industry's Gross Domestic Product (GDP))

Indirect & induced impacts

Indirect effects arise from the demand by the quarrying and aggregate production industry for inputs from supplier companies – i.e. every dollar of quarry and aggregate production requires additional output elsewhere in the economy.

Induced effects arise from expenditure out of the incomes generated in quarrying and aggregate companies and their suppliers.

We estimate these effects through the application of *multipliers*, which show for each dollar of output in the quarrying and aggregate production industries, how much additional output is generated through indirect effects (Type I multipliers) and induced impacts (Type II multipliers). Equivalent multipliers are used to estimate effects on employment and value added.

(A technical description of the theory, derivation and limitations of multipliers is contained in Appendix A.)

The results are shown below.

Table 1 Quarrying & aggregate production: economic impacts

	Gross Output $000	Value Added $000	Employment Number
Direct	549,867	240,132	1,890
Direct + Indirect	1,076,384	455,024	4,967
Direct + Indirect + Induced	2,161,548	720,275	9,707

Notes: Based on 2003 inter-industry data

Source: NZIER

In total, direct, indirect and induced economic impact of quarrying and aggregate production resulted in $2,162 million of output throughout the economy 2007.

This in turn resulted in 9,707 jobs (0.5% of total employment) and value added of $720 million (0.4% of New Zealand's GDP).

The industry's medium-term prospects will be influenced by two key factors. On the upside, there will be sustained demand for roading materials (given the commitment of the Government to investment in infrastructure). On the downside demand for materials for construction of houses and (to a lesser extent) commercial buildings will be weaker.

A critical element of the industry's ability to deliver the required outputs is its access to quarrying land, ideally close to where construction is occurring (as aggregates are low value relative to weight, increasing the distance over which they are transported from quarry to construction site adds significantly to costs).

Access to such land is subject to the normal processes of the Resource Management Act, at the local (District/City Council) level.

We note by way of comparison that in the state of Victoria, state planning documents explicitly identify land suitable for quarrying on the periphery of urban areas. The effect of this is to facilitate quarrying within identified zones and provide access to low-cost material close to urban growth areas.

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1. Introduction

> *Nearly 46 million tonnes of rock, sand, and aggregate worth over $557M are produced annually for roading and construction, making a vital contribution to New Zealand's infrastructure development.*

(MED 2008[1])

This report has been commissioned by the Aggregate and Quarrying Association of New Zealand (AQANZ) to assess the contribution of quarrying and aggregate production to the New Zealand economy. The report:

- describes and values the economic activity that takes place within this industry, and
- estimates how much this industry's production increases demand for goods and services across the entire New Zealand economy.

This report is an independent and realistic assessment of the economic impact of the industry, using standard economic tools and recent economic data. It is structured as follows:

- section 2 provides an overview of the industry, including values for the direct effects of quarrying and aggregate production
- section 3.1 describes the methodology used to measure the economic impacts of the industry, in terms of the indirect and induced impacts of its production
- section 3.2 describes the measures used to estimate indirect and induced impacts – what are known as *multipliers*
- section 3.3 provides our estimates of the total economic impacts of the industry on the New Zealand economy
- section 4 briefly summarises the prospects for the industry
- Appendix A describes how multipliers are derived, and the limitations on their use.

[1] Crown Minerals, Ministry of Economic Development (MED) 2008 http://www.crownminerals.govt.nz/cms/minerals/overview

2. Industry profile

2.1 Production

The aggregate and quarrying industry extracts natural products – rock, gravel and sand – and processes them through crushing and similar processes, for use as a construction material. It also extracts limestone as an input for cement and fertiliser.

In 2007, a total of 45.4 million tonnes of aggregate were extracted[2], worth an estimated $550 million[3].

Table 2 Aggregate production, 2007

	000 tonnes	$000
Rock, sand and gravel for roading	23,782	267,308
Rock, sand and gravel for building	9,601	140,567
Rock, sand, gravel & clay for fill	4,704	28,259
Sand for industry	1,896	27,056
Limestone for agriculture	2,180	38,849
Limestone and marl for cement	1,965	14,433
Limestone for industry & roading	948	29,287
Rock for reclamation & protection	329	4,107
Total	**45,405**	**549,867**

Source: MED (*op.cit*), NZIER

Note: Data may have been rounded and therefore may not sum precisely

Over half of the industry's production is used for roading –

> *Depending on design and site condition, over 4,000 tonnes of aggregates are used in the construction of just one kilometre of standard highway pavement, while the building of a new six lane motorway can consume in excess of 20,000 tonnes for the same distance.*

(Aggregate & Quarrying Association 2008)[4]

and 21% (over a quarter by value) is used for construction of residential and commercial/industrial buildings.

Production has increased significantly over the current decade, through the boom in house building, and rising investment in commercial/industrial construction and

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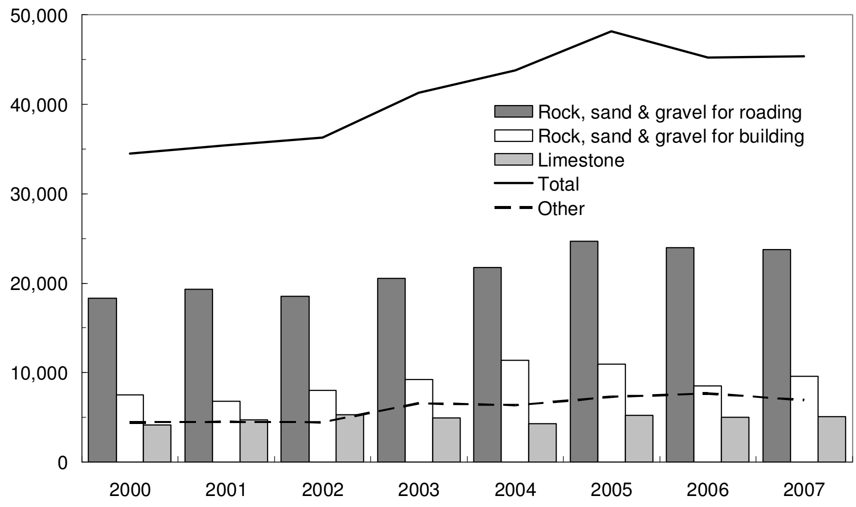
2 MED (*ibid.*)

3 NZIER estimate from MED (*op.cit*)

4 Aggregate & Quarrying Association (AQA) 2008 http://www.aqa.org.nz/Quarrying.asp

infrastructure. Production in 2007 was 32% higher than in 2000; between 2000 and the peak year, 2005, it increased by 40%.

Figure 1 Aggregate production, 2000-07
000 tonnes



Source: MED (*op.cit*)

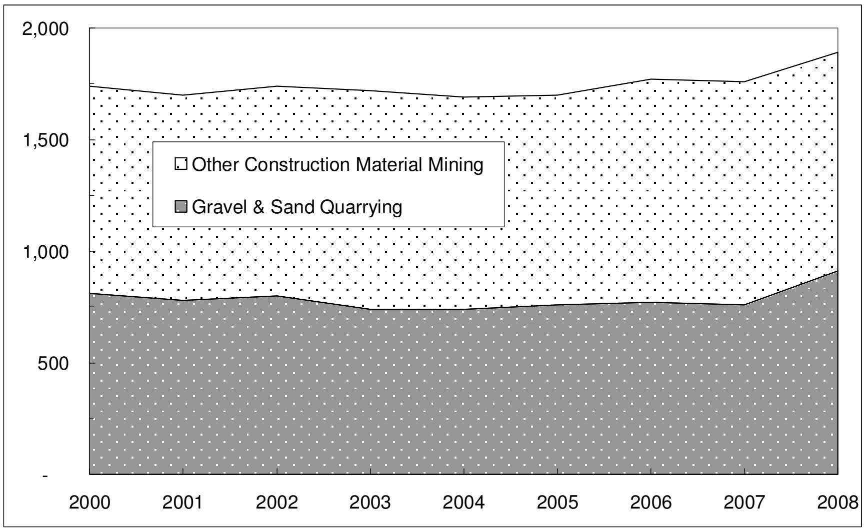
Aggregate production for infrastructure has stabilised over the last three years, whereas building-related production has fallen with the downturn in residential and non-residential construction.

2.2 Employment

There were 1,890 people employed in the Construction Material Mining industry in March 2008, divided approximately equally between Gravel & Sand Quarrying and Other Construction Material Mining (which includes aggregate, stone and clay extraction)[5].

[5] Construction Material Mining – B091 in the Australia and New Zealand Standard Industrial Classification 2006 – most closely approximates the aggregate and quarrying industry, although we believe it may not include all of the industry. For this reason the above employee numbers may understate total employment in the industry.

Figure 2 Aggregate & quarrying employment
Employee count, as at March



Note: Employee count is the number of salary and wage earners employed in relevant enterprises at a particular point in time

Source: Statistics New Zealand *Business Demographics*

Employees in the industry earned above average incomes, averaging $49,338 in the year to March 2006. This was 25% above the national average of $39,622[6].

2.3 Value added

Value added is the standard measure of the contribution an industry makes to economic activity, representing the *increase* in the value of goods or services generated during production in the given industry.

Value added is calculated as the value of gross output less all intermediate goods or services used during production. Intermediate goods and services are the required inputs to production which are purchased from other firms. Firms purchase intermediate goods and services, which they then combine with their own capital and labour and transform into other goods to sell to firms and households.

The three main components of value added are:

- labour - *Compensation of Employees* (wages, salaries, superannuation etc)
- depreciation – *Consumption of Fixed Capital*
- profit - *Net Operating Surplus* (gross income less all other expenses).[7].

The sum of value added across all businesses is one measure of Gross Domestic Product (GDP).

[6] Source: Statistics New Zealand, *Linked Employer-Employer Database*

[7] Indirect taxes net of subsidies, such as fuel exercise, are also part of an industry's value added.

The table below provides our estimate of value added in the aggregate and quarrying industry in 2007, based on:

- gross output per our estimate of $549.9 million of production (above)
- average ratios of each measure to gross output for the three years to March 2006 for the Construction Material Mining industry[8]

Table 3 Gross output and value added in the aggregate & quarrying industry, 2007

$000

Gross Output	549,867
Value Added	240,132
Compensation of Employees	83,089
Consumption of Fixed Capital	38,282
Operating Surplus	117,891

Source: NZIER

The ratio of value added to gross output for the industry, of 43.7%, is roughly in line with the economy-wide average of 44.5%.

[8] Equivalent data for the March 2007 year were not available for Gravel & Sand Quarrying, and hence the Construction Material Mining industry as a whole.

3. Economic impact analysis

To determine the total economic impact of quarrying and aggregate production, we begin with the estimates of gross output, value added and employment set out in the previous section. These *direct* impacts are used to derive *indirect* and *induced* impacts.

3.1 Indirect and induced impacts

3.1.1 Indirect impacts

Indirect economic impacts are the effects of direct production on demand for goods and services from other industries.

The production of aggregates causes demand for inputs from firms which supply goods and services to quarrying and aggregate companies. The demand of these firms for inputs from their own suppliers in turn creates a ripple effect of demand throughout the economy.

3.1.2 Induced impacts

The induced economic impact from production of aggregates results from the demand for goods and services created by incomes generated in quarrying and aggregate companies and supplier industries.

Induced effects arise from the influence of the household sector on economic activity. Wages and other incomes generated in the production of aggregates (including in supplier industries) are spent on services and goods produced in other sectors, with a further ripple effect as this demand spreads through the economy.

3.2 Multipliers

Multipliers are sets of numbers which are typically used to estimate how a change in demand in one industry or sector changes economic activity in the wider economy. Multipliers consider an industry's backwards linkages, i.e. how activity in an industry increases demand from, and hence output in, supplying industries.

(Multipliers can also be used to estimate the downstream effects of an industry, i.e. how changes in aggregate production would affect production in industries using its products. This is not normally done, as it is difficult to interpret downstream effects in a meaningful way due to the difficulty of determining causation.)

An output multiplier of 1.75 for an industry means that for each dollar increase in its output, output in other sectors that supply it will increase by 75 cents, in order to provide the industry with the extra inputs required.

The size of a multiplier for a given sector is determined by the inter-connectedness of that sector with other sectors in the economy. Typically the more a given sector relies on inputs from businesses in other sectors, the larger its multiplier will be.

Multipliers can be derived for a number of economic variables. In the following analysis we provide multipliers for the same variables we provided direct values for in Section 2 above, namely gross output, value added and employment.

Multipliers are derived from Input-Output (I-O) tables originally sourced from Statistics New Zealand, for 126 industries.

For this analysis we use multipliers for the larger *Other Mining* industry, which includes all mining not related to coal, gas or oil, including quarrying and aggregate production.

Table 4 Other Mining multipliers

	Gross Output	Value Added	Employment
Type I	1.9575	1.8949	2.6278
Type II	3.9310	2.9995	5.1358

Notes: Based on 2003 inter-industry data

Source: NZIER

3.3 Total impacts

Multiplying the values of the direct impacts (per section 2 above) by the multipliers in Table 4 above provides estimates of the economy-wide impact of the quarrying and aggregate production industry.

Table 5 Quarrying & aggregate production: economic impacts

	Gross Output $000	Value Added $000	Employment Number
Direct	549,867	240,132	1,890
Indirect	526,517	214,893	3,077
Direct + Indirect	1,076,384	455,024	4,967
Induced	1,085,164	265,251	4,740
Direct + Indirect + Induced	2,161,548	720,275	9,707

Notes: Based on 2003 inter-industry data

Source: NZIER

This table shows that the total direct, indirect and induced economic impact from aggregate extraction is

- gross output of $2,162 million (calendar 2007)
- value added of $720 million (calendar 2007)
- employment of 9,707 persons (as at March 2008).

4. Prospects for the industry

Looking ahead over the next three to five years, the critical factor for the industry will be the strength of demand for its products. In this, it faces two quite different prospects:

- demand for roading materials – over half the industry's output - is likely to be at least maintained with the commitment of the Government to investment in infrastructure
- prospects for materials used in construction of houses and (to a lesser extent) commercial buildings are much less positive, given the downturn that is already occurring.

This suggests that there will be a downturn in the quarrying and aggregate production industry over the next two years or so, until commercial construction picks up (in about a year) and residential construction (some time later). Investment in infrastructure should provide the industry with a steady level of demand, at what are still relatively high levels of activity in historical terms.

The industry is relatively small, with its direct value added representing 0.1% of New Zealand's GDP, and its total contribution to value added (including indirect and induced effects), 0.4%. Direct employment in quarrying and aggregate production is 0.1% of New Zealand's total employment, and the industry's total contribution to employment is 0.5%.

However, its relatively small size belies its importance to the New Zealand economy. In particular, it provides a key input to new infrastructural assets, and sustained investment in infrastructure is regarded as critical to New Zealand's future.

Does the industry have the capacity to deliver the output necessary for infrastructure development? We do not have the data with which to readily answer this question (nor were we asked to).

But we observe that like all resource-based industries, access to the resource, i.e. quarrying land, will be critical for its ability to deliver the required output. Quarry operators must secure this through the normal processes of obtaining a Resource Consent through the Resource Management Act at the local (District/City Council) level.

Moreover, quarry location is significant as aggregates are low-value relative to weight, so increasing the distance over which they are transported from quarry to construction site adds significantly to costs. Quarries are also subject to significant scale economies, i.e. large quarries are more cost-effective than small ones.

We note by way of comparison, that in the state of Victoria, there is a stand-alone act governing these industries, the Extractive Industries Development Act 1995, with regulations promulgated under it. Under this Act and state-wide planning documents (the Victoria Planning Provisions), *Extractive Industry Interest Areas* (EIIAs), including land suitable for quarrying, are identified on the periphery of urban areas.[9]

The effect of identifying EIIAs is to facilitate quarrying on urban peripheries by protecting potential quarrying sites, and thus to ensure that aggregates are available close to where they are to be used (avoiding the need to transport them long distances which would significantly add to their costs).

Note however that quarry operators seeking to commence operation within these EIIAs do not have planning approval as of right – they must go through standard planning processes at local council level – nor are they precluded from seeking to establish operations outside these areas. What these provisions do is ensure that there is some alignment between expected supply and demand for aggregates around main urban areas.

9 http://www.dpi.vic.gov.au/DPI/nrenmp.nsf/LinkView/6BFBD6FB0EA7C2104A2569E4000CACCDD933E43B5C5BDF864A256A8000118238

Appendix A Methodology for estimating multipliers[10]

A.1.1 The formal model

In this section, the formal model is presented. An algebraic treatment of the problem is supplemented with a small example. Notation is developed and defined along the way. The example and the notation will persist throughout the appendix. Vectors and matrices will appear in bold type.

Consider a 3 sector economy; agriculture (Agr), manufacturing (Mfg), and services (Srv). The table below presents a simple Input-Output (I-O) table for this economy.

Table 6 Sector Input-Output Matrix

	Agr	Mfg	Srv	Final Demand	Gross Output
Agr	80	160	0	160	400
Mfg	40	40	20	300	400
Srv	0	40	10	50	100
Lab	60	100	80	10	250

Source: NZIER

Initially we assume that this table represents physical flows rather than monetary flows. Hence, it makes no sense to sum the columns. In general, we say that the production sectors of an economy use primary inputs (e.g. capital and labour) and intermediate inputs (e.g. the output of other production sectors).

Let x_i denote the gross output of the i^{th} sector,

x_{ij} denote sales from the i^{th} sector to the j^{th} sector,

D_i denote final demand in the i^{th} sector, and

L_j denote the amount of labour (number of units) purchased by the j^{th} sector.

Then,

$$x_i = \sum_{j=1}^{3} x_{ij} + D_i \qquad \forall\, i = 1,2,3. \tag{1}$$

[10] Based on New Zealand Institute of Economic Research (2001) *Economic Impact and Welfare Analysis* – internal paper

We can define the production (or technological) coefficients as

$$a_{ij} = \frac{x_{ij}}{x_j} \qquad (2)$$

which we can restate as

$$x_{ij} = a_{ij} x_j \qquad (3)$$

Similarly, we can define the labour requirement as

$$l_j = \frac{L_j}{x_j} \qquad (4)$$

Computing the table of a_{ij}'s and l_j's for our 3 sector economy yields the table below.

Table 7 Technical Coefficients

	Agr	Mfg	Srv
Agr	0.2	0.4	0
Mfg	0.1	0.1	0.2
Srv	0	0.1	0.1

Source: NZIER

As an example, consider the computation of a_{12}, that is, the coefficient describing the amount of agricultural output required by the manufacturing sector to produce 400 units of gross manufacturing output. In this case,

a_{12} = xAgr,Mfg/xMfg = 160/400 = 0.4.

Similarly, l_3, the amount of labour required by the services sector to produce 100 units of gross output from the service sector is equal to 80/100 = 0.8.

Now, if we ignore labour for the moment[11], and substitute (3) into (1), we get

$$x_i = \sum_{j=1}^{3} x_{ij} + D_i = \sum_{j=1}^{3} a_{ij} x_j + D_i \qquad \forall\, i = 1,2,3. \qquad (5)$$

or in matrix form

$$\mathbf{X} = \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} = \begin{bmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} + \begin{bmatrix} D_1 \\ D_2 \\ D_3 \end{bmatrix} \qquad (6)$$

[11] We can do this if we assume that sufficient labour exists to produce any level of output. This was a typical assumption in the early days of I-O analysis.

More compactly, we can write

$$\mathbf{X} = \mathbf{AX} + \mathbf{D}$$
$$\Rightarrow \quad \mathbf{X} - \mathbf{AX} = \mathbf{D}$$
$$\Rightarrow \quad (\mathbf{I} - \mathbf{A})\mathbf{X} = \mathbf{D} \tag{7}$$

which we can rearrange as

$$\mathbf{X} = (\mathbf{I} - \mathbf{A})^{-1}\mathbf{D} \tag{8}$$

So, we now have a general equilibrium system which we can use to solve for X. But note, this assumes we are given a set of final demands, or in other words, final demand is exogenous. Note too that in order to solve this system, the matrix A must be non–singular which implies it can be inverted. If (I-A)–1 exists, then we can be assured that a unique solution to the system exists. Finally, recall that we are still assuming all primary inputs, labour in our example, are perfectly elastically supplied.

Finally, before we move on, let's consider the interpretation of the terms in the (I-A)–1 matrix. Define C as (I-A)–1: then c_{ij} denotes the (i–j)th element of (I-A)–1. Further, suppose that

$$\mathbf{D} = \begin{bmatrix} 1 \\ 0 \\ 0 \end{bmatrix}$$

That is, final demand for manufacturing and services is zero and for agriculture it is a single unit. Substituting into (8) we now get

$$\mathbf{X} = \mathbf{CD} \tag{9}$$

Which we can rewrite as

$$\mathbf{X} = \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} = \begin{bmatrix} c_{11} & c_{12} & c_{13} \\ c_{21} & c_{22} & c_{23} \\ c_{31} & c_{32} & c_{33} \end{bmatrix} \begin{bmatrix} 1 \\ 0 \\ 0 \end{bmatrix} = \begin{bmatrix} c_{11} \\ c_{21} \\ c_{31} \end{bmatrix} = \mathbf{c}^{Agr} \tag{10}$$

In these equations, in the case of the agricultural sector, total gross output is equal to the one unit going to final demand plus the agricultural output used by the agricultural sector. Similarly, the gross output of the manufacturing and services sectors is exactly the amount that each of those sectors supply to the agricultural sector.

What this is then telling us, given the way final demand is valued exogenously, is that the total production of agriculture in the system is c_{11}. Likewise, total production of manufacturing is c_{21}, and total production of services is c_{31}. The general interpretation of c_{ij} is that it is a measure of the gross output of the ith

sector needed to deliver 1 unit of the j^{th} good to final demand. As will be explained later, this is a useful result.

For our 3 sector example of the economy,

$$\mathbf{C} = [\mathbf{I} - \mathbf{A}]^{-1} = \begin{bmatrix} 1.33 & 0.6 & 0.13 \\ 0.15 & 1.2 & 0.27 \\ 0.02 & 0.13 & 1.14 \end{bmatrix}$$

We observe that the diagonal element must be at least one.

A.1.2 Multipliers

Our initial example was of an I-O table measured in physical flows. However, the methodology also applies to a table measured in monetary flows.

The way to think about the multipliers is as follows.

Let's focus for the moment on the agricultural sector. First, consider the delivery of one more unit of agricultural output to final demand. This has an immediate or direct impact on all sectors via the A matrix. In other words, to get one more unit produced by the agricultural sector requires 0.2 units from the agricultural sector, 0.1 units from the manufacturing sector, and nothing from the services sector. The indirect impacts stem from the fact that these first round effects have caused some change in the output level of each sector.

And note that an increase in agricultural output had no direct effect on the services sector. However, it has an indirect effect because the direct effect on manufacturing in turn requires input from the services sector.

In former times, people were interested in the multiplier effects of different sectors so that the government could stimulate the economy by influencing final demand. Clearly, if the multipliers differed across sectors, then the government could induce varying levels of activity depending on which sector it chose to direct its expenditure at.

According to standard calculus and linear algebra, the series expansion of C = (I-A)–1 is equal to $(I + A^1 + A^2 + A^3 + \ldots + A^m)$ when m is infinity. This turns out to be a useful result. Note that A^x quite literally means we raise the matrix to the power of x. But this is not the same as individually raising each element of the matrix A to the power of x. Without going into the mathematics in detail, the following example should clarify.

Consider the example from above of supplying an extra unit of agricultural output to final demand. The (1–1) element of the identity matrix, I, denotes this. To see the direct effect of this on all other sectors we look at the terms from the first column of the A, or A1, matrix, that is, $a_{11} = 0.2$, $a_{21} = 0.1$, and $a_{31} = 0.0$. Now, to see the first round of indirect effects, we must look at the first column of A_2, where A_2 is equal to A*A. The matrix multiplication shows that $a_{211} = 0.08$,

$a_{221} = 0.03$, and $a_{231} = 0.1$. The next round of indirect effects are given by and $a_{311} = 0.028$, $a_{321} = 0.013$, and $a_{331} = 0.004$. And so on and so forth. One can see that by the third round the effects are getting pretty small.

Consider the case of the direct and indirect output effects of only the agricultural sector delivering one more unit of agricultural output to final demand. In this case, we look at just the (1–1) element of the individual matrices in the series to $(I + A^1 + A^2 + A^3 + \ldots + A^m)$. Suppose we restrict ourselves to the direct effect and just the first two rounds of indirect effects. The sum of these effects is then $1 + 0.2 + 0.08 + 0.028 = 1.308$ which we can see is almost as much as the (1–1) element of the C matrix, i.e. 1.33. In other words, the series would generally be close to full convergence after one or two more rounds.

A.1.3 Limitations of multiplier analysis

Multipliers are useful for determining how economic activity in a given sector affects economic activity in other sectors. However they have limitations that require care in interpreting results. There are three main points which should be considered:

- multipliers assume that sectors combine inputs, and produce outputs, in fixed proportions.
- multipliers take no account of induced changes in relative prices.
- multipliers assume that labour and capital are available in unlimited quantities.

Where these assumptions do not hold, the resulting numbers are not necessarily a good representation of reality. Businesses can, to some extent alter their input mix by substituting between different goods. Changes in the supply and demand of goods and services will affect the price of those products. And the factors of production, particularly short-run labour supply, are only available in limited quantities in New Zealand.

The limitations to the underlying assumptions are not usually a problem when the direct economic impact is relatively small within the total economy – for example, when multipliers are used to consider how a small change in output in one sector affects demand in other sectors.

The analysis used in this report is done with this in mind.

As a corollary, the larger the economic change being modelled, the more unrealistic these assumptions become.

A practical issue in New Zealand is that the national I/O table from which all multipliers were derived was last updated in for the 1995/96 year. Although sector details can be updated by reference to sector employment and other data, there is a risk that inter-industry relationships embedded in the table no longer apply, due to technological change and shifts in the sectoral composition of the economy.