Report

nzier
authoritative analysis

Value of oil and gas exploration

Hypothetical scenarios

NZIER report to the Ministry of Economic Development

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Key points

- We use a computable general equilibrium model to estimate the impact on the New Zealand economy of a P50 oil and gas development scenario.
- We look at an average year of production and exports only. Exploration, construction and decommissioning would have additional economic benefits.
- The development would generate an additional $1.5 billion of export revenue in an average year of production.
- Gross domestic product rises by 1.2%, on average, for the duration of the field's production.
- The impact of the export revenues is dampened by the fact that the profits go to the owners, who are likely to be offshore. After tax and royalty payments – which account for about 42% of the gross profit -- 90% of the remainder go offshore, so a better measure of returns to NZ is gross national disposable income. It rises by 0.77%: even after offshore payments, the New Zealand economy is considerably better off.
- Royalties are $320m per average year of production. These are assumed to be used to reduce national debt, which increases disposable incomes.
- Households also benefit through slightly higher real wages. Aggregate employment at a national level is assumed to be fixed, but there is strong growth in employment in the oil and gas industry and supporting supply and investment sectors. That reflects the higher effective productivity of labour in those industries following a major find.
- There are some offsetting effects from the appreciation of the currency as other exporters suffer a loss of competitiveness overseas. This is exactly what has been seen in Australia as their mining boom has retarded the growth of other major export industries

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1. Introduction

The Ministry of Economic Development wishes to know what impact a major oil and gas development may have on the New Zealand economy. We use a computable general equilibrium (CGE) model to estimate the long run impact of the find.

2. Approach

2.1 The ORANI-NZ model

The ORANI-NZ CGE model contains information on 131 industries and 210 commodities in its basic form. CGE modelling is a highly-respected and well-developed technique that has a rich history for assessing policy, regional and industry questions. Our model was developed in close collaboration with Monash University, a global leader in building and applying CGE models. It captures the various inter-linkages between these sectors, as well as their links to households (via the labour market), the government sector, capital markets and the global economy (via imports and exports). More technical detail on the model is presented in Appendix A.

A benefit of the CGE model is that it is based on an empirical database that identifies the structure of the industries involved. Simulating the increase in exports that the developments generate causes the oil and gas industry to expand. That, in turn, leads to investment in capital, increased employment, bigger operational budgets, and higher tax receipts for the government.

The second benefit of a CGE model is that it considers both the first round effects of the project – increased production and increased returns to capital within the oil and gas industry – as well as the impact that this first round effect has on the rest of the New Zealand economy.

On the other hand, the static approach used for this project has a number of limitations. These are presented in Appendix B. Many of the caveats mentioned could be addressed using NZIER's dynamic CGE model.

2.2 The oil and gas extraction industry

The oil and gas extraction sector in our database is represented by an industry that produces crude oil and gas for both domestic use and export. The cost structure of the industry is important for our results and is shown in **Error! Reference source not ound.**. The industry pays most of its revenues to 'land'. That means that the owners of the rights to the natural resources being extracted receive most of the revenues from the extraction. One can think of the payments to 'land' in our table as being the profits of the extraction that go to the owners of the mining licence.

Table 1 Extraction industry structure

Input	Share	Comment
Land	47%	Includes Gross Margin
Capital	30%	
Labour	8%	
Intermediates	13%	Engineering, mining services
Imported intermediates	1%	Industrial machinery
Margins	1%	Transport
Indirect/Production Taxes	0%	Excludes royalties

Source: Statistics NZ, NZIER

2.3 Shocks

We are interested in estimating the potential contribution that a hypothetical, but realistic, natural resource find could make over the long term to the New Zealand economy. We therefore do not explicitly model the *timing* of the developments (exploration and discovery, followed by investment and ramp up) but instead analyse a static, long-term scenario that estimates the overall contribution of the developments to the New Zealand economy. We allow capital to move in response to growth but fix the labour supply at a long run trend level.[1]

2.3.1 Increased production

All production is assumed to be exported, so the first impact that we model is the increase in export quantities. The value of the export shock, for a P50 scenario, is $1.5 billion per year, on average, for each of the thirty years that the field is operational.[2]

To model these shocks, we fix the export price and increase the supply of oil and gas to export markets. To do this, we need an 'outlet': with prices fixed, what is causing production to increase in the model? In this case we allow the 'land' available to the industry to become more productive based on the increases in exports.[3] The 'land' productivity is a proxy for the discovery of natural resources and reflects the rise in value that mining rights owners enjoy when a major field commences production.

2.3.2 Royalties

An unusual feature of extractive industries is the royalties that must be paid to the government. We model them as a production tax and levy a tax of $320 million per year on the industry.[4] That is essentially a tax on the firm's profits, additional to the ordinary indirect taxes levied by the Crown. We assume that the government uses the revenue to

[1] The movement in capital stocks is justified on two grounds: First, capital stocks ordinarily move with rates of return in the medium to long run. Secondly, we expect some of the investment to come from outside New Zealand, so the aggregate level of investment is also expected to rise.

[2] Value calculated from data provided by MED using their time series forecasts of oil and gas prices along with projected production profiles.

[3] The possible alternatives of increasing primary factor productivity or land volume are unappealing. The former implies a direct rise in capital and labour productivity, which we do not expect to occur. The latter causes a drop in the return to land, which is contrary to the stylised outcome we expect.

[4] Calculated by averaging the time series of royalty payments from the development estimated by MED.

reduce the nation's foreign liabilities. That assumption ensures that the royalty payment to the crown is reflected in increased private incomes and consumption within the model.

2.3.3 Overseas ownership

BERL and MED estimate that the firms conducting the extraction would be approximately 90% owned by foreigners. That means it is likely that the profits generated from the right to mine will go overseas, after taxes and royalties have been paid. We proxy this in our modelling with a lump-sum payment of 90% of the after-tax 'land' and capital value to foreigners. In this scenario that amounts to a payment of over $410 million of the annual $1.5 billion of revenues.[5]

3. Results

3.1 Interpretation of results

Interpreting the results of the modelling requires some understanding of how the results are calculated and reported. We review the method of presentation below to aid in understanding the results presented in the following section.

3.1.1 Representative year

To intuitively capture the effect of the extraction on the country we model the impact in a representative year during operation of the field. The results can be interpreted as the persistent change in the economy due to extraction during the period that the field is operational. That means we do not capture the effect of the prior exploration and development, nor the decommissioning of the wells. It also means that the effects we estimate should not be expected to persist beyond the lifetime of the field.

Note that this approach also means that we will not capture any of the fluctuations in the economy as it moves towards the steady production state that we model. These fluctuations may have significant impacts in their own right and might be captured by using a more sophisticated, dynamic modelling approach.

3.1.2 Change from baseline

The CGE technique used by NZIER calculates impacts as changes from an implicit counterfactual. Results are then reported as percentage changes from the counterfactual. In order to make it easier to understand the figures we also provide dollar values for some variables. Those are calculated using current macroeconomic data so they show the dollar value that the field would have if it were in operation today. For the values to be relevant to future periods they would need to be inflated accordingly.

3.1.3 Direct and indirect effects

In analysing the modelling results we track the impacts as they flow through the economy, beginning with the direct impacts on the extraction industry itself. We then analyse the flow-on or indirect impacts. It can aid understanding to split indirect impacts into the following categories:

[5] $630 million is 90% of the 47% of revenues that accrue to 'land' in our database.

- **Supplying industries** – industries that supply the extraction sector with intermediate inputs.
- **Household expenditure industries** – industries that households spend money on.
- **Investment industries** – industries that are used for investment and capital creation.
- **Export competing industries** – industries that suffer from the appreciation of the exchange rate as oil and gas exports expand.

3.1.4 Macroeconomic effects

The national results flow logically from the direct and indirect impacts. We focus on key macroeconomic variables such as employment and gross domestic product (GDP), as well as gross national disposable income (GNDI) which is a measure of economic welfare (how 'well off' we are).

The scenarios will have differing impacts on GDP and GNDI, and not always in the same direction. GDP is essentially a measure of how many goods and services New Zealand produces – it shows the size of the economy. GNDI shows how much household incomes increases following a change in the economy. It is more appropriate than GDP as a measure of welfare[6] and particularly appropriate for this modelling: GDP will include the production revenues that accrue to foreigners, while GNDI excludes those payments and measures the increase in incomes of New Zealand residents.

3.2 Direct effects

The direct impact of the increased production is a rise in oil and gas export revenues of $1.5 billion per annum. That directly increase the wages of those working in the industry and increases the returns to capital earned by the owners of the firms working the field. It also boosts government revenues as the industry pays more taxes and royalties. Royalties rise by $320 million while commercial taxes are levied at the usual rate.

3.3 Indirect effects

The flow-on impacts for household expenditure industries of the increased incomes are clearly positive. Higher returns to capital and land boost households' incomes leading to increased spending in industries such as retail and other service sectors.

The mining services industry, a supplying industry for the oil and gas extraction industry, experiences strong growth from the development as its engineering services are used more heavily. It is possible that further substitution towards imported intermediates than we have captured would occur. We do not have data on the likely domestic/imported composition of the intermediates used by the development during production but it is plausible that this effect is overestimated.

Sectors that provide investment services and build capital for the mining sector, such as non-building construction, also grow as the industry builds and maintains capital stocks to sustain production.

[6] W. Coleman, "Gauging Economic Performance Under Changing Terms of Trade: Real Gross Domestic Income Or Real Gross Domestic Product?," *Economic Papers: A journal of applied economics and policy* 27, no. 4 (2008): 329–342.

Finally, the enormous increase in exports causes an appreciation in the currency that reduces the competitiveness of exporters' goods. Major exporters such as the dairy and horticulture sectors suffer a slight decline in output as a consequence.

Table 2 Indirect impacts

Percentage change in value added, selected industries

Industry	Type	Impact
Mining services	Supplying	179%
Bars & restaurants	Household expenditure	2.1%
Clothing	Household expenditure	2.2%
Non-building construction	Investment	2.3%
Dairy	Competing exporter	-0.01%
Horticulture	Competing exporter	-0.19%

Source: NZIER

We assume that, in the long run, aggregate employment grows only at the population growth rate; however, there are significant shifts in employment between industries generated by the development. The oil and gas industry, as well as supporting mining services, increase their employment in line with their rising output. Household expenditure industries also grow, with the restaurant industry employing 1.6% more people as it grows, for example. In addition, there is a small rise in the average real wage of 0.04%, as discussed in the next section. These movements are reallocations of labour resources, rather than aggregate growth, and are offset by job losses in shrinking export industries. The textiles industry, for example, reduces employment by 0.5% and the horticulture industry sheds 0.2% of its workforce.

3.4 National effects

The economy benefits from the wealth generated by utilising previously dormant resources, resulting in increasing wages and returns to capital for the natural resource sector.

The increased exports' net result is an increase in GNDI of 0.77%, which would be an extra $1.4 billion of value if the field were operational today. The rise in GDP is even greater at 1.2%, or $2.2 billion in 2011. The main reason for the large difference between GNDI and GDP changes is the payment offshore of over $410 million of the revenue. That revenue boosts GDP but doesn't end up adding to the income of New Zealanders. In addition, some of the GDP is diverted to investment to take advantage of the attractive rates of return offered by the mining sector. That generates increases in the nation's capital stock of 1.4% in total. **Error! Reference source not found.** summarises these ffects.

Table 3 National results of a P50 scenario

Real percentage change

Indicator	Percentage change	Real value change
GDP	1.2%	$2.1 billion
GNDI	0.77%	$1.4 billion
Private Consumption	0.72%	$800 million
Public Consumption	0.72%	$280 million
Exports (volume)	3.0%	
Imports (volume)	2.0%	
Real wage	0.02%	
Capital stock	1.4%	

Source: NZIER

Overall, the increase export values generate higher incomes for New Zealanders, which leads to an increase in our wealth and, thus, our living standards. However, not all sectors of the economy benefit. In particular, the appreciation of our exchange rate has a negative impact on competing exporters, although that effect is dwarfed in aggregate by the rise in oil and gas export value. The appreciation also allows consumers to access cheaper imports from overseas, as can be seen by the rise in import volumes.

From the Crown's perspective there has been an improvement in the balance of trade due to the huge increase in exports but that is counterbalanced by a rise in the nation's net foreign liabilities. There has also been a rise in Crown revenue as the increased economic activity generates indirect tax revenues, along with the $320 million of additional royalties. The total rise in tax revenues is expected to be approximately $720 million as a consequence of the oil and gas development.

For the purposes of this simulation we assumed that government expenditure moves in step with private consumption; any additional government revenues are used to pay off overseas debt. Consequently, we may underestimate the value of additional government revenues if they would be of more value to the Crown than to households.

Appendix A CGE modelling framework

A.1 ORANI-NZ

Our results were produced on a model of the New Zealand economy based on a tried and tested generic model (ORANI-G) that has been found effective for policy analysis in Australia and around the world. The model has been calibrated to the local setting and loaded with New Zealand data. The assumptions needed are based on consultation with industry specialists and reflect best practice.

The model has been developed with considerable assistance from CGE modelling experts at the Centre of Policy Studies at Monash University in Melbourne Australia.

A.2 Database structure

The model is based on a large database containing the value flows of the economy. The database defines the initial structure of the economy, which by definition is assumed to be in equilibrium in all markets. The structure of the database is similar to traditional input-output tables; for example commodities may be used as intermediate input for further production, utilised in investment, exported or consumed by households and the government. Industry costs include the cost of intermediates, margins, taxes and primary factor costs for labour, land and capital. As per the accounting identities in input-output tables, the total value sum of producers' input costs (including margins, taxes, returns to factors and other costs) equates to the total value of output production (the 'MAKE' matrix in the database).

The ORANI-NZ model consists of:

- 131 industries
- 210 commodities
- 1 household

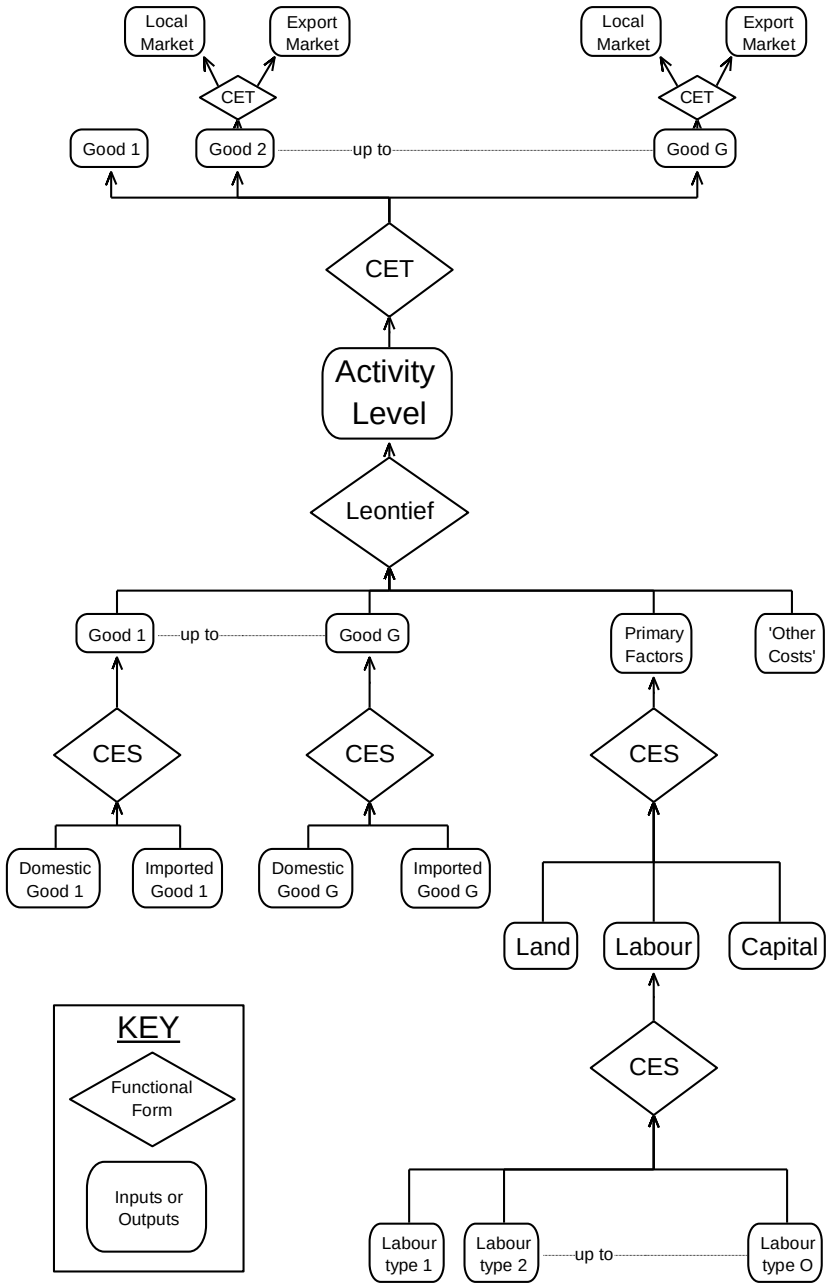
The database has been sourced initially from Statistics New Zealand 1995/96 Inter-Industry tables, updated using the subsequently released 2003 Supply and Use tables, and finally 'up-scaled' to 2010 levels using latest Statistics New Zealand macroeconomic data.

A.3 Production structure

The production structure of the model is presented in Figure 1.[7] Each industry can produce a number of different commodities. Production inputs are intermediate commodities, both domestic and imported, and primary factors labour, land and capital. Working from bottom to top, we see constant elasticity of substitution (CES) production nests for occupations, primary factors and the choice between imported and domestic commodities. In this case, an increase in price moves sourcing towards another input, for example, if the price of imports increases, more domestic commodities are demanded in the intermediate sourcing CES nest.

[7] Mark Horridge, Monash University. Centre of Policy Studies, and IMPACT Project (Australia), *ORANI-G: A General Equilibrium Model of the Australian Economy* (Centre of Policy Studies, 2000).

Figure 1 Production structure



Source: Horridge, 2000

At the activity level, intermediate goods, primary factors and other costs are combined using a Leontief production function. This means the proportion of production inputs does not change. On the output side, there are two further constant elasticity of ransformation (CET)[8] nests. The production mix of each industry is dependent on the relative prices of each commodity. Similarly, the export nest determines local and export market shares depending on relative prices.

[8] A CET function is identical to a CES function except that the transformation parameter has the opposite sign (i.e. increasing price increases output in a CET; in a CES, increasing price reduces demand).

Appendix B Modelling caveats

As with any economic modelling approach, the technique we have employed has its limitations. These caveats include:

- We have used a productivity shock to deliver the increased wealth that the developments will generate. This is a simplification of how the projects will operate.
- The analysis is static, looking at the impacts of the developments on the New Zealand economy at a point in time many years in advance. In reality, the benefits of the developments will be spread across the life of the projects, initially with investment into the facility increasing demand for construction and building; operational expenses including demand for intermediate inputs and labour; supply of fuel after the facility is running; and taxation revenue varying across the project lifetime. We do not explicitly model the dynamics of the developments over time.
- The oilfield project will generate carbon dioxide emissions. However we have not included the cost of carbon explicitly within this modelling.
- While the model database is highly disaggregated, it still invariably suffers from aggregation bias – we are modelling the entire oil and gas industry rather than one firm.
- The CGE model is based on Statistics New Zealand Input Output tables, with decisions based on neoclassical economics. Structural changes to the economy from the developments are therefore not captured in the modelling, nor are any non-competitive market structures. This means the actual distribution of costs and benefits may differ in reality if firms with market power absorb price and cost movements in their profits.