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authoritative analysis

Cement and concrete production

Economic impact assessment

Report to the Cement & Concrete Association of New Zealand

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Preface

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NZIER was established in 1958.

Authorship

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Executive Summary

This report estimates the contribution of cement and concrete production to the New Zealand economy. Measures of output, employment and value added are derived for each of the four sectors comprising the cement and concrete industries. Mining for minerals to be used in the production of cement; cement manufacturing; ready mix concrete and concrete product manufacturing; and concrete construction.

The total economic contribution consists of direct, indirect and induced effects. The direct effects come from the value of business generated in the cement and concrete industries. Indirect effects are the value created in supplying industries when they generate inputs for the cement and concrete industries. Induced effects comprise of the value created due to the expenditure of recipients of incomes from cement and concrete industries.

Direct impact

Values for output, employment and value added measure the direct economic impact of each of these four sectors on the New Zealand economy, as shown in Table 1.

Table 1 Direct economic impacts from cement and concrete production
Year ended March 2006

	Output $0000	Employment number	Value Added $000
Limestone marl mining	13,093	30	5,748
Aggregate extraction	115,296	194	50,618
Cement manufacturing	196,500	290	77,386
Concrete manufacturing	1,191,000	4,270	402,000
Concrete construction services	429,800	2,540	203,893
Total	**1,945,689**	**7,324**	**739,645**

Source: NZIER estimates – see Section 2.3

We estimate that the industries directly involved in cement and concrete production were directly responsible for output of $1.946 billion in the March 2006 year. They provided 7,324 jobs, and generated value added of $740 million.

Indirect and induced impacts

The indirect and induced contribution of these four sectors to output, employment and value added are estimated by using the above values together with multipliers. Multipliers measure how economic activity in each of these sectors increases demand for goods and services from other sectors of the New Zealand economy.

The total direct, indirect and induced economic contribution of the cement and concrete industry to the New Zealand economy are shown in Table 2.

Table 2 Economic impacts of cement and concrete production
Year ended March 2006

	Output $000	Employment number	Value Added $000
Limestone marl mining	51,471	154	17,242
Aggregate extraction	453,235	998	151,828
Cement manufacture	751,459	1,110	300,073
Concrete manufacture	4,554,642	16,343	1,558,799
Concreting services to construction	1,632,563	5,710	772,654
Total	**7,443,370**	**24,315**	**2,800,596**

Source: NZIER estimates – see Section 2.3

In total, direct, indirect and induced economic impact of cement and concrete resulted in $7.44 billion of output throughout the economy in the year to March 2006. This in turn resulted in

- 24,315 field jobs
- value added of $2.8 billion, 1.8 percent of New Zealand's Gross Domestic Product in 2006.

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1. Introduction

This report has been commissioned by the Cement & Concrete Association of New Zealand (CCANZ) to assess the contribution of New Zealand cement and concrete production to the New Zealand economy. The report:

- describes and values the economic activity that takes place within cement and concrete industries (cement and concrete-related mineral extraction; cement and concrete production; and concrete construction services)
- estimates how much cement and concrete industries' production increases demand for goods and services across the entire New Zealand economy

This report is an independent assessment of the economic impact of the industries, using standard economic tools and recent economic data. It provides a realistic assessment of the industries' actual economic worth for those interested in the economic impact of cement and concrete production.

1.1 Structure of this report

This report is structured as follows:

- section 2 describes the variables used to measure economic impacts and discusses how direct, indirect and induced impacts affect the economy
- section 3 provides values for the direct effects of cement and concrete production
- section 4 describes multipliers and provides an account of the indirect and induced effects of cement and concrete production
- section 5 concludes with a summing up of the total economic impacts of the industry on the New Zealand economy
- Appendix A describes in more detail how multipliers are derived
- Appendix B outlines the limitations of multiplier analysis

2. Economic impact analysis

There are a number of economic variables which are commonly used to measure the economic impact of an industry. For this analysis we use the three most common measures, gross output, value added and employment. A description of these variables is provided below in 2.1.

For each of these variables we source or estimate a value to measure direct effects, and derive values for indirect and induced effects. The rationale behind indirect and induced impacts is described in Section 2.2.

2.1 Direct impacts

Direct impacts from cement and concrete production are estimated by measuring gross output, employment and value added generated during production.

Gross output

Gross output is the value of production. This closely corresponds to the sales revenue generated by firms supplying goods and services. In the following analysis gross output for a particular sector is the estimated sum of sales revenue for all firms within that sector.

Employment

Employment refers to employee count, i.e. a the number of salary and wage earners employed in relevant enterprises at a particular point in time.

Value added

The value added represents the increase in the worth of a good or service during production. It is the value of gross output less all intermediate goods or services used during production. The sum of value added across all businesses is Gross Domestic Product (GDP).

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 and transform into other goods to sell to firms and households. This transformation 'adds value' to the intermediate goods and services.

The three main components of value added are labour, depreciation and profit.[1] Labour is measured as Compensation of Employees (wages, salaries, superannuation etc); depreciation as Consumption of Fixed Capital; and profit as Net Operating Surplus (gross income less all other expenses).

[1] Indirect taxes net of subsidies, such as fuel exercise, are also part of a sectors value added.

2.2 Indirect and induced impacts

2.2.1 Indirect impacts

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

The production of cement and concrete causes demand for inputs from firms which supply goods and services to cement and concrete producing companies. The demand for inputs from these supporting firms in turn creates demand from their own supporting firms. The ripple effect of demand and its effect on activity throughout the economy is known as a *Type I multiplier*.

2.2.2 Induced impacts

The induced economic impact from production of cement and concrete estimates the demand created for goods and services in all sectors resulting from the incomes generated in cement, concrete and their supplying industries.

Induced effects arise from the influence of the household sector on economic activity. Wages and other incomes generated in the production of cement and concrete (including in supplier industries) are spent on services and goods produced in other sectors. The demand for these services and goods increases employment in these sectors which in turn boosts household income, leading to more demand. The influence from employment and household incomes on economic activity is know as a *Type II multiplier*.

2.3 Data sources

The data used in this report come largely from Statistics New Zealand (SNZ). Data on employee and firm numbers come from SNZ Business Demographics database; and data on incomes come from the SNZ Linked Employer Employee Data set and the Census of Population and Dwellings. Other data on output and value added were prepared for this report by SNZ from the Annual Enterprise Survey. The data provided through SNZ are typically of very high quality and were the preferred source when it was available.

Other sources of secondary data included New Zealand Crown Mineral accounts, International Cement Review 2007 Global Cement Report, Seventh Edition, and the Companies Office for Holcim company reports.

A number of CCANZ member companies provided primary data to be used in aggregate in this report.

Whenever possible we have gathered data on the same variable from more than one source. This has allowed a degree of cross checking to guarantee accuracy of data.

3. Industry profile

This report examines the economic impact of cement and concrete production by first separating production into five distinct stages:

- the quarrying of limestone and marl specifically for the production of cement
- the production of cement through the mixing, heating and grounding of quarried ingredients
- the extraction of fine and coarse aggregates for use in the production of concrete
- the mixing of cement with additional fine and coarse aggregates to produce concrete, both for construction of concrete structures and production of concrete products (pipes, culverts etc)
- the use of concrete for construction, in particular through specialist concreting companies.

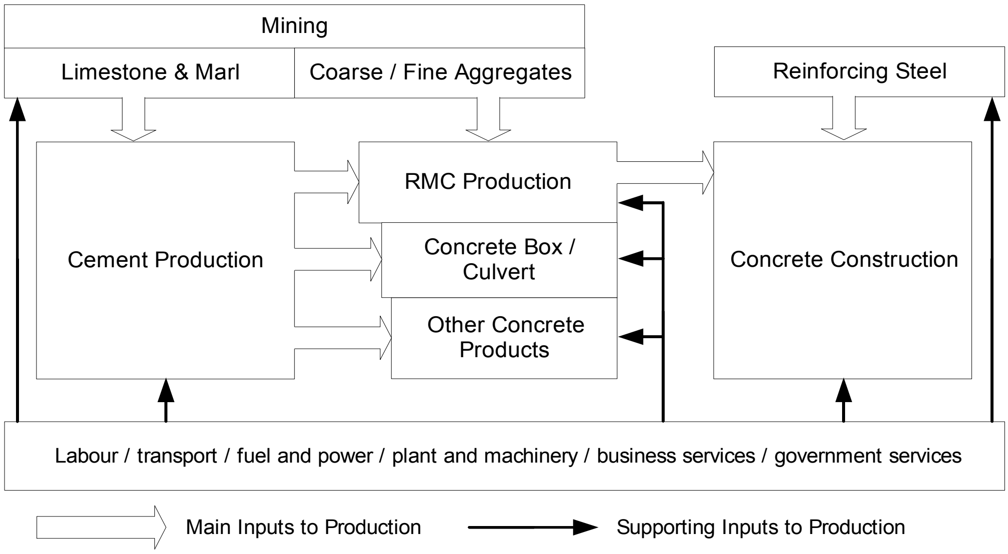
During the first four stages of production, each stage's output is also the main input, or one of the main inputs, to the following stage of production. That is, limestone and marl is mined specifically for cement production, cement in turn is one of the key ingredients of concrete product manufacturing and ready mix concrete (RMC), and RMC is the primary input to concrete construction.[2]

Supporting these five stages of production are a wide range of secondary inputs, ranging from fuel and power used during manufacturing, to transportation services. Mining plays a central role in both cement and concrete production, and reinforcing steel is manufactured solely for use in concrete.

The cement and concrete industries, with the main and supporting inputs to production, are represented in Figure 1.

[2] The strong direct links between sectors is relevant for deriving multipliers. This is discussed in section 4.1.1.

Figure 1 Cement and Concrete production



Source: NZIER

3.1 Economic background

The four segments of cement and concrete production, defined above, operate in three separate industries, as classified by the Australia New Zealand Standard Industry Classification (ANZSIC) codes.

Mining & Quarrying

As well as the mining of limestone and marl for the production of cement, *Mining & Quarrying* includes oil and gas extraction, coal and metal ore (mainly gold) mining. For the year ending March 2006 Mining & Quarrying's share of New Zealand's GDP was about $618 million. Mining of limestone and marl for cement, and extraction of coarse and fine aggregates for concrete, directly contributed over $56 million to New Zealand's GDP in 2006.

Non-Metallic Mineral Product Manufacturing

Both Cement Production, and RMC and Concrete Product Manufacturing are classified in the ANZSIC codes as *Non-Metallic Mineral Product Manufacturing*. This industry contributed $937 million to New Zealand's GDP in the year ending March 2006. Cement manufacturing was responsible for roughly 8 percent of value added in the sector. The value added during 2006 of RMC and other concrete products was in the region of $356 million, 38 percent of the sector total.

Building Structure Services - Construction

Concreting services – provision of concrete by specialist firms (excluding concrete laid by builders etc) - is classified under the ANZSIC codes as part of *Building Structure Services* in the Construction sector. For the year ending March

2006 the direct value added from concrete services to construction to New Zealand GDP was $204 million.

3.2 Mining & Quarrying

Golden Bay and Holcim are the only two companies which produce cement in New Zealand. Both operate their own quarries. Golden Bay's limestone and marl is mined from quarries within the vicinity of the company's Portland plant near Whangarei, Northland. Holcim limestone and marl is mined and crushed at the company's Cape Foulwind quarry, west of Wesport.

There was little difference in the amount of limestone and marl mined by Golden Bay relative to Holcim for the year ending March 2006. New Zealand Crown Mineral accounts show total output of limestone and marl for cement of 1,761,718 tonnes.[3] Of this, 921,718 tonnes, approximately 52 percent, was produced in Northland by Golden Bay. The remaining 840,000 tonnes was produced on the West Coast by Holcim.

Table 3 estimates the gross output, number employed and value added of limestone and marl quarrying in 2006.

Table 3 Quarrying of limestone and marl

Year ended 2006

Gross Output $000	13,093
Employment number	30
Value Added $000	5,748
Operating Surplus $000	2,777
Compensation of Employees $000	1,513
Consumption of Fixed Capital $000	1,264

Notes: (1) Gross output based on 1.76 million tonnes produced in 2006 at 2005 value per unit plus 4% price inflation
(2) Number employed from company data
(3) Compensation of employees based on mean wage for sector
(4) Other values based on total mining industry ratios

Source: New Zealand Crown Minerals, Statistics New Zealand, NZIER

Extraction of coarse and fine aggregates for concrete construction is also an important part of the cement and concrete industries. Coarse aggregates typically make up 41% of concrete, and fine aggregates a further 25%. Table 4 estimates the gross output, number employed and value added in mining for coarse and fine aggregates for concrete in 2006.

[3] New Zealand Crown Minerals at http://www.crownminerals.govt.nz

Table 4 Extraction of aggregates for concrete production

Year ended March 2006

Gross Output $000	115,296
Employment number	194
Value Added $000	50,618
Operating Surplus $000	25,309
Compensation of Employees $000	17,128
Consumption of Fixed Capital $000	7,669

Source: New Zealand Crown Minerals, Statistics New Zealand, NZIER

3.3 Cement manufacturing

As mentioned above, Golden Bay and Holcim are the only two companies producing cement in New Zealand. In 2005 domestic demand was greater than production capacity, and New Zealand imported approximately 0.11 million tonnes of cement. In 2006 Golden Bay Cement completed an upgrade of their plant, increasing capacity from 0.6 to 0.9 million tonnes per annum, and bringing total New Zealand capacity to approximately 1.4 million tonnes. Forecast demand for 2008 is expected to be slightly under this figure. About 10% of the cement produced here is bagged, either for export (about $6.5 million of cement was exported in 2007), or to be sold through wholesale or domestic retailers for applications such as mortar.

The location of the two New Zealand cement works, one near Whangarei, about 170 km from Auckland, the other in Westport, minimises the distance cement needs to travel before being consumed. Typically New Zealand cement travels less than a few hundred kilometres before being used. As a comparison 10 million tonnes of cement used in the United States in 2006 was transported from China.[4] While it is necessary at some stages for New Zealand cement to be transported via road, much of it is transported in bulk, by ship or rail, between the two cement works and cement depots. This limits the greenhouse gas emissions from moving cement, and wear and tear on New Zealand roads.

Because only two companies produce cement in New Zealand, industry level data on cement production is commercially sensitive. It would be possible to determine company specific values for total cement sales, value added and employment for Golden Bay Cement and Holcim, using aggregated industry values.

To avoid disclosing sensitive data, in this section we use publicly available data to estimate values for output, employment and the components of value added.

[4] International Cement Review 2007, The Global Cement Report, seventh edition

Golden Bay Cement and Holcim have both provided comments on the accuracy of the data, and while not precise these data do provide a reasonable estimate of the industry's activity.

Information available on Golden Bay Cement and Holcim websites shows New Zealand total cement production capacity of 1.4 million tonnes, (900,000 and 500,000 tonnes respectively). This is within the region of the Global Cement Report estimation of 1.35 million tonnes of cement produced in New Zealand in 2006. As the Golden Bay Cement and Holcim websites don't state actual output, our estimations of 2006 gross output are based on the smaller value of 1.35 million tonnes. We believe this value is within about 5 percent of actual output. If anything, our calculations will slightly underestimate the economic contribution of cement to the New Zealand economy.

We have data from RMC companies on the cost of cement per unit which allows us to estimate the total value of cement produced in 2006. To check the accuracy of this figure we used SNZ data on the value of cement exports, together with Global Cement Report figures on the ratio of exports to production.

We used the ratios of sales to value added and sales to depreciation, evident in publically available Holcim company accounts, to estimate value added and depreciation for the sector. SNZ provided data on the number of employees in the sector. This value was multiplied by average earnings in the industry to derive wages, used to proxy Compensation of Employees. 2006 Census data were used to cross check values for employment and Compensation of Employees. These estimates are displayed in Table 5.

Table 5 Cement manufacturing

Year ended March 2006

Gross Output $000	196,500
Employment number	290
Value Added $000	77,386
Operating Surplus $000	51,337
Compensation of Employees $000	17,400
Consumption of Fixed Capital $000	8,649

Notes: Estimates as explained in text

Source: Holcim company report 2006, Statistics New Zealand, NZIER

3.3.1 Regional impacts of cement production

This analysis considers the economic contribution of cement and concrete to the whole of New Zealand. However, it is worth pointing out that the economic contribution of mining and cement production is of special importance to the regions where it occurs. In 2006 half of one percent in Northland and the West Coast was in these industries. To put it differently, for every 200 people employed in these regions, one person was employed directly in limestone and marl mining or cement production.

The 2006 mean yearly income for the two industry sectors covering mining and cement production, are $50,440 and $49,720 respectively. People employed in these sectors earned approximately a third as much again as the average regional wages of $36,690 in Northland, and $36,270 on the West Coast.[5]

Mining and production of cement make significant direct contributions to the economies of both of these regions. Indirect effects, while difficult to quantify at a regional level, would be greater again.

3.4 Concrete manufacturing

Unlike cement manufacturing, the production of concrete and concrete products is characterised by a relatively large number of widely dispersed firms. SNZ 2006 data show 48 RMC companies (including Holcim, which is vertically integrated and has concrete interests) in operation in 15 regions across New Zealand. Unlike alternative building materials, RMC has shelf life of only a few hours, necessitating a large number of locally based operators.

In the year to March 2006, the total output of ready mix concrete was 3,725,000 m^3. A further 19 enterprises produced precast concrete boxes and culverts, and 213 enterprises were involved in other forms of concrete production. New technology in the development of precast concrete has led to an innovative re-usable pre-cast concreting system being used to construct car parking buildings around New Zealand.[6] Most pre-cast concrete products are sold domestically, but there is also a small export market.

Values for the economic variables of interest for the RMC and other concrete manufacturing, as derived from sector specific and census data from SNZ, are shown in Table 6 .

Table 6 Ready mix concrete, precast boxes and culverts, concrete products production 2006

Gross Output $000	1,191,000
Employment number	4,270
Value Added $000	402,000
Operating Surplus $000	160,000
Compensation of Employees $000	196,000
Depreciation $000	46,000

Source: Statistics New Zealand, NZIER

[5] Latest available annual regional mean income, September 2005.

[6] Cement & Concrete Association of New Zealand 2007, Concrete[3]

3.5 Concreting services to construction

Concreting services sector is characterised by a large number of relatively small firms active throughout New Zealand. In 2007 there were 1,096 concreting services enterprises, with typically one or two employees each, in over 1,000 different geographical locations. It is obvious from these figures that a large amount of employment is provided to small towns in New Zealand through concrete construction.

The values for output, employment and value added in concreting services are derived from sector specific and census data from SNZ, see Table 7.

Table 7 Concreting services to construction,
year ended March 2006

Gross Output $000	429,800
Employment number	2,540
Value Added $000	203,893
Operating Surplus $000	56,000
Compensation of Employees $000	131,793
Depreciation $000	16,100

Source: Statistics New Zealand, NZIER

3.6 Pacific Steel

Reinforcing steel is an additional input which is essential for the production of concrete for construction. Pacific Steel is the sole manufacturing of all of the reinforcing steel produced in New Zealand. As such information on reinforcing steel manufacturing is commercially sensitive. However, Pacific Steel have provided approximate values to enable a rough estimation of the direct contribution of this industry to the New Zealand economy.

In 2007 approximately 250,000 tonnes of reinforcing steel. Of this roughly 40%, was exported. The remaining production was used predominately in concrete construction around New Zealand.

A key feature of Pacific Steel's reinforcing steel production is the use of scrap metal. Each year Pacific Steel converts over 280,000 tonnes of scrap metal, or 90,000 old car bodies, into reinforcing steel for concrete construction. Pacific Steel are also responsible for recycling and selling scrap metal directly to foreign markets. In addition, each year Pacific Steel uses approximately 3,000 tonnes of end-of-life tyres during the steel making process, further reducing the amount of waste produced in New Zealand.[7]

[7] Cement & Concrete Association of New Zealand 2007, Concrete[3]

Table 8 estimates the direct contribution to New Zealand from the production of reinforcing steel.

Table 8 Reinforcing steel, estimated values for 2007

Gross Output metric tonnes	240,000
Employment number	400

Source: Pacific Steel, NZIER

4. Indirect and induced economic impacts

The purpose of this economic impact analysis is to determine the total contribution of the industry to the New Zealand economy. In this section we consider how demand for cement and concrete creates demand for goods and services in supporting industries using Type I multipliers; and how household incomes generated in cement and concrete and supplier industries create demand for goods and services in a wide range of sectors using Type II multipliers.

4.1 Multipliers

Multipliers are sets of numbers which are typically used to estimate how a change in demand in one industry or sector, changes demand or economic activity in the wider economy. Multipliers consider an industry's backwards linkages, how activity in an industry increases demand from, and hence output in supplying industries. Multipliers do not estimate the downstream effects of an industry, or how cement and concrete production changes output in industries using concrete.[8]

An output multiplier of 1.75 for the mining industry means that for each dollar increase in mining output, output in other sectors that supply mining will increase by 75 cents. The increase of 75 cents in supplier industries is necessary to provide the mining sector with the extra inputs required to increase its output.

In this report we use multipliers (with some adjustment as described in 4.1.1) to estimate how the cement and concrete industries contribute to the wider New Zealand economy.

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 2.1, output, value added and employment. Each of these direct impact values is allocated a multiplier for estimating the indirect and induced effects from cement and concrete production.

Multipliers are derived from Input-Output (I-O) tables originally sourced from SNZ. Multipliers are defined for 126 industries, with each of the four cement and concrete industry groups, defined above, part of one of these larger industries. Limestone and marl are part of, and hence allocated the multipliers derived for all mining not related to coal or gas. For the manufacture of both cement and concrete and concrete products we use the multipliers derived for non-metallic

[8] It is very difficult to accurately estimate downstream effects from economic activity due to the difficulty of determining causation.

mineral product manufacturing. For concrete construction services we use the multipliers derived for building structure services.

4.1.1 Adjustment to multipliers

As described above in 3.1, cement and concrete production spans five different inter-related sectors. For three of the last four stages of production, cement manufacturing, concrete manufacturing and concrete construction, the main input is the previous stage's output. Hence each of these three stages of production has a strong influence on demand and economic activity in the previous stage.

If we simply calculate direct, indirect and induced effects for each sector, and add these together, we would be double counting values. Our measure of direct effects considers how demand in each sector creates demand in the previous stage of production. Standard multipliers also consider this effect. To avoid counting this effect twice we have adjusted the multipliers we use for cement production, concrete production and concrete construction to remove that part of the multiplier which measures the impact of demand for the previous sector's key output.

4.1.2 Mining multipliers

The mining multipliers in Table 9 are derived for Other Mining - all mining which is not related to coal, gas or oil.

Table 9 Mining & quarrying multipliers

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

Notes: Based on 2003 inter-industry data
Source: NZIER

Multiplying the values of the direct impacts of mining from Table 3 by the multipliers displayed in Table 9 estimates the economy-wide impact on output, employment and value added from mining limestone and marl.

Table 10 Mining limestone and marl: economic impact

	Output $000	Employment number	Value Added $000
Type I	25,631	79	10,892
Type II	51,471	154	17,242

Notes: Based on 2003 inter-industry data
Source: NZIER

Determining the total economic impact of limestone and marl mining using Table 10 is straightforward. For an assessment of the whole economy we consider only values obtained from Type II multipliers, as these include, direct effects, indirect effects (Type I multipliers) and induced effects on the economy.

Table 10 shows that the total direct, indirect and induced economic impact from limestone and marl mining is output of $51 million, employment of 154 people, and value added of $17 million.

The mining multipliers displayed in Table 9 are also used for the extraction of coarse and fine aggregates for concrete manufacturing. Multiplying the mining multipliers by the direct economic effects of extraction of aggregates, displayed in Table 4, estimates the economy-wide impact of extraction of aggregates on output, value added and employment, Table 11.

Table 11 Extraction of aggregates for concrete: economic impact

	Output $000	Employment number	Value Added $000
Type I	225,697	511	95,916
Type II	453,235	998	151,828

Notes: Based on 2003 inter-industry data

Source: NZIER

Table 11 shows that the total direct, indirect and induced economic impact from aggregate extraction for concrete manufacturing is output of $453 million, employment of 998 people, and value added of $152 million.

4.1.3 Manufacturing multipliers

The manufacturing multipliers displayed in Table 12 are derived for Non-Metallic Mineral Production and are used for both cement and concrete manufacturing.

Table 12 Manufacturing multipliers

	Output	Employment	Value Added
Type I	1.7515	2.0311	1.8543
Type II	3.8242	3.8274	3.8776

Notes: Based on 2003 inter-industry data

Source: NZIER

Cement production

Multiplying the values of the direct impacts of cement production from Table 5, with the multipliers displayed in Table 12, shows the economy wide impact on output, employment and value added from cement production, see Table 13.

Table 13 Cement manufacturing: economic impacts

	Output $000	Employment number	Value Added $000
Type I	$344,163	589	$143,493
Type II	$751,459	1,110	$300,073

Notes: Based on 2003 inter-industry data

Source: NZIER

The interpretation of Table 13 is the same as for Table 10. The total direct, indirect and induced economic impact from cement manufacturing is output of $751 million, employment of 1,110 people, and value added of $300 million.

Concrete production

Multiplying the values of the direct impacts of manufacturing RMC and concrete products from Table 6, with the multipliers displayed in Table 12 shows the economy wide impact on output, employment and value added from concrete manufacturing, see Table 14.

Table 14 Concrete manufacturing: economic impacts

	Output $000	Employment number	Value Added $000
Type I	$2,085,997	8,673	$745,410
Type II	$4,554,642	16,343	$1,558,799

Notes: Based on 2003 inter-industry data

Source: NZIER

The total direct, indirect and induced economic impact from concrete manufacturing is output of $4.555 billion, employment of 16,343 people, and value added of $1.559 billion.

4.1.4 Construction multipliers

The construction sector multipliers displayed in Table 15 are derived for building structure services.

Table 15 Construction multipliers

	Output	Employment	Value-Added
Type I	1.7543	1.5231	1.8273
Type II	3.7984	2.2479	3.7895

Notes: Based on 2003 inter-industry data
Source: NZIER

Multiplying the values of the direct impacts of concreting services construction from Table 7, with the multipliers displayed in Table 15, shows the economy wide impact on output, employment and value added from concreting services, see Table 16.

Table 16 Concreting services to construction: economic impacts

	Output $000	Employment number	Value Added $000
Type I	$754,017	3,869	$372,567
Type II	$1,632,563	5,710	$772,654

Notes: Based on 2003 inter-industry data
Source: NZIER

The total direct, indirect and induced economic impact from concreting services to construction is output of $1.633 billion, employment of 5,710 people, and value added of $773 million.

5. Total economic impact

To determine the total contribution of cement and concrete to the New Zealand economy we simply sum the values derived from Type II multipliers. Type II multipliers include direct effects, indirect effects (Type I multipliers) and induced effects on the economy.

The results of summing the economic effects of cement and concrete production are displayed in Table 17.

Table 17 Total economic impacts: cement and concrete production, year ended March 2006

	Output $000	Employment	Value Added $000
Limestone marl mining	51,471	154	17,242
Aggregate extraction	453,235	998	151,828
Cement manufacture	751,459	1,110	300,073
Concrete manufacture	4,554,642	16,343	1,558,799
Concreting services to construction	1,632,563	5,710	772,654
Total	**7,443,370**	**24,315**	**2,800,596**

Source: NZIER

In 2006 the combined direct, indirect and induced effects of limestone and marl mining, aggregate extraction, cement and concrete manufacturing and concrete construction created output of $7.44 billion, and provided 24,315 jobs. In total, the value added to the economy from cement and concrete is $2.80 billion, 1.8 percent of New Zealand's 2006 GDP.

5.1 The significance of the industries

Economic impact analysis estimates the measurable transactions generated by the cement and concrete industries across the economy. There are additional economic benefits from cement and concrete which have not been discussed in this report. For example, the production of cement and concrete enables New Zealand's natural resources, such as lime and aggregates, to be harnessed and used to create valuable products, such as buildings and roads. Waste car bodies are transformed into reinforcing steel to be used to manufacture valuable concrete products. The value of these benefits is not so much in the measurable transactions, but in the avoided cost of the next best alternative that would be employed in the absence of domestic cement and concrete industries (e.g. imported cement in place of local product).

It is worth considering how a reduction in the production of cement and concrete may impact on the New Zealand economy, especially when this results from substitution by some other product, rather than a fall in construction demand. A thorough analysis along these lines is outside of the scope of this report, but some of the more obvious effects are outlined below.

5.1.1 Ramifications of reducing cement production

A halt or decline in New Zealand cement production would increase the amount of cement imported into the country. With domestic capacity roughly equal to domestic demand, reducing production without a similar decrease in demand, would lead to an increase in imported cement. Importing more cement would have an immediate negative impact on New Zealand's trade balance.

More significantly, any reduction in cement production would lead to an equivalent reduction in the indirect and induced multiplier effects. This would magnify the initial reduction, and would be especially felt in the two regions (Northland, West Coast) where quarrying of lime and marl and production of cement is concentrated.

Imported cement would be more expensive and suffer from greater price volatility than domestically produced cement. The final price of a good includes the cost of transporting that good from where it is produced to where it is used, and as a high weight/low value product, transport costs can be significant for cement, The cost of transporting cement from Whangarei to Auckland is considerably cheaper than the cost of transporting cement from Indonesia, or any other cement exporting country, to Auckland. The price of imported cement will fluctuate with the value of our currency, and with the cost of transportation (including transport fuels). Higher prices for cement will filter through to higher prices for construction throughout New Zealand.

Importing cement could increase carbon emissions, given the higher transport costs and associated emissions. Whether this is the case depends on emissions from transport relative to production - for example, higher transport emissions might be offset to a greater or lesser extent by more efficient production - and this would be an empirical question[9]. But given the significance of transport's shares of cement costs, *a priori* it is likely that a shift from local to imported cement would increase emissions.

Cement manufacturers here are very aware of the New Zealand public's attitudes towards pollution, and look for ways to reduce waste, and limit the impact their output has on the environment. For example, Golden Bay uses forestry waste during production, while Holcim uses used oils. Production in many other cement

[9] This is of course analogous to the debate about "food miles" for New Zealand exports.

manufacturing countries is not subject to the same public scrutiny or high environmental standards as in New Zealand.

5.1.2 Ramifications of reducing concrete production

The most likely scenario for lower concrete production is substitution by timber, the other main construction material in this country. The impacts of such a substitution would depend on its extent and circumstances that gave rise to it.

If the substitution were to result from market signals – for example, a shift in relative prices of the two products in favour of timber – then the substitution would enhance efficiency. However, if there is another reason – for example, changes to the Building Code or a Government decision to increase the use of wood in construction of state buildings – then it is likely that such a substitution would result in efficiency losses.

Both concrete and timber (from extraction of raw materials through processing to supply on-site ready for use in construction) are sourced mainly within New Zealand. We cannot say in advance of empirical analysis whether such a substitution would have a net gain or loss to overall economic activity because of differences in indirect and induced effects.

However, a substitution for other than market-led causes would result in efficiency losses, which could increase construction costs, the time it takes to complete a project, and / or the use of alternative materials (e.g. structural steel). Ultimately this would result in a decrease in activity in the construction sector and a net decrease in New Zealand's economic well-being.

While New Zealand's wood resource is plentiful, a problem already facing the harvesting part of the industry is the cost of extracting it from less easily accessible land. This and the relatively labour-intensive nature of timber harvesting suggests that increased use of timber at the expense of other materials may only be viable at higher prices.

This is in addition to other factors likely to increase the cost of wood in the near future, such as the liability on foresters for carbon emissions on harvesting under New Zealand's Emissions Trading Scheme.

The environmental impacts of a substitution from concrete to timber are not clearcut. Concrete is based on non-renewable resources (from quarrying), but is potentially recyclable (e.g. through crushing and re-use as aggregate); timber is drawn from renewable resources, but has limited scope for recycling (because of the use of chemical preservatives and the high labour costs of preparation for re-use).

6. References

Cement & Concrete Association of New Zealand 2007. *Concrete[3] Economic, Social, Environmental. Concrete in Sustainable Development*

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Appendix A Methodology[10]

1. The Formal Model
2. Multipliers
3. Prices in an I-O System
4. Monetary Flows

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). Table 1 presents a simple Input–Output table for this economy.

Table 1. 3 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

For now, let's consider that this table is representing physical flows rather than monetary flows. Hence, it makes no sense to sum the columns. In general, we say 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 xi denote the gross output of the ith sector,

xij denote sales from the ith sector to the jth sector,

Di denote final demand in the ith sector, and

Lj denote the amount of labour (number of units) purchased by the jth sector.

Then,

[10] From NZIER Economic Impact and Welfare Analysis 2001

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

We can define the production (or technological) coefficients as

$$a_{ij} = \frac{x_{ij}}{x_j} \tag{2}$$

which we can restate as

$$x_{ij} = a_{ij} x_j \tag{3}$$

Similarly, we can define the labour requirement as

$$l_j = \frac{L_j}{x_j} \tag{4}$$

Computing the table of aij's and lj's for our 3 sector economy yields Table 2.

Table 2. Technical Coefficients

	Agr	Mfg	Srv
Agr	0.2	0.4	0
Mfg	0.1	0.1	0.2
Srv	0	0.1	0.1
Lab	0.15	0.25	0.8

As an example, consider the computation of a12, 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, a12 = xAgr,Mfg/xMfg = 160/400 = 0.4. Similarly, l3, 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

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

or in matrix form

[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.

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

More compactly, we can write

$$\begin{aligned}&\mathbf{X}=\mathbf{AX}+\mathbf{D}\\ \Rightarrow\ &\mathbf{X}-\mathbf{AX}=\mathbf{D}\\ \Rightarrow\ &(\mathbf{I}-\mathbf{A})\mathbf{X}=\mathbf{D}\end{aligned} \quad (7)$$

which we can rearrange as

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

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 cij 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

$$\mathbf{X}=\mathbf{CD} \quad (9)$$

Which we can rewrite as

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

Just to be clear, what we’ve set up here is system where 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 that amount that each of those sectors supply to the agricultural sector. What this is then telling us, given the way we’ve exogenously valued final demand, is that the total production of agriculture in the system is c11. Likewise, total production of manufacturing is c21, and total production of services is c31. The general interpretation of cij is that it is a measure of the gross output of the ith sector needed to deliver 1 unit of the jth good to final demand. Think about this, it is a useful result.

For our example 3 sector economy,

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

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

A.1.2 Multipliers

One of the attractive features of an I-O framework is that it can be used to assess the 'multiplier' effect of a given production sector, that is, the output multiplier. More than this, we can determine the direct, or first round, effects as well as the indirect, or subsequent round effects. Let's continue to ignore the primary inputs and recall that we're still talking about an I–O table measured in physical flows, although, 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 just to force home the point, note that an increase in agricultural output had no direct effect on the services sector. However, it has an indirect effect because it has a direct effect on manufacturing which in turn requires input from the services sector.

So, in the bad old days, 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. As we'll see in a moment, the C matrix describes the sum of all direct and indirect effects.

Students of calculus and linear algebra may recall that the series expansion of C = (I-A)–1 is equal to (I + A1 + A2 + A3 + … + Am) when m is infinity. This turns out to be a useful result. Note that Ax quite literally means we raise the matrix to the power of x. But be careful, this is not the same as individually raising each element of the matrix A to the power of x. I'm not going to go into the mathematics here so you'll have to just trust me. 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, a11 = 0.2, a21 = 0.1, and a31 = 0.0. Now, to see the first round of indirect effects, we must look at the first column of A2, where A2 is equal to A*A. I've done the matrix multiplication and a211 = 0.08, a221 = 0.03, and a231 = 0.1. The next round of indirect effects are given by and a311 = 0.028, a321 = 0.013, and a331 = 0.004. And so on and so forth. One can see that by the third round the effects are getting pretty small.

But what if we want to look just at the direct and indirect output effects of only the agricultural sector following the delivery of 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 + A1 + A2 + A3 + … + Am). 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 probably be close to full convergence after one or two more rounds.

Appendix B 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 can in interpreting results. There are three main points which should be considered:

(i) Multipliers assume that sectors combine inputs, and produce outputs, in fixed proportions.

(ii) Multipliers take no account of induced changes in relative prices.

(iii) 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.