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Economy-Wide Impacts of Industry Policy

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Economy-Wide Impacts of Industry Policy

Anita King

NEW ZEALAND TREASURY

WORKING PAPER 12/05

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Abstract

The economy-wide effects of an economic development or industry policy are often ignored when developing or evaluating such a policy. However, these effects may be important for national welfare and can be estimated using CGE modelling. This paper explains the basics of CGE modelling in general and for the two models used in this paper. It then applies CGE modelling to four industry policy scenarios for the New Zealand economy to illustrate how it can be used and the range of results (including counter-intuitive results) that such models can provide. The scenarios span a range of topics: the effect of a 10% increase in demand for exports; comparing the effect of a 10% productivity improvement in large but low value-added sectors to the same improvement in small but high value-added sectors; a 15% R&D tax credit; and a 10% improvement in international freight productivity.

JEL CLASSIFICATION

C68 Computable General Equilibrium Models
D58 Computable and Other Applied General Equilibrium Models
E29 Consumption, Saving, Production, Employment, and Investment – Other
E61 Policy Objectives; Policy Designs and Consistency; Policy Coordination

KEYWORDS

CGE modelling; industry policy; economy-wide effects

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Economy-Wide Impacts of Industry Policy

Executive Summary

The economy-wide effects of an economic development or industry policy are often ignored when developing or evaluating such a policy. However, these effects may be important for national welfare and can be estimated using CGE modelling. This paper explains the basics of CGE modelling in general and for the two models used in this paper. It then applies CGE modelling to four industry policy scenarios for the New Zealand economy to illustrate how it can be used and the range of results (including counter-intuitive results) that such models can provide. The scenarios span a range of topics: the effect of a 10% increase in demand for exports; comparing the effect of a 10% productivity improvement in large but low value-added sectors to the same improvement in small but high value-added sectors; a 15% R&D tax credit; and a 10% improvement in international freight productivity.

Each industry policy studied had both predictable and unexpected effects on the wider economy. Increased export demand increased export prices and caused the exchange rate to appreciate, but it also resulted in the balance of trade deteriorating. Increased productivity had a bigger effect when it occurred in bigger sectors (agriculture rather than manufacturing), but the imports used by the sector were as important as the level of value-added provided by the sector. A BERD subsidy has a generally positive effect on the whole economy, but a few sectors with high value-added but no direct R&D productivity benefits are negatively impacted by the increased cost of factors of production. Improving international freight efficiency has an overall positive effect on the New Zealand economy, with the best effect when routes to and from New Zealand (but not elsewhere) improve; however it is the lowest value-added sectors that benefit most, and many higher value-added sectors suffer.

While a variety of results have been given in this paper, they are still a selection of the most interesting aspects of the results for each scenario. The raw results contain a much richer array of information that can be analysed and interpreted to learn more about the economy-wide effects of a possible policy. However, it is important when doing this to know enough about the modelling and the underlying economics to understand the real-world situations where the results are relevant. To interpret the results and get the best value from a CGE model requires opening the black box to gain some understanding of how the model works.

1 Introduction

The success or failure of an economic development or industry policy is often judged on whether it has contributed to the development of the supported sector or possibly a small group of closely-related sectors. However, because we should be interested in the impact on *national* welfare from policy interventions, this narrow focus on the supported sector(s) misses important flow-on or economy-wide effects that are a critical part of the assessment of policy proposals.

These economy-wide effects arise because every sector is linked to the rest of the economy through their demand for inputs such as land, capital, labour; and their provision of outputs. The growth in the targeted sector will change the demand and price for both inputs and outputs, which in turn affects other sectors and the overall economy. A growing sector will demand more labour and intermediate inputs, raising prices of those inputs across the economy often to the detriment of other sectors. A growing sector will also produce more outputs, which may lower their price, leaving consumers more money to spend elsewhere or providing cheaper inputs to other sectors. These flow-on effects quickly multiply, but it is the net effect of all these impacts that is important for assessing the overall welfare implications of a particular industry policy.

However, these economy-wide effects are rarely quantified and sometimes not considered at all. This could be due to the difficulty in identifying all the various flow-on impacts in a systematic way. However, computable general equilibrium (CGE) modelling is an established economic modelling technique that can be used to highlight and quantify the effects of an industry policy that extend beyond the targeted sector. Originally developed for studying trade and taxation policies, these models are now also heavily used for analysis of climate change policies. The Australian Productivity Commission (and its predecessors) in particular have been using CGE models regularly in their enquiries since 1977 (Powell & Snape, 1992). Examples include studying the effects of greenhouse gas emissions and policies to reduce those effect on the economy (Industry Commission, 1991); support packages provided to the automotive industry (Productivity Commission, 2008); and reducing regulatory burdens for multi-jurisdiction firms (Productivity Commission, 2012). CGE models have also been used to study the economy-wide effects of regulatory reform and of energy efficiency; but their use is not limited to these areas.

This paper describes what CGE modelling is, then shows how CGE modelling is used to study the economy-wide effects of four illustrative industry policy scenarios. The scenarios span a range of topics: the effect of a policy that results in a 10% increase in demand for exports; comparing the effect of a policy that brings about a 10% productivity improvement in large but low value-added sectors to a policy that brings about the same improvement in small but high value-added sectors; a 15% R&D tax credit; and a policy that brings about a 10% improvement in international freight productivity. They include some results that are initially counter-intuitive, and show the importance of considering the economy-wide effects of a policy change rather than just the effects on the directly affected sector. The New Zealand Treasury commissioned NZIER¹ to study these scenarios and provide the results summarised in this paper.

¹ New Zealand Institute of Economic Research Inc., <http://nzier.org.nz>

It is important to stress that the analysis presented here does not purport to be a full cost-benefit analysis of various policy proposals. In fact, aside from the R&D tax credit scenario, we do not attempt to specify the policy that brings about the scenario being modelling. The scenarios simply seek to illustrate how the economy-wide effects might work through in each case. The aim of this paper is to inspire greater use of CGE modelling to understand the economy-wide effects of industry policies, rather than to provide advice on the example policy scenarios provided.

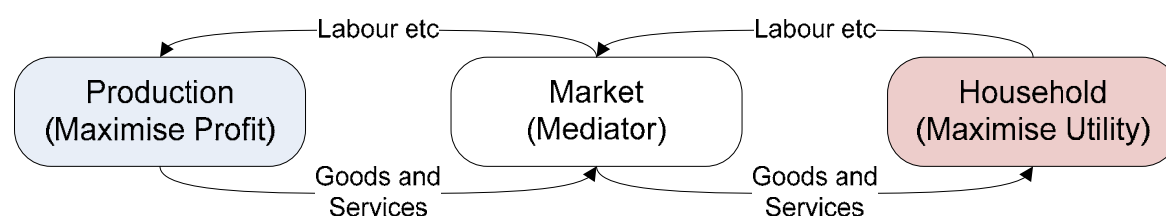
2 CGE Modelling

Computable general equilibrium (CGE) modelling is an established method for studying the economy-wide impacts of economic policies. It has been used for economic policy analysis for several decades, and the concept of general equilibrium has been around for many more decades. CGE models are whole-of-economy models, so they automatically calculate the economy-wide effects of a policy change. They were first developed to study tax policies and trade policies including tariff reduction, and are also heavily used for climate change economic policy.

At their most basic, CGE models balance profit-maximising firms and utility-maximising households using a market that clears completely. They include the whole economy, and measure the changes in prices and quantities that a policy change produces. Because they include the whole economy, the economy-wide impacts – including all the flow-on effects – of an industry policy can be determined. Here, we will only consider static CGE models that compare the current, pre-policy market equilibrium with the new, post-policy market equilibrium. Dynamic models also exist that allow some transition effects to be studied, and can be particularly useful for studying the interaction between multiple policies introduced at different times. However, they are somewhat more complex than is necessary for the scenarios studied here.

CGE models model the economy by assuming that all players – productive firms, households, government, etc – maximise either their utility or their profits, and the market that matches buyers with sellers clears for all products. A very simple CGE model might have one representative household, and one or two productive sectors, as shown in Figure 1.

Figure 1 – A very simple CGE model showing physical flows



The production sector or sectors will buy labour and any other inputs from the market, and will use these to produce goods and services that it sells to the market at prices that will maximise their profits. These inputs include both factors of production such as capital and land, and intermediate inputs – goods and services produced by that sector and other sectors that are used as inputs into production. The household sector will sell labour to the market to raise income and allow them to buy goods and services that maximise their

utility and so their welfare. The market ensures that the prices and quantities are set at levels where there is no excess supply or demand for any good, service, or factor of production such as labour.

A more complex CGE model will have many more productive sectors. It will also have other parts of the economy that interact with the market, such as government and investment sectors. A government sector will get income from taxes on products, income, or other sources, which it can then spend on goods and services. An investment sector will use savings to buy capital goods. If the model is for a closed economy, there will be no imports or exports and the whole economy must be contained within the model – every good that is produced must be bought, every unit of labour sold must be used, everything is priced, and nothing can come from or vanish into thin air. An open economy model relaxes this constraint slightly, by allowing imports and exports from an outside source in a pre-determined way. A multi-region model describes that outside source (or sources) in a similar level of detail to the economy it is linking to. Many models also relax the constraints described above by including inventories or unemployment which allows for differences between supply and demand, but all the goods and labour must still be accounted for.

Static CGE models as used here are a scenario-based tool. They are designed to perform policy experiments to help understand the potential economic results of a particular policy change. They are not designed for forecasting, where many changes occur at once. Imagine throwing a handful of pebbles into a pond. The resulting pattern of ripples will be very complex, and it is difficult to know which pebble caused which ripple or effect. However, if just one pebble is dropped into a still pond, a very clear pattern of ripples emerges which can be directly attributed to that pebble. Similarly, (although multiple policy changes can be made in a static CGE model) studying one policy change at a time makes it easier to understand the effects of that specific change, and to know whether it is worthwhile. But it will not help you to forecast when the ripples will hit the shore when there are multiple changes (pebbles) happening.

Like all models, CGE models are limited by the data they use. This applies both to the quality of the data and the availability of the data. Generally, a CGE model needs values or quantities and prices of all goods, services, factors of production, and any other variables for the initial (unchanged) state of the economy; as well as elasticities describing how they respond to a change. These are used to calculate the remaining parameters, check the model design, and for comparing with the post-change results. Elasticities are usually parameters in a CGE model; the results of the model are the changes in prices and quantities and their effects on macro variables such as GDP. Data limitations are the main constraint on the number of sectors and the level of detail a CGE model can attain. Much of the data comes from either input-output tables or supply and use tables, which are published infrequently and often with several years' delay (as is the case in New Zealand). Fortunately, input-output tables and supply and use tables remain useful despite delayed releases unless there have been major structural shifts in the economy in the interim; and there also exist mathematical tools to update the tables where limited updated data is available if necessary.

3 Model Specifics

Two different CGE models have been used for the scenarios studied here. Three of the scenarios use a New Zealand version of ORANI-G, which is a single region model that includes imports and exports. The international freight scenario uses GTAP, a global multi-region model with greater detail in international freight.

3.1 ORANI-G for New Zealand

This model, which belongs to NZIER, uses the ORANI-G model design with New Zealand data and sectoral breakdown. The original ORANI-G model is Monash University's model of the Australian economy and has been used for many years in a variety of contexts. In the New Zealand version of the model, the production parts of the economy are divided into 131 industries, which produce 210 commodities. The data for the model mostly originates from 1996 and 2003 supply and use tables produced by Statistics New Zealand, which has then been calibrated to 2010 data by rescaling and updating specific data points where available.

In any CGE model, a small number of prices and quantities must be held constant (known as the model's "closure"). The modeller can choose which prices and quantities are held constant, to suit the scenario they are studying. For the scenarios studied here, the ORANI-G model is used in a long-run mode, where the quantity of labour and the long-run rates of return to capital are held constant. The labour market can therefore increase wages but not the quantity of labour, if demand for labour increases. Industries can create capital (the quantity of capital is not fixed), but their long-run rate of return on that capital (its price) is fixed for each industry.

New Zealand is a very small player in most world markets. This means we have little or no effect on prices. Our level of imports is too small to be noticed relative to world demand, and increasing our demand does not cause world prices to increase. In the New Zealand version of the ORANI-G model, this is represented as fixed import prices. Similarly, in most markets New Zealand only supplies a small proportion of the international market (dairy products being a notable exception), and so a change in supply from New Zealand will have very little impact on prices. In this model, this is represented by high export elasticities in most industries.

ORANI-G has production, household, investment, and government parts; it interacts with the rest of the world through imports and exports. Inventory levels can change. The investment sector creates fixed capital to sell to each industry from domestic and imported commodities, minimising the cost to do so. Exports are inversely related to price (with a high elasticity as noted above).

The production part of the model assumes perfect competition and maximises profits. Each industry uses intermediate inputs, which might be domestically produced or imported, and primary factors. The primary factors are land, capital, and several types of labour, brought from one representative household. Each industry can also produce more than one commodity, which are then destined for local and export markets.

The household maximises their utility by buying domestic and imported commodities. Some of this consumption is deemed to meet subsistence needs, and the rest is due to

desires for luxuries. They receive income to finance their consumption from selling primary factors – labour, capital, and land – to the production sectors.

Government demand is determined by a fixed ratio to the demand by households. The percentage change of commodities going into inventories is the same as the percentage change in production and importation of those commodities. The government gets income from taxes on intermediate goods, investment, households, exports, and government consumption.

The full technical documentation (Horridge, 2003) for the ORANI-G model can be found at Monash University's Centre of Policy Studies (CoPS) website www.monash.edu.au/policy/oranig.htm

3.2 GTAP

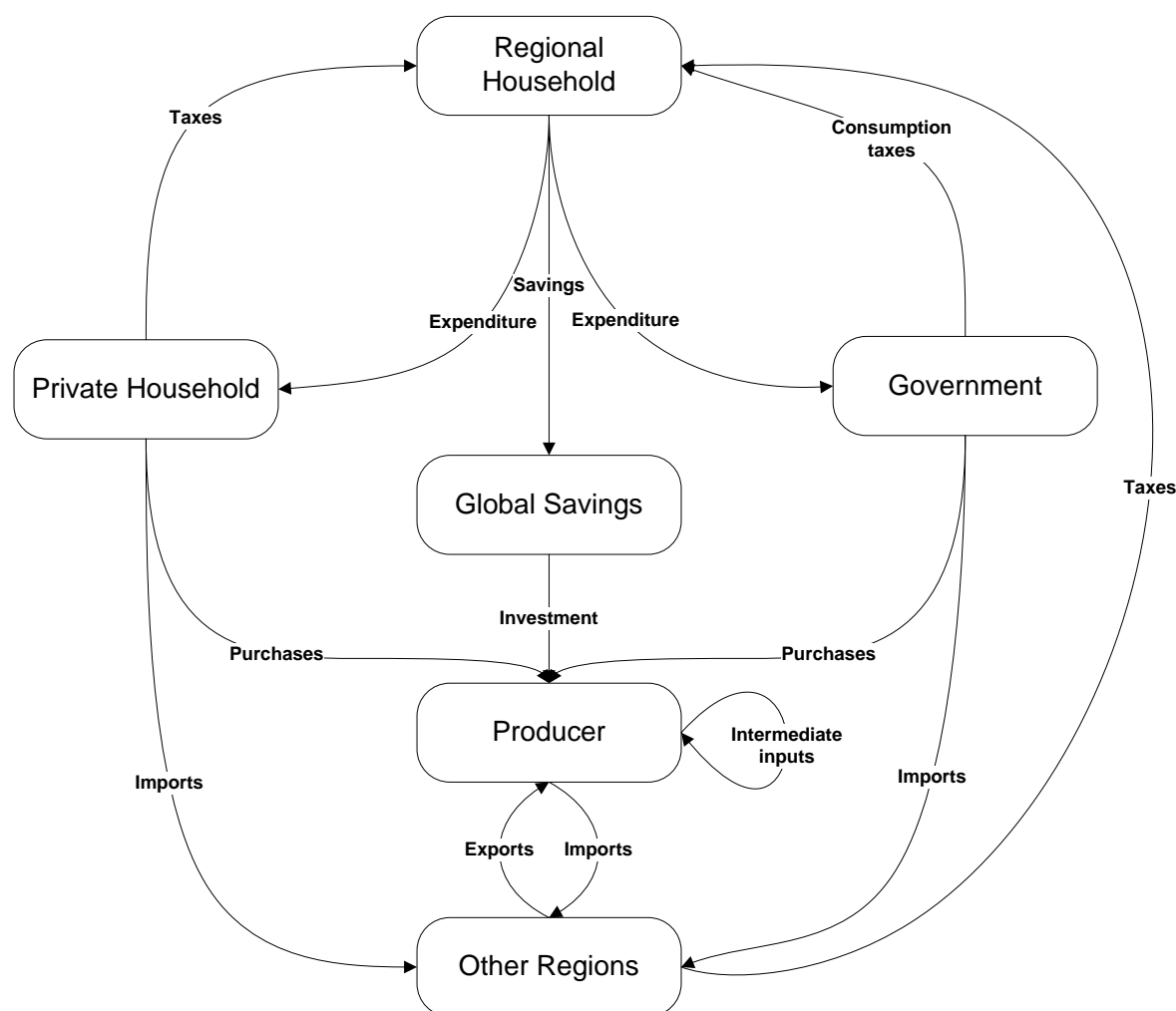
GTAP (Global Trade Analysis Project) is a large CGE model developed at Purdue University and used widely around the world. It is a multi-regional model that includes households, producers, and government for each region, interactions between the regions, and global savings.

For this report, the GTAP version 7.0 database is used. This database (the most recent available at time of writing) collates data for 57 production sectors in each of the 113 regions of the world, adjusted to make a consistent data set for 2004. This has then been aggregated to 19 sectors in 27 regions (as listed in the Appendix) so that it is more manageable. The model is closed by fixing the quantity of land, labour, capital, and natural resources; all prices and other quantities in the model can change.

The GTAP model has regional “households” (one per region) that aggregate taxes then distribute income within the region for savings and spending. These are different to private households, which receive money from the regional household for spending on taxes and purchases. Income comes from producers in the value-added they receive from capital, labour, and agricultural land. It also comes from taxes paid by private households, governments (as consumption taxes), producers, and other regions (import and export duties). Subsidies are treated as negative taxes. The income is then distributed (in approximately constant proportions) to government and private household for expenditure, and to global savings.

Private households and government both use their funds to purchase goods and services both from the producers in their own region and from other regions. Producers also sell their products to the savings sector as investment goods, to other producers as intermediate goods, and import from and export to other regions. Each production sector has exactly one output. A diagram of the GTAP model is given in Figure 2 (adapted from (Brockmeier, 2001)).

Figure 2 – The GTAP CGE model



Further information on the GTAP model and the full technical documentation can be found on the GTAP website www.gtap.org

4 The Scenarios

Four scenarios are modelled in this paper to illustrate how CGE modelling can be used to understand the economy-wide effects of industry policies. The scenarios are derived from:

- a policy intervention that results in increased export demand
- a policy intervention that raises productivity in a particular sector or group of sectors
- the introduction of an R&D tax credit
- a policy intervention that raises productivity in the key margin industry of international freight.

One of the challenges of any modelling exercise is to accurately link the policy intervention to the size of the shock that will be modelled. As this paper focuses on the use of CGE modelling rather than specific policies, this step has generally been glossed over in the scenarios.

4.1 Increased Export Demand

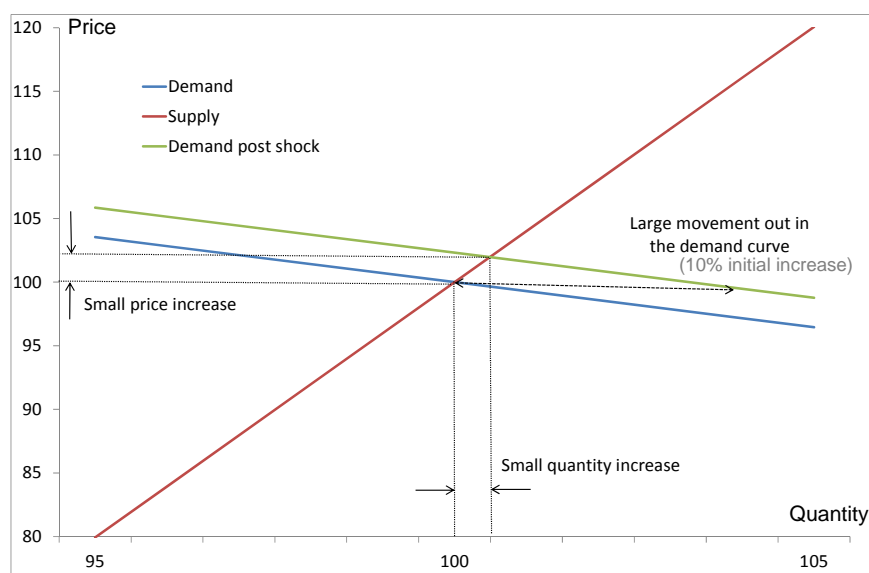
The motivation for particular industry policies is sometimes couched in terms of an objective of increasing export demand. For example, this scenario looks at the long run economy-wide impacts of a 10% increase in demand for exports across all export sectors. Policies such as supporting better branding, pursuing free trade agreements, or investing more in offshore representation could have such an impact. Alternatively, this increase in demand might arise from factors that are external to New Zealand policy settings such as an increase of the size of the international market from middle income growth in large developing markets such as China and India.

Increasing exports is generally considered to be beneficial to the economy. It increases production and GDP, and (all else remaining the same) improves the balance of trade. However, the increase in production will increase demand for inputs which may have negative effects on other sectors; and the increase in exports could cause the exchange rate to appreciate. These economy-wide effects may partially (or even completely) cancel out the beneficial effects of the increase in exports. This scenario looks at the aggregate impact of these various different effects.

Macroeconomic Results

New Zealand is a small player in most international markets, and so it is unable to have much influence over international prices. This results in nearly-flat (highly elastic) export demand curves that are very sensitive to price increases. By contrast, the export supply curve is much less elastic, and a large increase in the quantity supplied to meet that increased demand will need to come with a similarly large change in price to induce producers to meet that demand, all else remaining equal. If there is a large increase in export demand, such as the 10% increase in this scenario, a matching increase in supply would cause a large price rise. However, the price rise would scare away most of the price-sensitive international customers, who can get their products cheaper elsewhere. The net result of the large increase in demand is a very small increase in supply (and much smaller than the initial 10% increase in demand) and a similarly small increase in price. This is shown in Figure 3.

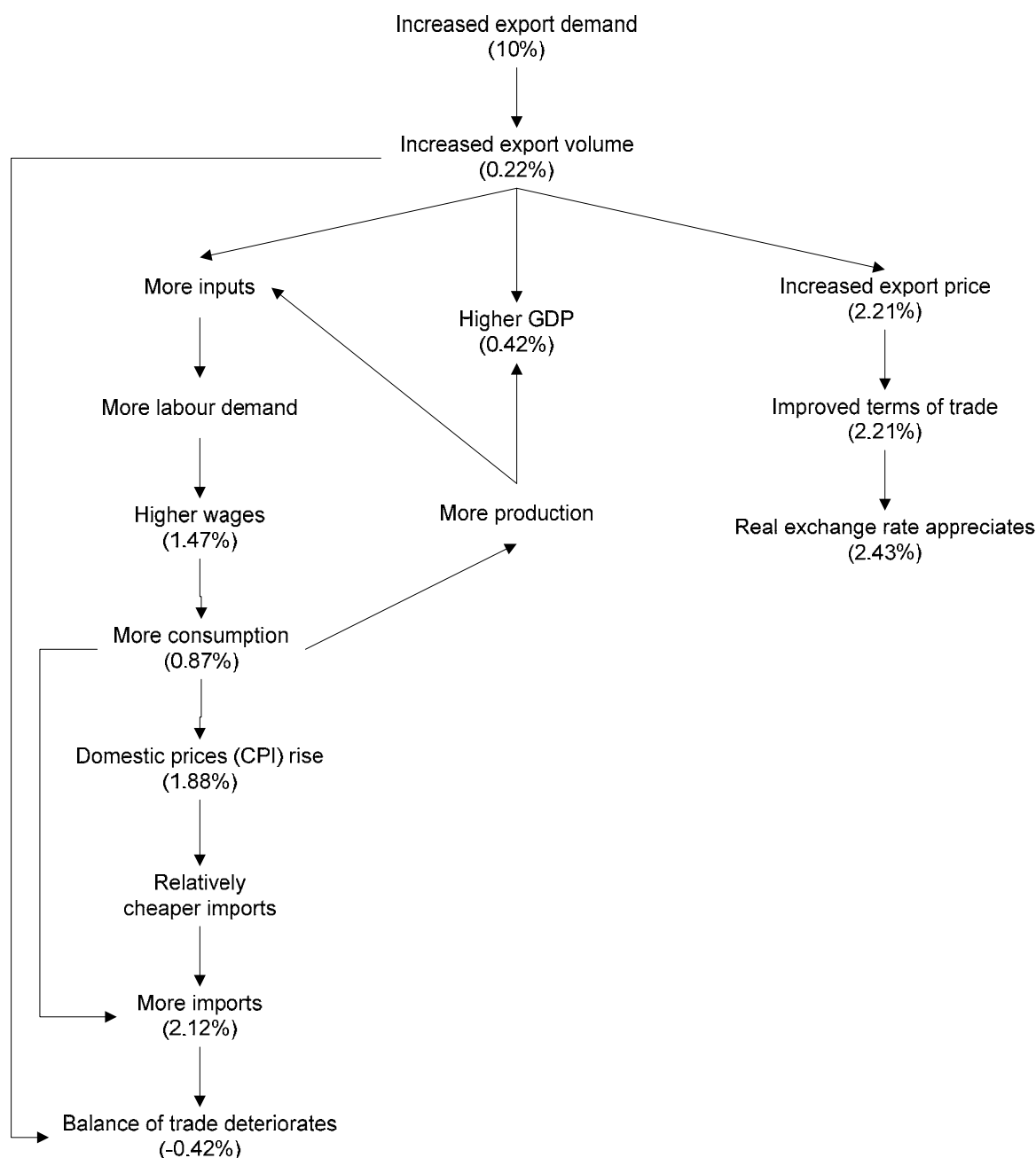
Figure 3 – Typical export supply and demand curve with high elasticity



Source: (Schilling, 2011)

Overall, the increase in exports has a positive effect on the New Zealand economy. It increases GDP and wages, as well as exports. However, because world import prices do not change, imports become cheaper relative to exports and the balance of trade deteriorates. Because imports are cheaper (in local prices) and wages are higher, consumption increases. These processes are shown in detail in Figure 4.

Figure 4 – Major causal links explaining the economy-wide effects of a 10% increase in export demand. Minor links and feedback loops not shown.



The 10% increase in demand for exports results in a 2.21% increase in export prices and a 0.22% increase in export volumes. This relatively small change is due to the high export price elasticities as described earlier – for most exports New Zealand is only a small part of the international market and so is a price-taker. If New Zealand exports become more expensive (because of the price increase required to induce a greater supply), the market can generally source them from elsewhere.

New Zealand is also a very small importer relative to world markets, and so it must be a price-taker for imports. In the model, the world prices of imports are constant. New Zealand's terms of trade are therefore only affected by the change in the export prices, and so improve by 2.21%, just as export prices did. The change in the terms of trade causes the real exchange rate to appreciate by 2.43%.

The increase in export volumes requires an increase in production of exports, which contributes to the increase of GDP by 0.42%. Included in this increase are both the direct effects of the increased production in the export sectors, and the indirect effects of more production in other sectors due to increased consumption. This is much smaller than what might have been expected from a simple back-of-the-envelope calculation, where a 10% increase in exports, which comprise about 30% of GDP, could be expected to cause roughly 3% increase in GDP. The difference between this simple calculation and the model result reflects the fact that increasing the supply of exports requires increasing their price (partly because of increased resource use), but because New Zealand is a price-taker, international demand for our exports rapidly decreases as the price increases.

As well as increasing GDP, the increase in the production of exports will require an increase in the inputs supplied by the economy to the export sectors. This includes greater demand for labour, increasing wages by 1.47% in real terms. Higher wages allow consumption to increase by 0.87%, which contributes to increased demand for imports of 2.12%. The growth in wage rates and consumption also causes a 1.88% increase in the CPI. Import prices are fixed in New Zealand dollars (because the nominal exchange rate is fixed), so they become cheaper relative to other consumption items, also increasing imports. The increase in imports is larger than the increase in exports and so the balance of trade deteriorates by 0.42%.

Sensitivity Analysis

The economy-wide effects of such an increase in exports are likely to be sensitive to the export elasticities of many of the industries modelled. Unfortunately these elasticities are among the weaker data points of the model, with no recent New Zealand-specific estimates available (Allen & Ballingall, 2011). To test the sensitivity of the effects to the export elasticities, this scenario is tested with all export elasticities reduced to half their usual values. Separately, the model is also tested with the standard elasticities and increases in export demand of 5% and 15%, to explore how sensitive the results are to the size of the increase in demand.

The effects of a 5% or 15% increase in the demand for exports are almost exactly proportional to the effect of a 10% increase. This means that a 5% increase in the demand for exports results in a 0.21% increase in GDP, and a 15% increase results in a 0.61% increase in GDP. The effects of a 15% increase are slightly less than if they were exactly proportional. Larger increases in export demand have a smaller effect than might be expected if they were proportional.

The importance of the high export price elasticities is underscored by the sensitivity analysis. If the elasticities are (arbitrarily) halved for the 10% increase scenario, export prices increase by 6.14% and export volumes increase by 0.76% compared to the baseline. The increase in export volumes is larger than the increases that flow through to the rest of the economy, and this analysis is very sensitive to the choice of export price elasticities.

Table 1 – Export demand sensitivity analysis – percent change over baseline

Metric	Result 10%	Sensitivities		
		5%	15%	10% with half elasticities
RGDP	0.42	0.21	0.61	1.11
Consumption	0.87	0.44	1.28	2.35
Export volumes	0.22	0.11	0.31	0.76
Export prices	2.21	1.12	3.28	6.14
Import volumes	2.12	1.08	3.14	6.07
Balance of trade	-0.42	-0.21	-0.62	-1.14
Wages	1.47	0.75	2.16	4.08
Terms of trade	2.21	1.12	3.28	6.14
Exchange rate	2.43	1.25	3.56	6.54
CPI	1.88	0.96	2.79	5.27

Source: (Schilling, 2011)

Sectoral Results

The increase in export demand does not affect all sectors of the economy in the same way. Many benefit from the increase in demand for their products, but for about a third of sectors the increase in wages and the appreciation of the exchange rate outweigh that gain. The large exporters such as agriculture tend to benefit because of the increase in demand, while manufacturers tend to suffer because of the real exchange rate appreciation.

The increase in demand for inputs and therefore their prices causes the nominal price of the output of almost every sector to increase. This is represented by the increase in CPI. For the sectors where demand decreases, real prices barely change and nominal prices increase due mostly to the increase in CPI. These sectors generally have the highest export elasticities, and the increase in nominal price causes the decrease in demand. For most sectors where demand increases, there is also an increase in real prices due to the increase in demand.

The biggest sectoral increases in demand (and price) are in the exporting sectors with the lower price elasticities, such as agricultural products and tourism-related sectors. Often these sectors are ones where New Zealand supplies a noticeable proportion of the world market, and so can have more impact on international prices with less reduction in demand.

Some non-exporting sectors are also beneficiaries of an increase in export demand. These sectors benefit from the increased consumption, improved terms of trade, and generally improved economy. Residential property and real estate both benefit as much as tourism sectors such as accommodation and bars and restaurants.

Exporters facing the highest export price elasticities do not benefit from the increase in export demand. Although they experience some small gains from increased demand, these are more than offset by the change in economic environment, with higher costs (due to higher demand) for inputs including labour, as well as the appreciation of the exchange rate. Both textiles and machinery equipment contract relative to the rest of the economy.

Table 2 – Selected industry results – percent change from baseline, 10% export demand increase

Industry	Result
Apple and Pear	1.71
Mining	1.69
Fishing	1.62
Dairy	1.20
Accommodation	0.97
Bars and Restaurants	0.70
Residential Property	1.14
Real Estate	0.92
Textiles	-1.45
Machinery Equipment	-2.75

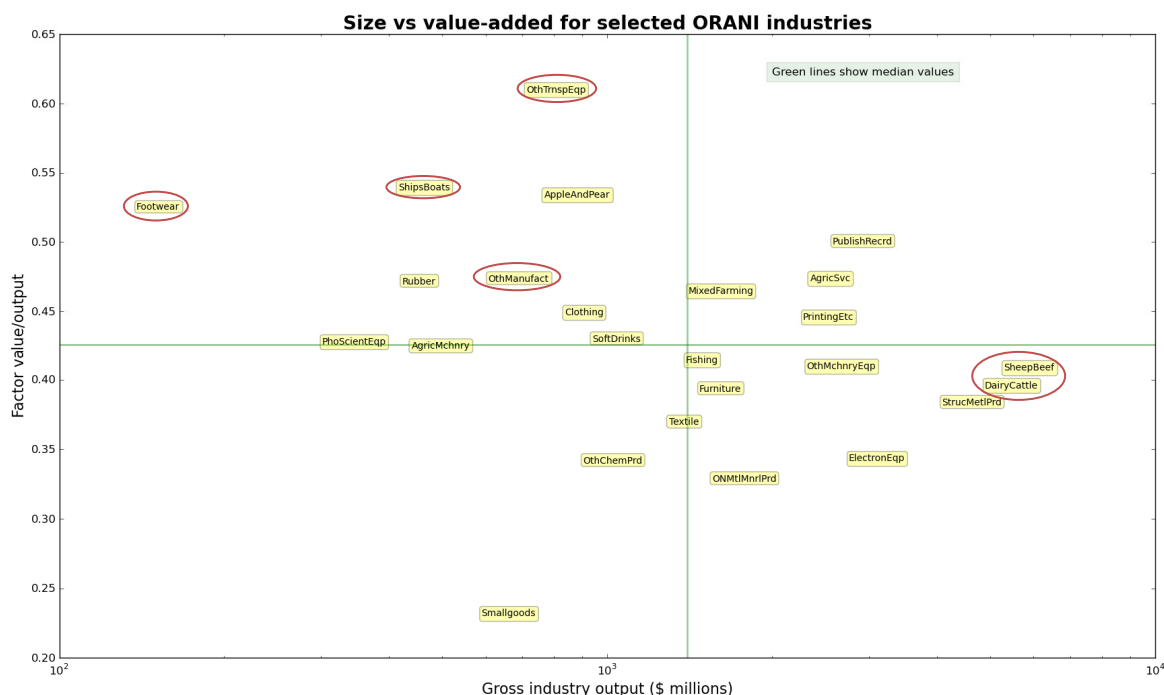
Source: (Schilling, 2011)

This analysis has brought up numerous effects that might not be expected from partial equilibrium analysis. Perhaps the two most unexpected results is the deterioration in the balance of trade, and the negative effects on some exporting sectors. The distributional effect may also be important, as it results in large export sectors getting larger and small export sectors getting smaller. This then reduces the diversity of the economy and makes it more susceptible to shocks.

4.2 Value-added Versus Sector Size

Increasing the productivity of a sector that is small but has high value-added is likely to increase GDP. Value-added is the increase in value that a sector adds to the intermediate inputs it uses by adding labour, capital, and other factors of production. Increasing the productivity of a high value-added sector could occur by targeted management training, increased or improved tertiary education, or a technology improvement like the recent information and communications technology revolution. But can this increase be enough to make up for the small size of the sector? This scenario compares a 10% increase in productivity in small but high value-added manufacturing sectors to a 10% increase in productivity in larger but lower value-added agricultural sectors. These are represented by sectors in the upper left and lower right quadrants respectively of Figure 5.

Figure 5 – Choosing the industries



Source: (Schilling, 2011)

Footwear, ship building, transport equipment, and other manufacturing are four manufacturing industries with high value-added, chosen for this scenario. Together, they contribute about 0.5% of total economy-wide gross output, but 0.6% of value-added, making them higher-than-average value-added sectors. By contrast, dairy, and beef and sheep farming are two agricultural sectors with a high contribution to GDP, but lower value-added. In total these two sectors contribute about 2.9% of economy-wide gross output, but only 2.5% of value-added. The agricultural sectors contribute 5.4 times more to gross output than the manufacturing sectors, but they only contribute 4.0 times more to value-added.

Table 3 – Sector output and value-added shares

	Share of economy output	Share of economy value-add
Specified agricultural sectors	2.9%	2.5%
Specified high value manufacturing sectors	0.5%	0.6%
Ratio of shares	5.4	4.0

Source: (Schilling, 2011)

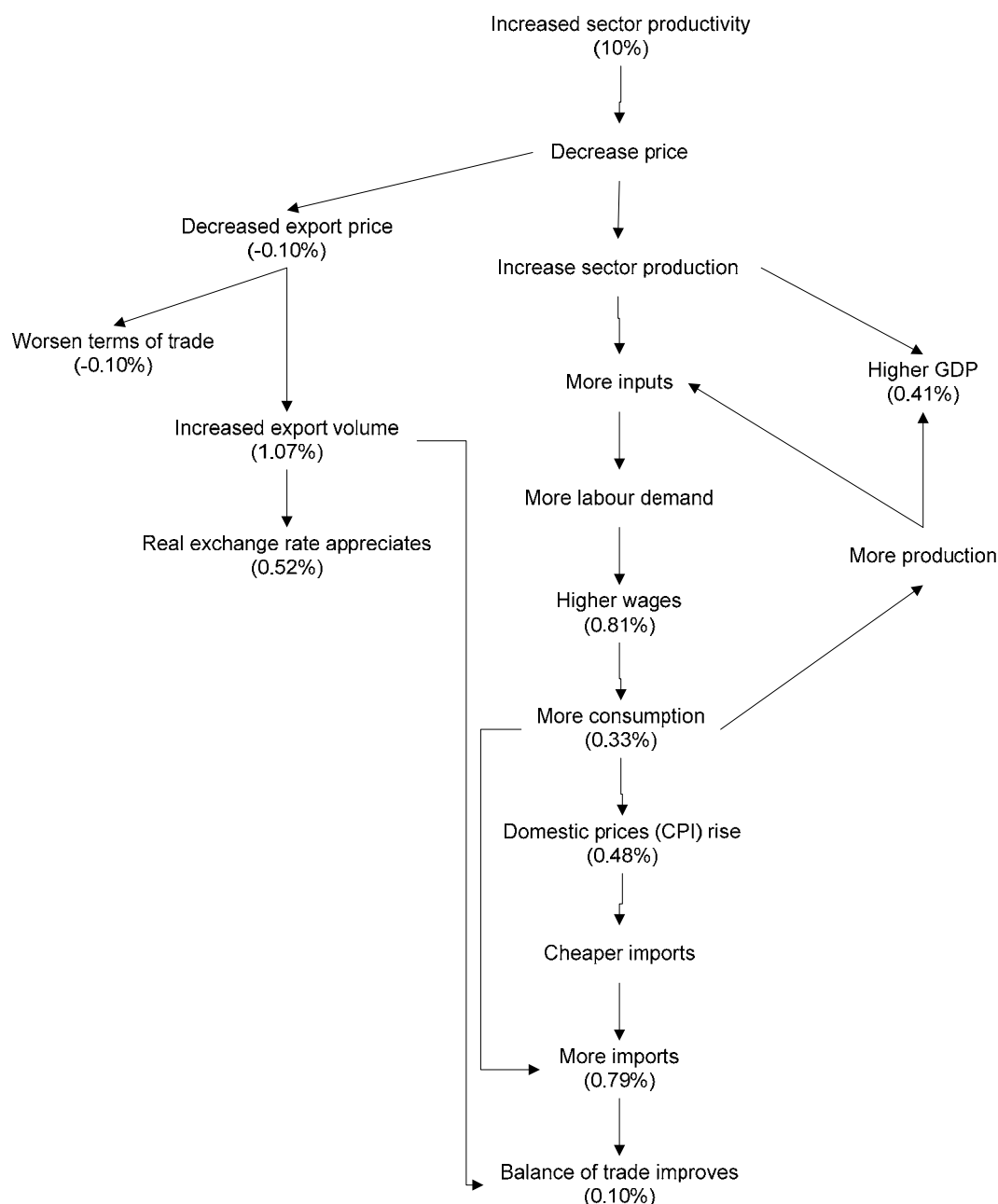
In addition to the differences in size and value-added, the agricultural sectors also differ from the manufacturing sectors in their proportions of outputs exported and intermediate inputs imported. The agricultural sectors export around 64% of their output and only import 13% of their intermediate inputs. The manufacturing sectors export a much lower proportion of their outputs, at 13%, but are more dependent on imports, which comprise 42% of their intermediate inputs.

The same change, applied to each of the two sets of sectors, is likely to have very different economy-wide effects. Changes to larger sectors tend to have larger effects on the economy. So do changes to the productivity of higher value-added sectors and high-exporting sectors. While larger sectors tend to scale up all effects, changes to high-value-added sectors and to high-exporting sectors concentrate their effects on specific and different parts of the economy.

Agriculture Results

Overall, increasing the productivity of the selected agricultural sectors by 10% has a positive effect on the economy. Exports and GDP increase, and the real exchange rate appreciates. Wages and consumption also increase, but the resulting increase in imports isn't so large that it offsets the increase in exports, so the balance of trade improves. However, the increase in productivity leads to a decrease in export prices, which in turn worsens the terms of trade. These processes are shown in detail in Figure 6.

Figure 6 – Major causal links explaining the economy-wide effects of a 10% productivity improvement in selected agricultural sectors. Minor links and feedback loops not shown.



Of the 0.41% increase in GDP, approximately 0.29% is due directly to the increased productivity of the agricultural sectors (based on a 10% improvement in the 2.9% share of the economy in the agricultural sectors), and the remaining 0.12% is due to the indirect effects of increased demand for inputs and consumption. Much of the improved productivity is turned into greater production in the agricultural sectors which is then exported.

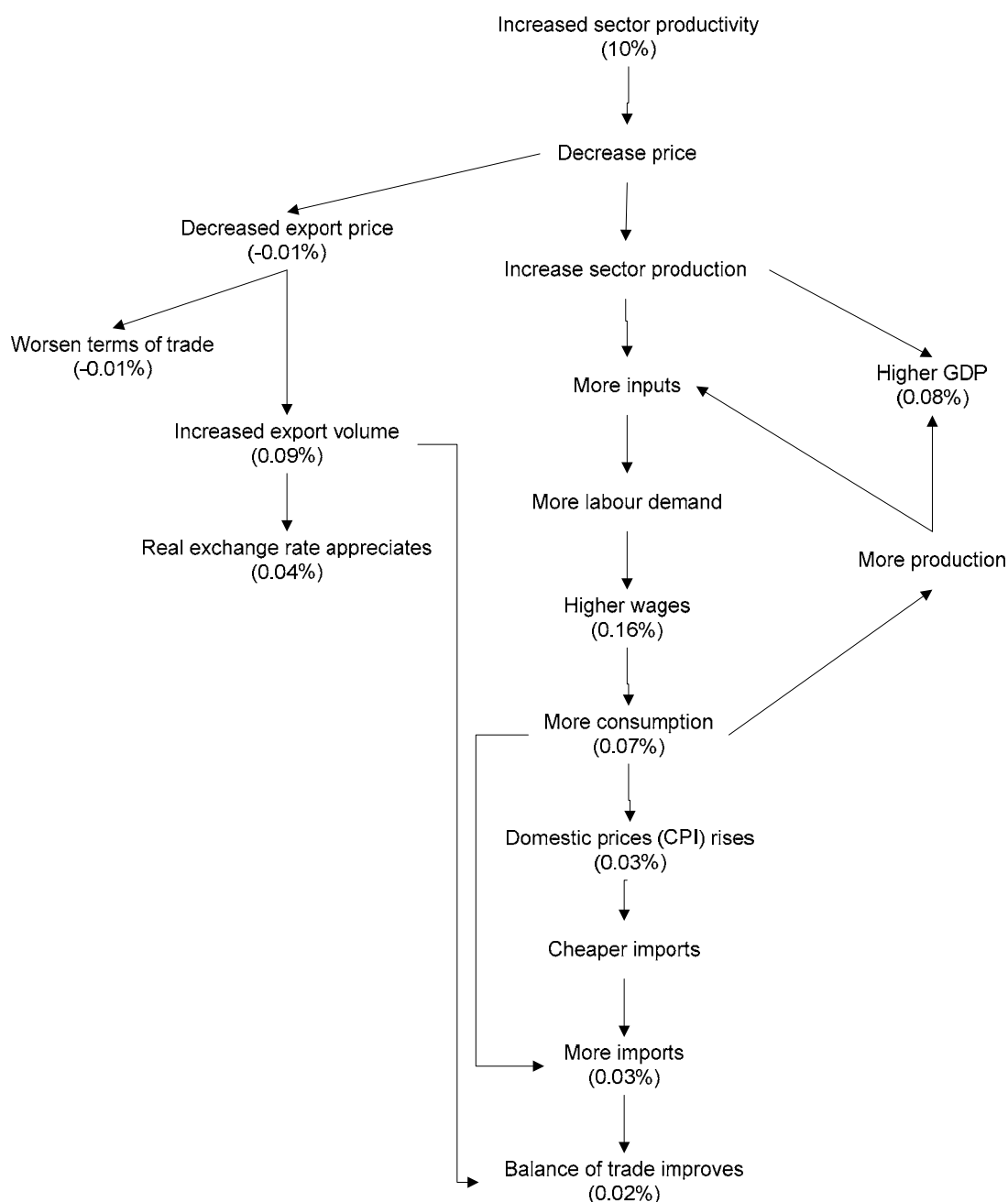
The increase in productivity in the agricultural sectors increases demand for inputs, increasing both the price and volume of the inputs. For example, fertiliser prices increase by 0.8% and volumes by 4.1%; agricultural services increase in price by 2.2% and in volume by 3.5%. It also decreases the price of downstream industries, increasing the general demand for those goods. Raw milk decreases in price by 4.4% and increases in volume by 7.7%. Few sectors decrease in volume – those that do are due to price increases from inputs and exchange rate appreciation. The worst affected are exporting manufacturers such as ships

(0.7% increase in prices, 1.8% decrease in volume) and domestic appliances (0.7% increase in prices, 1.7% decrease in volume).

Manufacturing Results

Overall, increasing the productivity of the selected manufacturing sectors by 10% has a positive but very small effect on the economy. As when the productivity improvement is applied to the agricultural sectors, wages and exports increase as well as GDP. The increase in wages leads to an increase in consumption, which increases GDP and imports. The small increase in exports leads to a small appreciation of the exchange rate. The ways the productivity improvement flow through the economy are the same as for the agricultural sectors, but with different emphases. These processes are shown in detail in Figure 7.

Figure 7 – Major causal links explaining the economy-wide effects of a 10% productivity improvement in selected manufacturing sectors. Minor links and feedback loops not shown.



Of the 0.08% increase in GDP, approximately 0.05% is due directly to the increased productivity of the manufacturing sectors, and the remaining 0.03% is due to the indirect effects of increased demand for inputs and consumption. Much of the improved productivity is turned into higher demand for labour which leads to higher wages and more consumption.

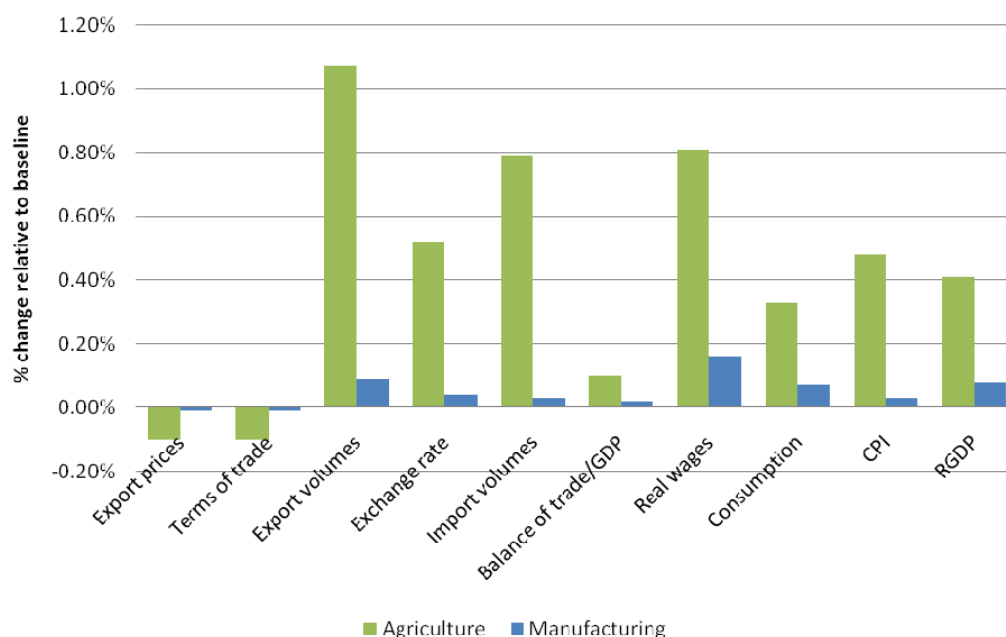
By contrast with the agricultural productivity improvement, none of the sectors with a large increase in volume had an increase in price when the increase in productivity was applied to the manufacturing sector. This is because the manufacturing sectors use much less intermediate inputs from New Zealand – a lower proportion of inputs are from other industries, and a large portion of those are imported.

Most of the sectors with a large increase in volume also had a large decrease in price. These sectors are mostly discretionary consumer goods, such as jewellery (price decrease 2.7%, volume increase 15.7%) and clocks (price decrease 3.8%, volume increase 15.2%), but they use inputs from the sectors with improved productivity. Because these inputs are now cheaper, the goods that are made from them are also cheaper. More are sold both because they are cheaper but also because households have more income. As with the agricultural sector shock, the sectors that shrink are only affected by a small amount – the worst affected are again the exporting manufacturers (except those included in the productivity improvement) such as food machinery (0.8% decrease in volume) and office equipment (0.6% decrease in volume).

Comparing Results – Unscaled

For all macroeconomic measures, the productivity improvement in the agricultural sectors has a larger effect than the productivity improvement in the manufacturing sectors, as would be expected due to their size differences. The difference due to size swamps all differences from other effects, as shown in Figure 8.

Figure 8 – Comparing changes in agriculture and manufacturing due to a 10% productivity increase



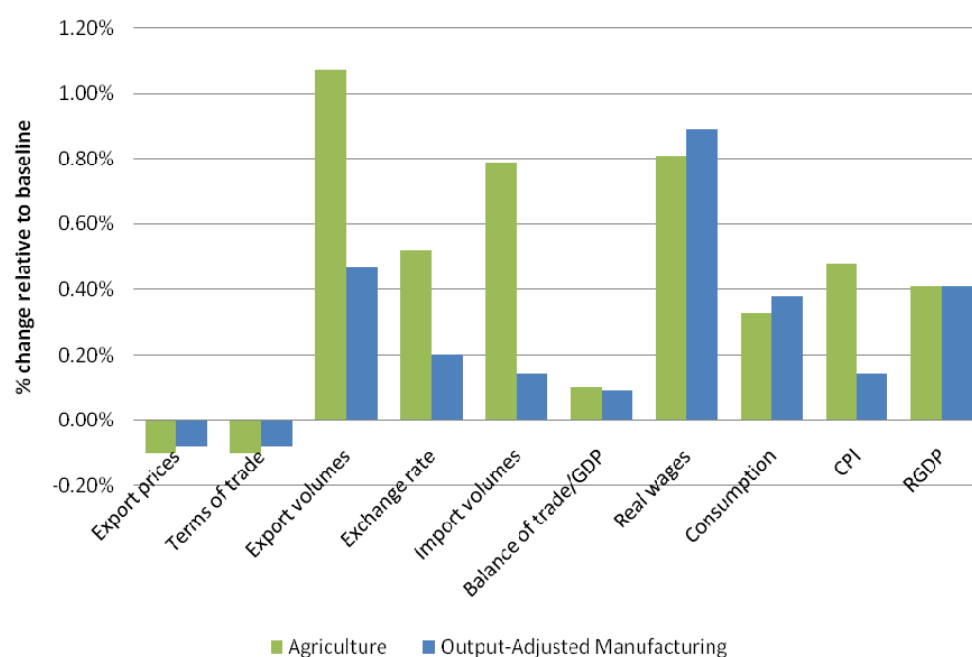
The productivity improvement does result in the same qualitative effects however, with all effects moving in the same direction, whether it is the agricultural or the manufacturing sectors which receive the productivity improvements.

The distributional effects of the productivity improvements are also quite different, depending on whether the manufacturing or the agricultural sectors get the improvement. In both cases, exporting manufacturers (except those included in the productivity improvement) decrease in volume because of the appreciation of the exchange rate. When the agricultural sectors improve their productivity, agricultural input sectors like fertiliser and output sectors like dairy factories all grow. When manufacturing sectors improve their productivity, it is the downstream sectors using their products as inputs that grow. This is tied to the amount of imports used by each sector – manufacturing uses a much higher proportion of imports than agriculture.

Comparing Results – Rescaled

As well as the significant differences in the size of the effects from a productivity change in manufacturing or agriculture, there are differences in the ways the productivity change affects the wider economy. To study this, we rescale the results in the manufacturing sectors by multiplying the results by 5.4 – the GDP size difference between the two sectors originally. All the manufacturing results in the section have been increased by this factor, so they are no longer the true results, but this makes it possible to compare the different ways the productivity change affects the wider economy.

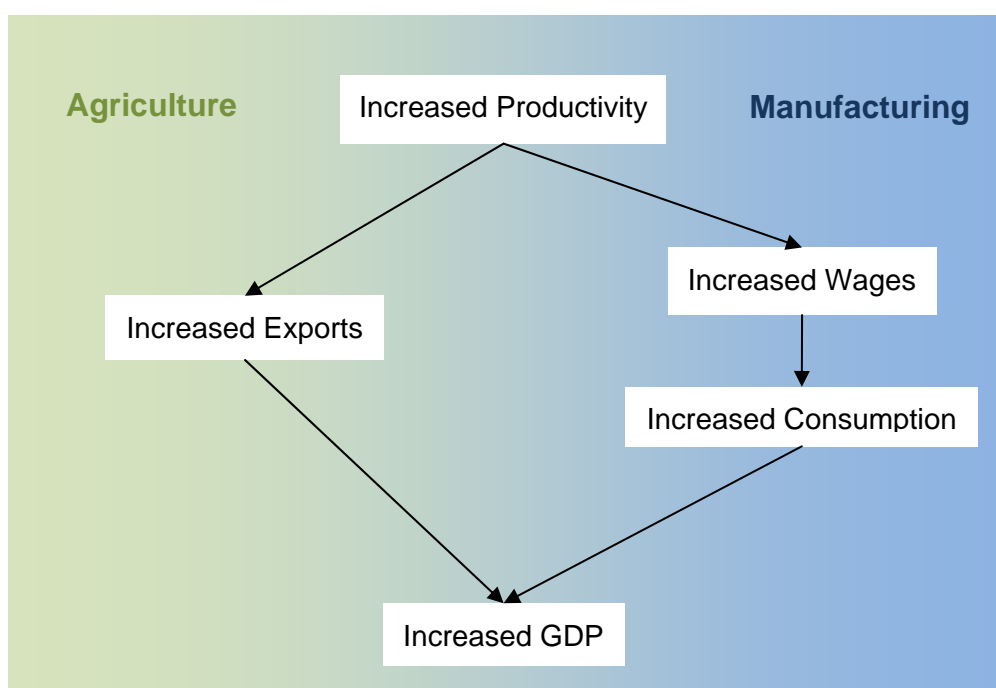
Figure 9 – Comparing changes in agriculture and (output-adjusted) manufacturing due to a 10% productivity increase



An increase in productivity in the agricultural sectors has a much larger impact on exports, imports, the exchange rate, and CPI than the equivalent change in the output-adjusted manufacturing sectors. As the agricultural sectors export a higher proportion of their outputs, the productivity improvement has a larger impact on export volumes than for the manufacturing sector. This in turn has a larger effect on the exchange rate and imports. Because a greater share of the inputs for the agricultural sectors are sourced within New Zealand (fewer imported intermediate inputs), the effect on CPI is also larger.

By contrast, an increase in productivity in the output-adjusted manufacturing sectors has a larger impact on wages and consumption than the equivalent change in the agricultural sectors. The greater increase in wages is due to the greater value-added of the manufacturing sectors, so when they increase production there is more demand for labour. The increased consumption then follows from the increase in wages.

Figure 10 – Main causal paths for GDP increase for agricultural and manufacturing sectors



Although the main causal pathways are different (as shown in Figure 10), the ultimate effect on GDP is (co-incidentally) the same for output-adjusted manufacturing as for agriculture. Thus, the main factor affecting GDP growth in this scenario is the size of the industry, but the distribution of effects is dependent on the nature of the industries – whether they are high in value-added so that improved productivity increases wages and consumption; or whether they export a high proportion of their output.

4.3 Increased Business Expenditure on R&D

Business expenditure on research and development (BERD) to develop and bring to market new technologies can give firms an important competitive edge. It can also make New Zealand more competitive internationally. There may be beneficial knowledge spill-over effects into the wider economy beyond those obtained by the firm that pays for the R&D. But because firms do not receive the full benefits of their investment, they may under-invest in R&D that would be beneficial to New Zealand as a whole.

This suggests there might be a role for government to provide assistance to encourage more BERD, and this scenario considers the effects of such assistance in the form of an R&D tax credit. However, tax credits are not free – the money must come from somewhere. In this case, it is assumed that there is a tax on households that covers the cost of the credits. This tax will affect the behaviour of households, including reducing their consumption levels (all else being equal). Balancing this is the knowledge spill-over effects of increased BERD, which are likely to act in the opposite direction. The overall value of the tax credits to the economy will be determined by whether the spill-over effects from the increase in BERD are large enough to outweigh the costs of the tax used to provide the credits.

However, R&D tax credits are difficult to model in a CGE framework because the link between the policy and the resulting impact on productivity is not clear and is not included in the model. This is the case even when the model includes R&D expenditure for each

sector as ORANI-G does. Instead, the productivity impact or the growth impact needs to be determined outside the model, which can then be used to gain some understanding of the sectoral impacts. These impacts in turn will be determined by the level of spillovers, which again are limited in the model to the extreme cases of zero spillovers or perfect spillovers. With so much uncertainty in the inputs into the model, CGE modelling is much less useful in this scenario than in the other scenarios considered in this paper.

This scenario considers a 15% increase in BERD, which is assumed to arise from a 15% tax credit. This is based on the elasticity of BERD expenditure to R&D tax credits of 1%. It is a conservative value chosen from the range 0.05-2.0% estimated econometrically in the literature, and matches the long-run value of (Bloom, Griffith, & Van Reenen, 2002). The tax credit would cost \$300 million, and generate an extra \$300 million in BERD.

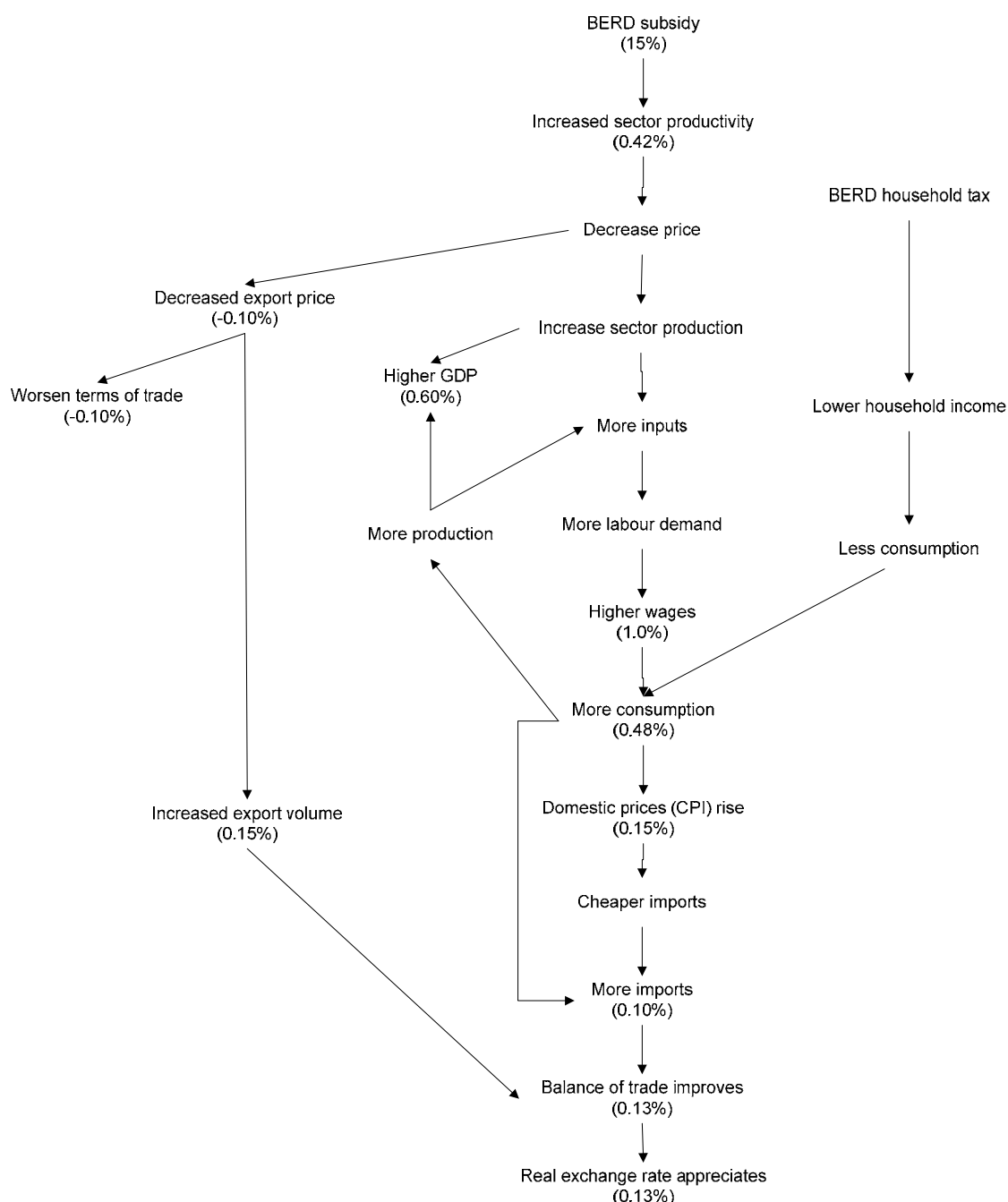
As with the effect of a tax credit on BERD, the effect on GDP of an increase in BERD has also been studied econometrically, with a wide range of results. However, the approximate mid-point of the literature suggests a 1% increase in BERD activity causes a 0.04% increase in GDP. Using these relationships, a 15% BERD tax credit (as assumed in the zero spillover case studied here) would result in a 0.6% increase in GDP. By putting this GDP increase into the CGE model, the productivity improvement that would cause that increase can be calculated.

Macroeconomic Results

A BERD subsidy is expected to cause an increase in BERD activity, resulting in improved productivity for all firms who receive the new knowledge. The nature of CGE modelling means that all firms within a sector must receive the same benefit; it depends on the model settings whether the knowledge benefits will further spill over to other sectors. These results assume there are no inter-industry spill-overs.

Overall, the improved productivity attributed to the BERD tax credit has a positive effect on the economy. GDP, wages, consumption, and export volumes all increase. The balance of trade improves, but export prices drop, worsening terms of trade at the same time. The tax on households used to pay for the BERD tax credit is not large enough to counter the positive benefits of increased productivity and higher wages. This is shown in Figure 11.

Figure 11 – Major causal links explaining the economy-wide effects of a 15% increase in BERD (zero spillovers). Minor links and feedback loops not shown.



The improved productivity due to the increase in BERD has a variety of benefits. The prices in sectors that receive the productivity improvements have lower costs. Perfect competition means their outputs therefore cost less, so sales and production of those outputs increases. This increases demand for inputs for those sectors, pushing up the price of labour (by 1.0%) and capital. Other industries face higher costs for labour and capital too, but lower costs for some intermediate outputs.

While higher labour prices mean households have more income, this is counterbalanced by the extra tax applied to pay for the BERD subsidy. This extra tax has less effect than might be expected however, as firms, which receive the resulting subsidy, are wholly owned by households in the model. As such, it does not outweigh the income gains, and households consume 0.48% more.

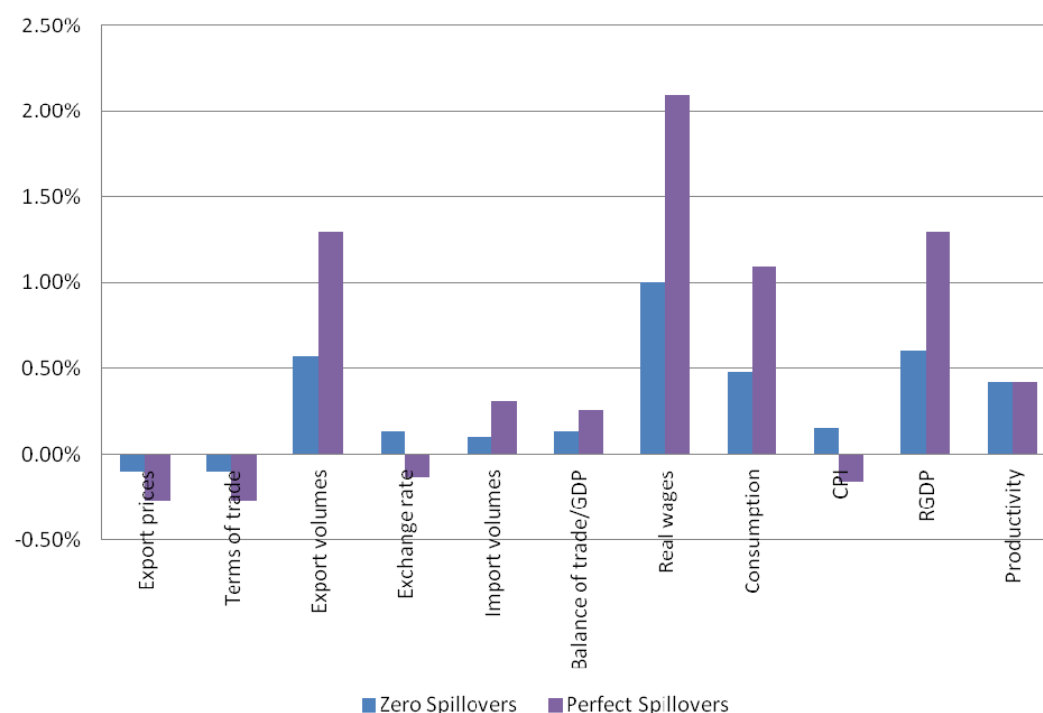
Some of the sectors with improved productivity are export sectors, and so export prices also decrease by 0.1%, cause the terms of trade to decrease by 0.1% at the same time. However, export volumes increase by 0.15%, as do imports (by 0.1%, due to greater consumption), and the balance of trade also improves by 0.13%. In the main scenario, the exchange rate appreciates by 0.13% and CPI increase by 0.15%.

Perfect Spillovers

The analysis above assumes zero knowledge spillovers between different sectors. However, it is likely there is some positive effect on productivity in other sectors. Studying perfect spillovers, while less realistic than zero spillovers, suggests an upper bound on the level of partial spillovers that probably exists in reality. Having perfect spillovers means the productivity improvement will apply to all sectors, not just those that receive the subsidy, so average productivity for the whole economy will be much higher with perfect spillovers than with zero spillovers.

If perfect spillovers are assumed instead of zero spillovers (holding the productivity improvement per sector constant), the results are larger but qualitatively the same for most of the macro-economic variables, with the exchange rate and the CPI being the exceptions. The CPI decreases when there are perfect spillovers as the effect of the improved productivity outweighs the higher prices from increased demand. The direction of change in the exchange rate is determined by whether the increase in imports or in exports dominates. This is shown in Figure 12.

Figure 12 – Macroeconomic effects of zero and perfect spillovers from a BERD credit



Sectoral Results

Both zero and perfect spillovers produces the same pattern of results between the sectors. Most sectors experience an increase in volume, most likely related to the general increase in productivity and GDP, but prices may have increased or decreased. Those sectors with the largest volume increases also had the greatest price decreases, while those with the greatest price increases had little or no increase in volume. Sectors that receive the BERD subsidy are more likely to be positively affected, but many sectors that do not receive it are also positively affected by the generally improved economy.

The sectors that received the productivity boost from the R&D tax credit increased in volume, and usually decreased in price. Prefab buildings in particular had a large increase in volume (3.3% with zero spillovers), which was also accompanied by a large decrease in price (-2.0% with zero spillovers). Both the increase in volume and decrease in price will be due to the productivity improvement (as the prefab buildings sector received the BERD subsidy), and this sector in particular likely benefited from the general increased consumption in the economy.

By contrast, the engines and aircraft sectors both decreased in volume (-2.2% and -1.7% respectively with zero spillovers) and increased in price (0.3% and 0.4% respectively with zero spillovers), irrespective of whether zero or perfect spillovers occurred. Neither of these sectors received the BERD subsidy, so only had a productivity improvement when there was perfect spillovers. These sectors have higher value-added, and the increased demand for capital and labour in the rest of the economy would result in higher input costs for these sectors. They are also exporters, and as such are negatively affected when the exchange rate appreciates in several of these scenarios.

4.4 International Freight Productivity Improvements

New Zealand is a long way from anywhere. The nearest country (of more than a million people) is Australia, more than 2,000km away and with port-to-port shipping times of approximately 3 days. As such, freight costs make a higher contribution to the costs of both imports and exports than they do for countries that are closer or better physically connected to their markets. However, this also means improvements in freight productivity, such as better ports or faster ships, may be more beneficial for New Zealand than for elsewhere. A productivity improvement in the freight sector may also have significant effects on the whole New Zealand economy as it benefits all sectors that import or export.

This scenario looks at three possibilities: more efficient export processes in New Zealand ports, more efficient import and export processes in New Zealand, and more efficient processes on all international shipping routes. The first two possibilities are most likely to occur through improvements in port processes. Ports are not specifically defined in GTAP, but sea shipping routes are, so these are used to model the increased import and export processes for all three possibilities. As shipping costs are proportional to the distance between trading partners, but port costs are not, this will not produce exactly the same results as improvements in port processes. Benefits from longer trading distances will be overestimated and shorter trading distances underestimated. In each case, a 10% productivity improvement is applied to the sea shipping routes in question.

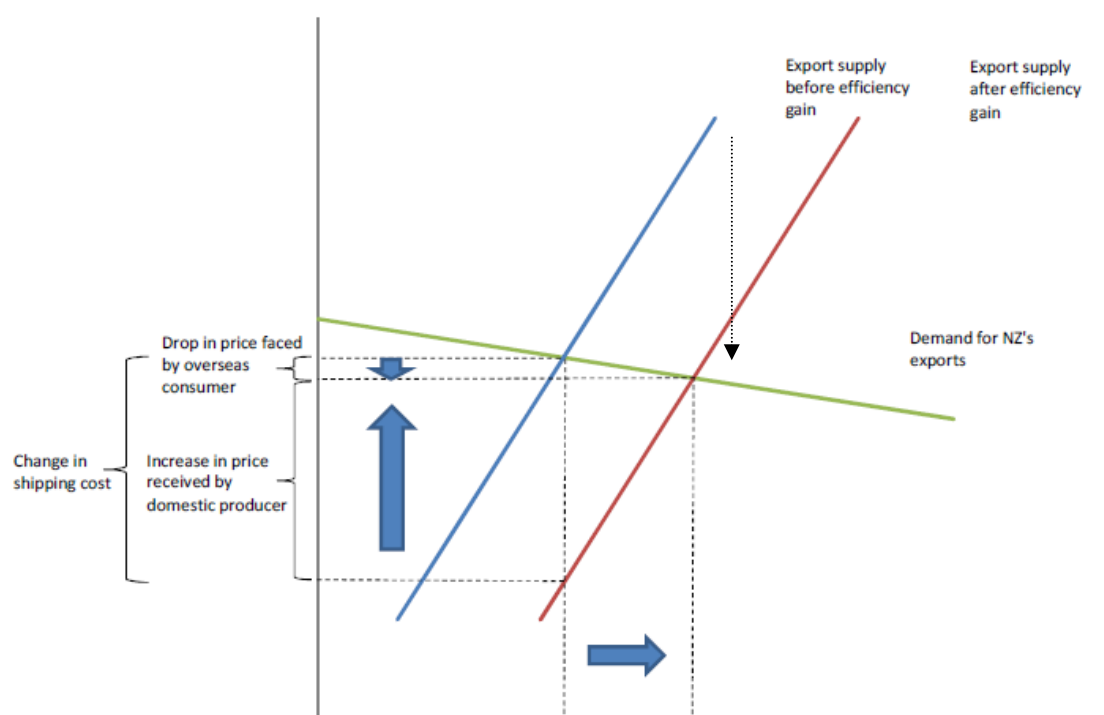
Unlike the other scenarios, this scenario is modelled using GTAP. GTAP is used as it can distinguish freight effects in more detail, partly because it is a multi-regional global model with a database that includes bilateral trade patterns.

Macroeconomic Results

All three possibilities considered in this scenario give similar qualitative results. The largest benefits for New Zealand occur when the improved efficiency is applied to both imports and exports, but not to the rest of the world. While it is always of benefit to New Zealand to improve freight productivity, when only New Zealand gains that productivity improvement it then gains a competitive advantage over the rest of the world which provides an additional benefit.

A 10% improvement in the productivity of sea freight has a limited direct effect on the prices of imported and exported goods. For most products, freight costs make up significantly less than 10% of the total cost, so decreasing the cost of freight will only have a small effect. Freight costs are the difference between the price an importer pays (c.i.f. – cost, insurance, and freight) and the price an exporter receives (f.o.b – free on board). Reducing the freight costs will both reduce the c.i.f. price paid by an importer, and increase the f.o.b. price received by the exporter. Because the export demand curve for most New Zealand products is highly elastic (as discussed above in Scenario 1: Increased export demand), most of the price change will occur on the f.o.b. side going to the New Zealand exporter, with only a small change to the c.i.f. price when New Zealand import and export processes are improved. This is shown in Figure 13. When all international shipping routes improve, the changes in the f.o.b. and c.i.f. prices are more even.

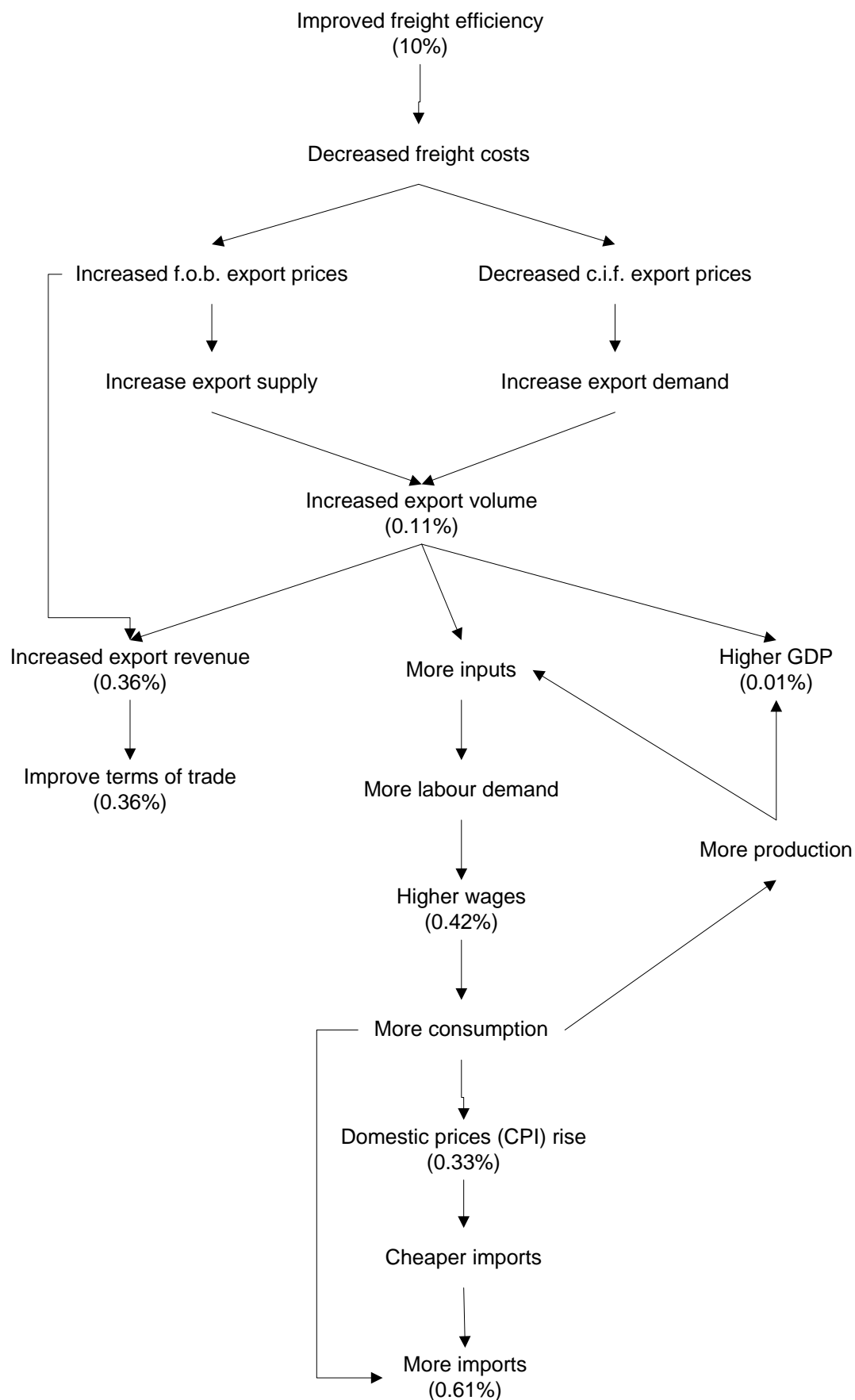
Figure 13 – Impact of efficiency gain on f.o.b. and c.i.f. prices for New Zealand import and export efficiency gains



Source: (Allen & Zuccollo, 2011)

The reduced c.i.f and increased f.o.b. prices due to reduced freight costs both contribute to an increase in exports. As well as the direct GDP impact, increased demand for inputs in these sectors leads to the price of labour increasing, households having more income, and therefore consuming more. Imports rise because consumption rises, because they are cheaper (with improved freight productivity), and because the improvement in terms of trade due to better export prices makes imports relatively cheaper as well. These effects are shown in Figure 14.

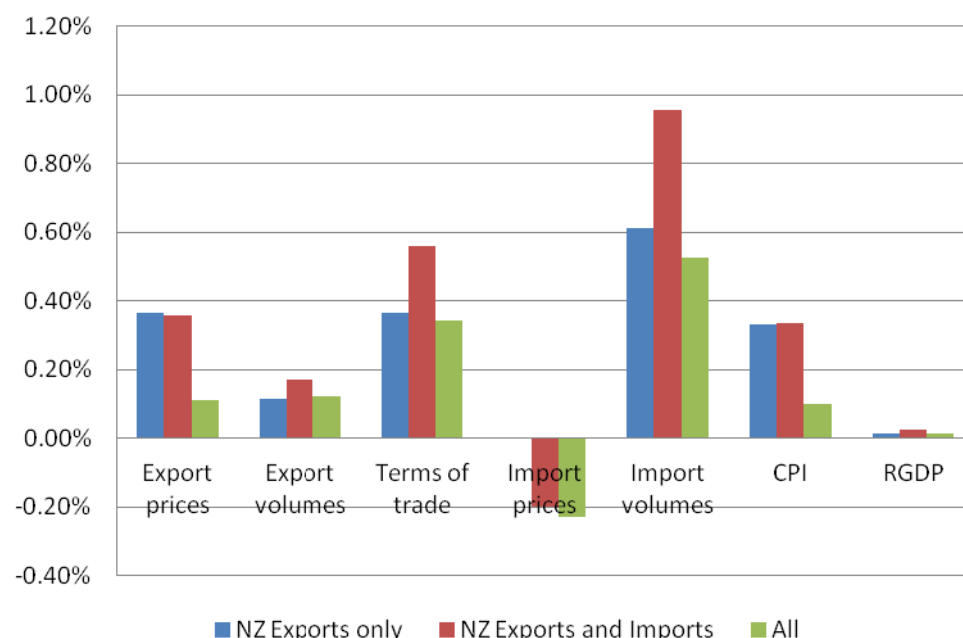
Figure 14 – Major causal links explaining the economy-wide effects of a 10% improvement in export efficiency in New Zealand ports. Minor links and feedback loops not shown.



Comparison

While the three possibilities give similar qualitative results, the quantitative results do differ. This is shown in Figure 15.

Figure 15 – Macroeconomic effects of different types of freight productivity improvements



Allowing imports as well as exports to benefit from freight productivity improvements in New Zealand decreases import prices, as well as noticeably increasing import volumes. However, sharing this freight efficiency improvement with the rest of the world reduces New Zealand's competitive advantage, still leading to an overall improvement but not as much as when the improvement is restricted to New Zealand.

In all three possibilities, the GDP effect is very small. Freight costs only make up a very small proportion of total costs for imports and exports, which in turn make up only about one third of total GDP. This limits the overall effect an improvement in freight efficiency can have on GDP.

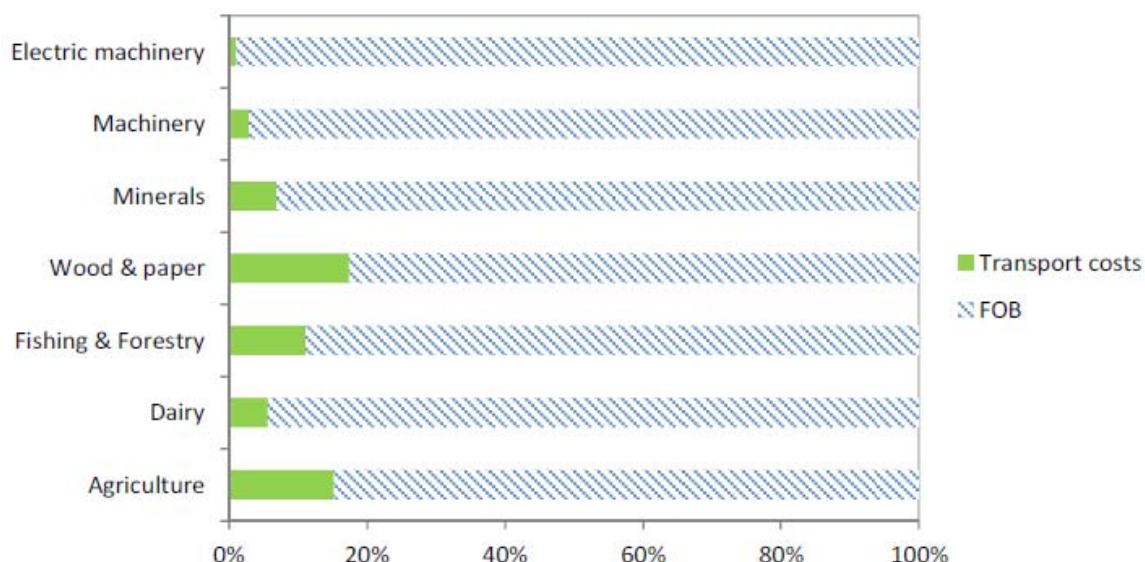
Sectoral Results

Shipping costs are different for different industries. Industries that export products that are bulky, such as wood, or require special treatment such as refrigeration, will have higher transport costs. The shipping costs for lower-value products will make up a higher proportion of the total cost of that product. Industries that export more to places that are further away from New Zealand will have higher transport costs than those that do not go so far.

These effects can be seen in Figure 16. Wood and paper are low value, bulky products, and as such transport costs make up a significant proportion of the c.i.f. price. Agricultural and fishing products often need refrigeration, and as primary products are also commonly lower in value relative to their size. Electric machinery exports are however much more expensive relative to their size and don't require refrigeration or other special treatment, so their relative transport costs are lower. Dairy products are generally higher value than agricultural products, and most dairy exports don't need refrigeration (butter and cheese

need refrigeration, but milk powders do not), so their transport costs are lower relative to their c.i.f. prices. Industries where transport costs make up a larger proportion of their c.i.f. prices can expect to see a larger benefit if those costs are reduced.

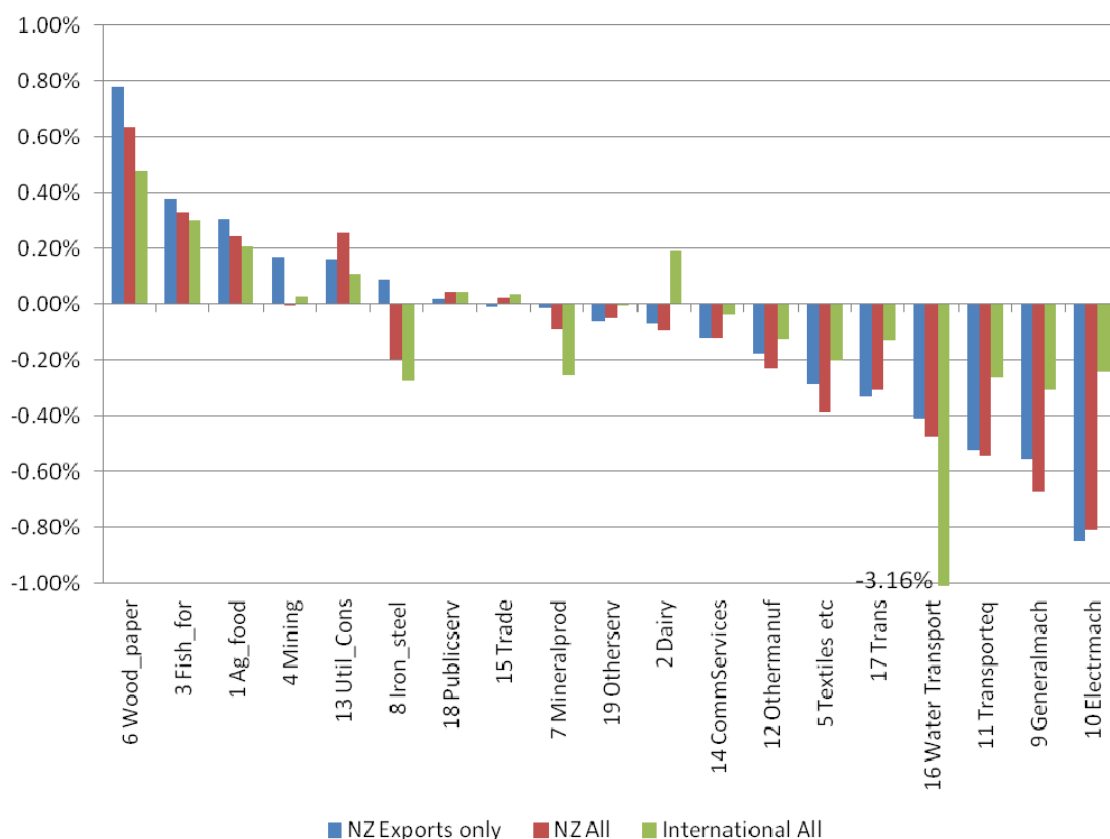
Figure 16 – c.i.f. prices for exports to Japan from New Zealand, separated into transport and f.o.b. costs



Source: (Allen & Zuccollo, 2011)

However, this direct effect is not the only effect. The flow-on effects increase the price of inputs as described earlier, counteracting the effect of the lower freight costs. The combined effect on individual sectors varies. Sectors where transport costs make up a high proportion of their costs and land, labour and capital are a small part benefit most. Wood & paper, fishing & forestry, and agriculture all fit in this category. Others, such as machinery and dairy, are worse off, with the increased costs of inputs outweighing the benefits of decreased transport costs. The changes for each industry for all three possibilities are shown in Figure 17.

Figure 17 – Percentage change in industry output when freight costs are decreased



In general, most sectors are affected similarly in each of the three possibilities. Reducing the transport costs for New Zealand exports only has the biggest effect, while reducing the transport costs for all international trade (both New Zealand and elsewhere) has the smallest effect. If imports have the reduced transportation costs (as well as exports), they will get a price advantage over locally produced alternatives, reducing demand for the local alternatives. Reducing the costs for international trade has the smallest effects because New Zealand does not gain the competitive advantage that it gains in the other possibilities studied.

A few sectors do not follow the general trend. Mining gets no benefit if both imports and exports from New Zealand have reduced transport costs, because the cheaper imports out-compete the local product. However, when all international trade has a productivity gain the increased world demand for mine products means the mining sector will expand. Iron and steel only benefits if the reduced transport costs are confined to exports only, because their lower price makes them more competitive. Unlike with mining products, increased world demand is not enough to offset the competitive disadvantage that occurs when imported iron and steel are also cheaper. By contrast, dairy only benefits if transport costs for all international trade are reduced, most likely due to increased world demand for dairy products. Water transport is severely affected if transport costs for all international trade are reduced, because less shipping is required if it has become more efficient. This effect is much larger if all shipping becomes more efficient than if just New Zealand shipping improves.

In most cases, the effect on prices is fairly uniform between sectors, f.o.b. prices increasing and c.i.f. prices decreasing. The effect on f.o.b. prices is larger than the effect on c.i.f. prices when only transport costs on New Zealand routes are reduced, due to New Zealand's status as a price-taker. When all transport costs are reduced, the effect on f.o.b. prices is similar to the effect on c.i.f. prices.

5 Conclusions

The economy-wide effects of industry policies can be as important as the direct effects of the policy that cause them, and in some cases they are unexpected. Unexpected results that are contrary to the aim of the policy are particularly important, and advance knowledge of those effects may change whether the policy is implemented. This paper has used CGE modelling to help determine the economy-wide effects of a selection of industry policies.

An important part of determining the effects of a policy, glossed over in this paper, is accurately linking the policy intervention to the size of the shock that will be modelled. Without this consideration in the work preparing for the modelling, any results of the modelling cannot usefully be linked back to the policy intended to cause them. This applies to any type of modelling including the CGE modelling studied here.

The interaction of these policies with the wider economy can be significant. For example, although there might be a large increase in demand for New Zealand's exports, competition for resources such as labour to meet that demand combined with high price elasticities in international markets mean the effect of that increase in demand is heavily muted.

Each industry policy studied also had both predictable and unexpected effects on the wider economy. Increased export demand increased export prices and caused the exchange rate to appreciate, but it also resulted in the balance of trade deteriorating. Increased productivity had a bigger effect when it occurred in bigger sectors (agriculture rather than manufacturing), but the imports used by the sector were as important as the level of value-added provided by the sector. A BERD subsidy has a generally positive effect on the whole economy, but a few sectors with high value-added but no direct R&D productivity benefits are negatively impacted by the increased cost of factors of production. Improving international freight efficiency has an overall positive effect on the New Zealand economy, with the best effect when routes to and from New Zealand (but not elsewhere) improve; however it is the lowest value-added sectors that benefit most, and many higher value-added sectors suffer.

While a variety of results have been given in this paper, they are still a selection of the most interesting aspects of the results for each scenario. The raw results contain a much richer array of information that can be analysed and interpreted to learn more about the economy-wide effects of a possible policy. However, it is important when doing this to know enough about the modelling and the underlying economics to understand the real-world situations where the results are relevant. The model's assumptions are tailored to each situation and the results do not always have general applications. For example, a simulation undertaken in boom times when there is almost full employment would be constructed differently than if there were a recession and consequent slack in the labour market. To interpret the results and get the best value from a CGE model requires opening the black box to gain some understanding of how the model works.

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Appendix – GTAP Regions and Sectors

Aggregated GTAP Regions: Japan, China, Korea, Indonesia, Malaysia, Philippines, Singapore, Thailand, Viet Nam, Cambodia, Myanmar, Lao PDR, Brunei Darussalam, Australia, New Zealand, India, Hong Kong, Chinese Taipei, Russian Federation, Chile, Canada, Peru, Mexico, United States of America, EU25, Latin America, Rest of World

Aggregated GTAP Sectors: Agriculture and food, Dairy, Fisheries and forestry, Mining, Textiles clothing and footwear, Wood and paper products, Mineral products, Iron and Steel products, General machinery, Electric machinery, Transport equipment, Other manufacturing, Utilities, Communication services, Trade Services, Water transport, Other transport, Public services, Other services