E Economy-wide modelling of economic integration

This supplementary paper documents modelling undertaken to illustrate some of the effects of various aspects of integration on the Australian and New Zealand economies. The Australia–New Zealand Economic Analysis (ANZEA) model was developed specifically for this study, and was based on the Global Trade Analysis Project (GTAP) model. It is a global general equilibrium model, which identifies separately Australia and New Zealand and 23 other economies (appendix E.1).

Section E.1 outlines the five scenarios that are modelled. Section E.2 summarises the features of the model, while section E.3 contains details and results of the scenarios examined. Due to a lack of information about the possible effects, some of the simulations are based on arbitrary 1 or 10 percent changes (that is, shocks). Results from these types of simulation can be interpreted as ‘reaction elasticities’ of the two economies to the shocks modelled.

Given uncertainty about reactions to changes in prices and incentives, particular attention has been paid to the sensitivity of results to alternative assumptions. Results are heavily dependent on model assumptions, including both the closure and parameter values chosen.[1] For most scenarios, changes in the closure have a greater impact on model results than changes in parameter values. Section E.4 presents a more detailed sensitivity analysis based on varying assumptions about the model closure and key parameters.

The ranges of effects on aggregate incomes are summarised in table E.19 to facilitate comparisons across simulations.

1 Models take certain settings as given, usually because they do not include mechanisms to explain some behaviour. This is referred to as the model closure. This is the case for the supply of capital in many global CGE models, including ANZEA. Simple assumptions are made and tested in this paper.

E.1 Scenarios

This paper contains simulation results and sensitivity analysis for five scenarios, each of which is designed to illustrate an aspect of the effects of integration or its interaction with the broader economy.

- *Eliminating Australian and New Zealand tariffs on imports from all sources* — which is designed to illustrate the effects of pursuing further tariff liberalisation.
- *Productivity improvements in Australia and New Zealand* — which is designed to illustrate the links between the Australian and New Zealand economies.
- *Economic expansion in Asia* (box 3.11, chapter 3 in the report) — which is designed to illustrate the links between Asia and the Australian and New Zealand economies.
- *Migration from New Zealand to Australia* (box 4.5, chapter 4 in the report) — which is designed to illustrate the economic effects of migration from New Zealand to Australia.
- *Liberalising trade in services via commercial presence (by reducing barriers to trans-Tasman foreign direct investment (FDI) in services)* — which is designed to illustrate the effects of removing barriers to commercial presence, considered to be an important area for trans-Tasman reform.

E.2 Modelling framework

The ANZEA model is a multi-region computable general equilibrium (CGE) model of the global economy. It has been developed for this study.

Model development

The ANZEA model is derived from the GTAP model and database. The GTAP model has been widely used to analyse the national and global effects of policy changes, with a particular focus on international trade.

The ANZEA model was developed as a simpler and more transparent version of the GTAP model. Its structure allows it to be solved more quickly than the GTAP model.

This facilitates a greater focus on:

- alternative model formulations and specifications for individual scenarios

- database calibration
- error checking
- sensitivity testing.

The ANZEA model differs from the GTAP model in two key respects.

First, the structure of the ANZEA model is relatively simple compared to that of the GTAP model. Specifically, the design of the ANZEA model starts from the minimum number of equations that is required to solve the general equilibrium problem. It therefore has fewer equations than the GTAP model and fewer indicator variables, such as those that aggregate quantity and price variables to national and industry levels.[2] Despite these simplifications, the ANZEA model contains the same behavioural assumptions as the GTAP model — in addition, it accounts for the behaviour of bilateral capital flows (discussed below).

All CGE modelling projects involve altering or extending a base model to meet the specific demands of the project. The simple structure of the core model on which ANZEA is based makes it easier to make such alterations. This is because each component of the core system of equations is clearly defined and can be easily replaced by an alternative component or linked with an extension.

Second, the ANZEA model accounts for bilateral capital flows. In the GTAP model, national savings are collected in a global bank; global savings are then reallocated across the world to finance national investments. The ANZEA model accounts for capital in three dimensions: that is, capital used by industry *j* in host country *h* is owned by households in source country *s*. The productive capacity is attributed to the sector in the host country, while post-tax capital incomes are returned to residents in the source region. Bilateral capital flows are based on a database created using 2004 data by Lakatos, Walmsley and Chappuis (2011). This database was altered to include more up-to-date information on bilateral capital ownership shares for Australia and New Zealand. This information was sourced from the OECD (2012a). The value of total foreign-owned capital in Australia and New Zealand in the original database was not altered in this process. Bilateral capital returns are presented in table E.1.

The bilateral capital structure allows the model to be used to analyse the effects of initiatives that affect the commercial presence of services and FDI more broadly.

2 The ANZEA model has approximately 150 equations, of which 35 can be considered core equations. In contrast, GTAP has approximately 300 equations.

Table E.1 **Updated bilateral capital returns in ANZEA[a]**
2004 US$b

	Destination of capital			
Source of capital	*Australia*	*New Zealand*	*Rest of the World*	*Total*
Australia	135.4	6.5	16.2	158.0
New Zealand	0.7	25.5	0.8	27.0
Rest of the World	53.4	3.8	12 314.4	12 371.6
Total	189.6	35.7	12 331.4	12 556.7

[a] OECD data on the share of FDI stock located in Australia and New Zealand that is owned by each region, and the share of Australian- and New Zealand-owned FDI stock located in each region, were applied to the bilateral capital returns in the original ANZEA database.

Source: Australian Commission estimates based on ANZEA database and OECD (2012a).

Model structure and theory

The ANZEA model is a 'bottom-up' model, which includes a range of industries, commodities and labour types. Each country's economy is modelled separately, with bilateral trade linkages to all other countries. The model includes:

- 57 industries and commodities in each economy (appendix E.1)
- 25 separate economies with Australia, New Zealand and the world's major economies identified separately (appendix E.1)
- region-specific skilled and unskilled labour markets
- region-specific sources of final demands (including consumption, investment, government and export demands)
- region-specific household sectors, which supply production factors, consume privately and publically supplied goods and services, and pay income and commodity taxes
- bilateral trade flows between all regions
- capital flows, identified by source and host country, as well as the industry destination of the capital.

Important elements of the behavioural structure of the ANZEA model (all of which are shared with the GTAP model) include:

- households change their consumption bundles in response to changes in their incomes and in relative prices, using the Constant Difference Elasticity (CDE) functional form (McDougall 2003) and subject to a budget constraint that is defined by the relevant factor income and net tax receipts

- producers adapt their output and their use of intermediate inputs and primary factors in response to changes in relative prices, using a 'constant-returns-to-scale' production technology
- productivity improvements can be modelled as a reduction in the amount of resources required per unit of output
- final demands in a region substitute between domestic and imported sources of goods and services based on relative prices

In contrast to the GTAP model, firms substitute between domestic and foreign sourced capital based on relative prices. The theory in the ANZEA model is summarised in appendix E.2.

The comparative static version of the model is used to illustrate the impacts of the scenarios. The results are presented in terms of percentage changes relative to the base, and are best interpreted as indicators of how the economy might differ if the agents faced the environment reflected in the modelled shocks and model closure, rather than the one that is reflected in the base data.

As previously mentioned, changes in the closure can have a significant impact on model results. This is because:

- different closures make different assumptions about degree to which capital responds to increases in returns through accumulation and international mobility
- the stock of capital used in production is a significant driver of model results.

The sensitivity of model results to alternative closures is presented in section E.4.

The following closure was used for the majority of the simulations to illustrate some of the underlying mechanics driving the model results. The analysis presented focuses on allocative efficiency gains resulting from the policies, and abstracts from any capital accumulation effects.

- Labour and land are fixed at the country level, but can move between industries.
- Capital can move between industries and countries; the capital owned by each country is fixed. Each country allocates the capital it owns in such a way that each additional unit of capital earns the same private return.
- Tax rates on consumption, income, production, exports and imports are all fixed.
- Household savings are fixed as a share of income, by fixing the average propensity to save. This implies that consumption as a share of income is also fixed.

In the trans-Tasman migration simulation, capital used and owned by each region was held fixed to isolate the effects of labour migration from the effects of any capital movement that may occur.

There are numerous caveats to the results presented in this paper. For example:

- the modelling does not include dynamic effects that might result from the scenarios (such as any increased competition from additional firms operating across the Tasman or any technological transfers that might be associated with additional FDI)
- the results also abstract from scale effects. Accounting for these effects would require substantial adjustments to model theory and data. In practice, scale effects are likely to be relatively small at the economy-wide level and are more likely to appear in reaction to large changes in the economic environment.

E.3 Scenarios and results

Results for the five scenarios are presented both as percentage changes from base and as changes in 2004 US$ (box E.1).

Box E.1 **Presentation of results**

Results in this paper are presented in 2004 US$, consistent with the database. It is possible to convert these results into 2010 A$ and NZ$ by using the conversion factors in the table below.

Table **Conversion factors, Australia and New Zealand[a]**

		Data used (GDP)		*Conversion factors[a]*	
Year	*Units*	*Australia*	*New Zealand*	*Australia*	*New Zealand*
		Billions	Billions		
2004	2004 US$	612	88	na	na
2010	2010 US$	1 220	138	2.0	1.6
2010	2010 A$	1 365	154	2.2	1.8
2010	2010 NZ$	1 715	194	2.8	2.2

[a] These factors can be applied to 2004 US$ amounts reported in this paper to obtain orders of magnitude in national currencies. Conversion factors are derived from GDP data from the IMF's World Economic Outlook and exchange rate data from the UN Comtrade.

Sources: GTAP database; World Economic Outlook (2012); UN Comtrade (2012).

Removing most-favoured-nation (MFN) tariffs

As a result of the Australia–New Zealand Closer Economic Relations Trade Agreement, tariffs and quantitative restrictions on trans-Tasman trade have been all but eliminated (supplementary paper A). Although the removal of the last trans-Tasman tariffs is likely to have some effects for specific industries, modelling a reduction in tariffs on trans-Tasman trade does not show any significant gains at the aggregate level, due to the relatively small shares of imports that are subject to some kind of protection and the low level of tariffs.

Only a few products from third countries are subject to a tariff greater than 5 percent in Australia and New Zealand (table E.2). For this reason modelling any multilateral reduction in tariffs to 5 percent does not show any significant gains at the aggregate level. However, there would be additional potential gains associated with reducing tariffs to 5 percent if this were accompanied by a waiver of CER rules of origin requirements for items in Australia and New Zealand with MFN tariffs of 5 percent or less (as discussed in supplementary paper A).

Table E.2 **Comparison of current Australian and New Zealand tariffs towards third countries, 2012**

HS-8 nomenclature[a]

Tariff rate grouping	*Australia*		*New Zealand*	
	No.	%	No.	%
Zero rate	2 944	47.6	4 314	57.4
4 percent	11	0.2	0	0
5 percent	2 987	48.3	2 638	35.1
10 percent	226	3.7	417	5.6
Specific tariff rate[b]	17	0.3	141	1.9
Total	**6 185**	**100.0**	**7 510**	**100.0**

[a] 8 digit classifications are not standardised across countries; therefore, the total number of items differ across countries. [b] Some specific tariff rate items for New Zealand relate to excise tariffs.

Sources: Australian Customs Service and New Zealand Customs Service.

Shocks

Tariffs still exist on many imports from other countries. Eliminating these tariffs has the potential to produce economic gains as resources are reallocated to higher valued uses within a country, and imports are sourced from the most cost-effective international supplier.

This simulation sets all MFN tariffs — and therefore the average tariffs — to zero in Australia and New Zealand to illustrate the size of these economic gains. For most industries, the tariffs used in the simulation are based on the 2004 GTAP database. However, textiles, clothing and footwear tariffs, and automotive tariffs, have been lowered in both Australia and New Zealand since 2004. Tariffs for 2010 sourced from the World Bank's World Integrated Tariff Solutions (WITS) were therefore used for these industries. As a result of different import patterns, imports from different countries are subject to different average tariffs (table E.3).

Table E.3 **Sample of average tariffs, Australia and New Zealand, 2010[a]**

Source of imports	*Australia*	*New Zealand*
	%	%
China	3.7	3.6
Japan	3.3	4.3
Republic of Korea	2.9	2.7

a Tariffs for textiles, clothing and footwear, and automotive tariffs are sourced from WITS using 2010 data. All other tariffs are sourced from the 2004 GTAP database, assuming that these tariffs have not changed as much over the period 2004 to 2010.

Sources: GTAP database; WITS.

Results

Setting tariff rates on traded goods from all countries to zero for both Australia and New Zealand leads to an increase in imports for commodities where tariffs previously existed (such as textiles and clothing) and a contraction in the corresponding domestic industries (table E.4). For example, the wearing apparel industry in Australia is no longer protected by an average 8 percent tariff. This leads to a 15 percent increase in imports of wearing apparel into Australia, and a reduction in Australian production of 6 percent.

Table E.4 **Effects of removing MFN tariffs on contracting industries**

	Australia			*New Zealand*		
	Size of tariff removed[a]	*Increase in imports*	*Change in output*	*Size of tariff removed[a]*	*Increase in imports*	*Change in output*
	%	% changes	% changes	%	% changes	% changes
Textiles	4.4	4.5	-3.1	2.3	2.7	-2.7
Wearing apparel	7.6	14.8	-6.2	7.1	20.8	-7.8
Motor vehicles and parts	3.5	3.1	-0.8	4.3	7.0	-3.0

a Weighted average of tariffs across countries.

Source: Australian Commission estimates.

The reduction in output in these formerly protected industries frees up labour and capital to be employed in industries where they can be used more productively (especially metals and minerals in Australia, and livestock in New Zealand). This leads to an expansion in the more productive industries and an increase in gross domestic product (GDP) of 0.3 percent for Australia and 0.4 percent for New Zealand (table E.5). Also, returns to Australian and New Zealand capital increase which attracts additional capital from abroad. This additional capital increases Australian and New Zealand GDP; it is remunerated through remittances to foreigners, which account for the smaller increase in GNI than in GDP in table E.5.

These results abstract from any dynamic gains that might arise from tariff reductions, including from any expansion in global capital availability. The effects of varying this assumption are explored in box E.2.

Detailed industry results are presented in table E.24 in appendix E.3.

Table E.5 **Effects of removing MFN tariffs on GDP, GNI and selected industry value-added**[a]

	Australia		*New Zealand*	
	% changes	*US$ million*[a]	*% changes*	*US$ million*[a]
GDP	0.3	1 855	0.4	378
GNI	0.1	820	0.2	145
Selected industry results				
Minerals (e.g. iron ore, uranium)	1.2	158	0.7	–
Food products	0.7	301	1.2	163
Textiles, wearing apparel and leather	-4.3	-334	-4.3	-84
Motor vehicle and parts	-0.8	-113	-3.0	-40
Metals (e.g. steel, iron, aluminium)	4.1	637	3.0	29
Other manufacturing	-0.3	-125	-0.3	-24
Services	0.2	1 008	0.3	205

[a] Results are in 2004 US$. Capital owned by each region is assumed to be fixed but able to move between regions to illustrate the allocative effects while abstracting from capital accumulation effects. – less than 0.5.

Source: Australian Commission estimates.

Box E.2 **Modelling of *Bilateral and regional trade agreements* (PC 2010)**

In its report on *Bilateral and regional trade agreements*, the Australian Productivity Commission (2010) presented results from various tariff experiments. The approach followed in that report differs in some respects from modelling undertaken in this report:

- PC (2010) presents results for global tariff removal, regional and bilateral tariff removals, and unilateral removal of tariffs for Australia as well as other trade and investment scenarios. This study analyses the effects of removing tariffs on all goods imported into Australia and New Zealand.
- The tariffs used in PC (2010) are based on 2004 data; this study uses updated tariffs to reflect intervening cuts to textiles, clothing and footwear, and automotive tariffs.
- In the central closure used in PC (2010), capital stocks owned by each region are assumed to expand such that rates of return on capital remain unchanged; the central closure used in this study focuses on allocative effects, and thus has abstracted from capital expansion effects. Both studies include sensitivity analysis to different model closures.

The key scenarios for this study are analysed using the model closure presented in PC (2010) and are presented in section E.4 on sensitivity to closure.

Source: PC (2010)

The results in this study also abstract from additional potential gains associated with eliminating the rules of origin, which are no longer required with the elimination of preferences. These gains can range between 1.5 and 8 percent of the value of imports (PC 2010). Such cost savings add to the reallocation gains that are reported in table E.5.

Productivity improvements in Australia and New Zealand

To explore the economic linkages between Australia and New Zealand, an improvement in productivity (specifically, factor augmenting technical change) of 1 percent for all factor inputs in each economy was modelled.

In the ANZEA model, productivity improvements in one country (country A) tend to affect output in its trading partner (country B) in three ways.

- They increase the relative competitiveness of country A, expanding its global market share and output, and decrease that of country B, decreasing its output.
- They increase returns to factors and incomes in country A, which increases demand for imports from country B and its aggregate output.

- An increase in returns in country A causes internationally mobile factors to shift from country B to country A. This contributes to decreasing aggregate output in country B.

The results stem from two separate simulations in which shocks were applied separately for Australia and New Zealand. In these simulations, capital can move between all countries, but other primary factors are fixed.

Results

A 1 percent productivity improvement in all factors translates into a 1 percent increase in GDP for the country in which the improvement occurs, when factors are fixed at the country level. When capital is free to move across countries, a 1 percent productivity improvement in all factors translates into a greater than 1 percent increase in GDP, as internationally-owned capital shifts to the country experiencing the productivity improvement in response to improved rates of return (table E.6).

Productivity improvements in New Zealand

Productivity improvements in New Zealand have little measurable effect on Australian aggregates. That said:

- growth in New Zealand incomes leads to increased consumption, and a 1 percent increase in New Zealand's demand for Australian exports (table E.7)
- there is some substitution in favour of New Zealand sourced production in global markets (in particular, in agriculture and food manufacturing), which contributes to an increase in New Zealand production and reduces Australian exports to these markets by 0.15 percent.

Increased incomes arising from an increase in Australian exports to New Zealand would in isolation lead to an increase in the consumption of domestically produced goods. However, the increase in the consumption of domestically produced goods is very small. This is in part due to a movement of Australian capital to New Zealand (equal to 0.04 percent of the capital stock in Australia), which reduces the productivity of labour and thus incomes in Australia.[3] Also, there is a substitution towards cheaper New Zealand imports (an increase of 0.09 percent) from the consumption of domestically produced goods.

3 This substitution effect is muted by any capital accumulation.

Table E.6 **Effects of productivity improvement in Australia on GDP and GNI in Australia and New Zealand[a]**

Percent changes relative to base

Productivity improvement in:	*Australia*	*New Zealand*
GDP		
Australia	1.31	-0.01
New Zealand	-0.09	1.37
GNI		
Australia	1.12	–
New Zealand	-0.01	1.17

[a] Capital owned by each region is assumed to be fixed but able to move between regions to illustrate the allocative effects while abstracting from capital accumulation effects. – less than 0.005.

Source: Australian Commission estimates.

Table E.7 **Effects on the Australian economy from productivity improvements in New Zealand[a]**

	Effect on Australian aggregates	
	% changes	US$ million
Domestic consumption	0.02	127
Total exports	-0.09	-92
Trans-Tasman exports	0.99	64
Other exports	-0.15	-156
Imports	0.09	105
GDP	-0.01	-71
GNI	–	-3

[a] Capital owned by each region is assumed to be fixed but able to move between regions to illustrate the allocative effects while abstracting from capital accumulation effects. – less than 0.005.

Source: Australian Commission estimates.

Thus, the increase in Australian exports to New Zealand is offset by a decrease in exports to other countries and an increase in imports and (table E.7). Effects on industry outputs are presented in table E.25 in appendix E.3.

Productivity improvements in Australia

A similar story can be told when productivity improves in Australia. An increase in Australian consumption leads to an increase in Australia's demand for New Zealand exports, most notably food and other manufacturing (table E.8).

Table E.8 **Effects on New Zealand of productivity improvements in Australia**[a]

	Effect on New Zealand aggregates	
	% changes	US$ million
Domestic consumption	0.06	61
Total exports	-0.32	-89
Trans-Tasman exports	0.38	19
Other exports	-0.50	-108
Imports	0.22	60
GDP	-0.09	-89
GNI	-0.01	-11

[a] Capital owned by each region is assumed to be fixed but able to move between regions to illustrate the allocative effects while abstracting from capital accumulation effects.

Source: Australian Commission estimates.

Australian demand accounts for 22 percent of New Zealand's total exports, and exports account for a third of New Zealand's GDP (Statistics New Zealand 2012a, 2012b). If these proportions remained the same and Australian gross domestic absorption increased by 1 percent, New Zealand's exports and GDP would increase by approximately 0.22 percent and 0.07 percent, respectively.

This simple input-output calculation does not account for the effects of behavioural responses to price changes, or capacity constraints in either economy, which will reduce this effect. Furthermore, this effect is offset by a 0.5 percent export contraction that New Zealand firms experience in other foreign markets as a result of improved Australian competitiveness. Overall, a 1 percent increase in Australia's productivity contributes to a 0.09 percent reduction in New Zealand GDP. However, the decrease in GNI (-0.01 percent) for New Zealand is smaller than the decrease in GDP. This is because GNI accounts for the payments made to New Zealand capital owners who have moved their capital from New Zealand to Australia seeking a higher return.

Asian economic growth

Shocks

The ANZEA model was used to illustrate the effects on Australia and New Zealand of a illustrative 10 percent increase in economic activity for all Asian economies. In 2011, China and India grew by approximately 9.1 and 6.9 percent respectively (World Economic Outlook Database 2012). This expansion was modelled as a uniform expansion in labour and capital (and therefore their corresponding aggregate incomes) of 10 percent in all Asian economies.

Results

A 10 percent increase in the size of Asian economies has two main effects on the Australian and New Zealand economies.

- First, as Asian incomes rise, Asian economies increase their demand for Australian and New Zealand (and other) exports. Australian and New Zealand exports to Asia increase by 3.8 and 3.6 percent respectively.
- Second, the increase in Asian primary factors leads to a reduction in production costs in Asian economies, which in turn crowds out Australian and New Zealand exports on global markets. Accordingly, Australian and New Zealand exports to non-Asian countries decrease by 2.1 and 1.5 percent. Asian growth also crowds out Australian and New Zealand exports to Asian markets (counteracting the first effect mentioned above).

The combination of these two effects translates into small increases in Australian and New Zealand exports (1.4 and 0.4 percent, respectively). Exports represent approximately 20 percent of GDP for Australia and 30 percent of GDP for New Zealand. This means that the effect on GDP is in the order of 0.2 percent for Australia and 0.1 percent for New Zealand (table E.9).

At the industry level, growth in the Asian construction sectors (especially in China) translates into increased demand for Australian mining output (table E.10). Also, growth in Asian consumer demand (especially in the Association of South East Asian Nations (ASEAN) translates into increased demand for agricultural goods, especially dairy and meat products from New Zealand. In both Australia and New Zealand, manufacturing industries contract as a result of crowding out by Asian exports. Factors from the manufacturing industries move to the service industries (and the expanding export industries mentioned above), which expand as Australian and New Zealand incomes increase. More detailed industry results are presented in table E.26 in appendix E.3.

Table E.9 **Effects of a 10 percent increase in Asian economies on trade and GDP in Australia and New Zealand[a]**

	Australia		*New Zealand*	
	% changes	*US$ million*	*% changes*	*US$ million*
Exports to Asia	3.8	2 453	3.6	377
Other exports	2.1	945	-1.5	-256
Total exports	1.4	1 565	0.4	122
GDP	0.2	1 089	0.1	121

[a] Capital owned by each region is assumed to be fixed but able to move between regions to illustrate the allocative effects while abstracting from capital accumulation effects.

Source: Australian Commission estimates.

Table E.10 **Effects of a 10 percent increase in Asian economies on industry outputs and exports in Australia and New Zealand[a]**

	Australia		*New Zealand*	
	% changes	*US$ million*	*% changes*	*US$ million*
Output				
Agriculture[b]	0.3	182	0.2	34
Mining	1.7	439	0.5	1
Manufacturing	-0.4	-367	-0.7	-116
Services	0.1	679	0.2	147
Exports				
Agriculture[a]	1.0	211	0.5	57
Mining[b]	3.1	712	3.0	5
Manufacturing	0.7	272	-0.6	-50
Services	1.4	369	1.5	109

[a] Capital owned by each region is assumed to be fixed but able to move between regions to illustrate the allocative effects while abstracting from capital accumulation effects.[b] Includes food processing. [c] Mining accounts for only 0.64 percent of New Zealand exports. Thus even a large percentage change in mining production contributes only a small change in New Zealand output. In contrast, mining accounts for more than 21 percent of Australian exports, and contributes significantly to output.

Source: Australian Commission estimates.

Trans-Tasman migration

The purpose of this simulation is to illustrate the mechanisms that are at work in trans-Tasman migration. Since the 1970s, the flow of migrants has been mainly from New Zealand to Australia.

Migration is positively related to the expected benefit from migrating. These net benefits are composed of any additional income that might arise from migrating, including additional income from higher remuneration less any costs of migration.

Abstracting from any differences in welfare benefits, and for a given level of costs, migration can be expected to occur as long as there are large enough differences in wages between Australia and New Zealand. Migration from New Zealand to Australia reduces this wage differential, as labour supply increases in the host country, and decreases in the source country.

Shocks and assumptions

To illustrate the effects of trans-Tasman labour migration, a 1 percent increase in the supply of New Zealand labour in Australia was modelled. This translates into a movement of approximately 3000 workers and is equivalent to a 0.14 percent decrease in the supply of labour in New Zealand and a 0.02 percent increase in the supply of labour in Australia.

The simulation concentrates on the economic effects of the movement of labour and abstracts from issues of citizenship and access to social safety nets (supplementary paper D). It does not attribute the modelled migration flow to any factor, but assumes that it reduces the trans-Tasman wage differential, which is allowed to adjust in response to this movement. The migrants are assumed to share the same average characteristics as Australians. They are assumed to (i) have similar qualifications and skills as Australians (and New Zealanders who remain in New Zealand), and (ii) be accompanied by a typical family (the structure of families in Australia and New Zealand are similar). The new demand for goods and services (for example, education and health) generated by the migrants is assumed to be similar to that generated by Australians. The analysis abstracts from foreign remittances as these have historically been a small fraction of income earned by New Zealanders abroad.[4] It is assumed that capital cannot move between countries. This assumption isolates the effects of labour migration from the effects of any capital movement that may occur.

Results

An increase in the supply of labour in Australia increases output and income in Australia, while the reverse occurs in New Zealand (table E.11). Given that labour income represents approximately 60 percent of GDP in Australia and 50 percent of GDP in New Zealand, the effect on GDP for both countries is in the order of half

4 Based on the number of New Zealand citizens working abroad (Statistics New Zealand 2012c) and current New Zealand remittance data (Migration and Remittances Database 2012), the average remittances paid back to New Zealand per person is just under US$ 1 500 per year.

the modelled change in labour supply. Output per worker in Australia declines as more workers are spread across the existing capital stock, while the converse occurs in New Zealand.

Table E.11 **Illustrative effects of trans-Tasman migration[a,b]**
Percent changes relative to base

	Australia	*New Zealand*
Change in employment	0.02	-0.14
GNI	0.01	-0.08
GNI per worker	-0.01	0.06

a 1 percent increase in New Zealand labour in Australia. **b** Sensitivity analysis did not produce ranges that are significantly different from the results reported. Capital owned by each region is assumed to be fixed but able to move between regions to illustrate the allocative effects while abstracting from capital accumulation effects.

Source: Australian Commission estimates.

Workers who migrate are better off as a result of the move. Applying model results to wage data for 2008 (OECD 2012b) suggests that, on average, workers who leave New Zealand increase their wage by approximately 26 percent.[5] With greater numbers of migrants (a greater shock), the average wage increase becomes smaller, and the wage gap between the two countries is reduced further.

The assumed migration behaviour is highly stylised and does not, for example account for lifestyle preferences and other determinants of migration. Also, migrant labour is assumed to substitute for incumbent labour. To the extent that New Zealand workers complement incumbent workers in Australia, the projected reduction in the wages of Australian labour could be limited and Australian GNI could be increased.

Reducing barriers to commercial presence in services

The purpose of these simulations is to illustrate the effects of barriers to trade in services in the form of barriers to commercial presence. These barriers can be barriers to establishment or barriers to ongoing operations. There are other barriers to trade in services (in particular, barriers that increase the cost of cross-border trade) but they are not considered here.

The barriers are assumed to apply only to FDI capital. FDI capital is assumed to be imperfectly substitutable and to earn different returns by industry and country.

5 Given the small shock modelled, this is equivalent to the initial gap between Australian and New Zealand wages, as reported by OECD (2012b).

A basis for the shocks

The shocks for these scenarios are derived from a Centre for International Economics (CIE 2010) report on *Quantifying the benefits of services trade liberalisation* (box E.3). The CIE (2010) examined the economic impact of reducing global barriers to services trade, by reducing barriers to cross-border trade in direct service provision (mode 1) and foreign commercial presence in service industries (mode 3).

Adjustments for this project

The shocks used for this project are a subset of the CIE's shocks: a reduction in barriers to commercial presence (mode 3) in Australia and New Zealand on trans-Tasman investment and on a non-discriminatory basis. These barriers are represented by two wedges added to the standard GTAP database that are assumed to account for a difference between market price and efficient cost of provision.

- *Cost-escalating barriers.* Cost-escalating barriers — such as a reporting requirement imposed on foreign firms — increase the ongoing costs of operation for (part- or wholly-owned) foreign firms. This blocks potentially lower-cost foreign entrants (who may have lower marginal costs than domestic producers, but for the cost-escalating barrier), protecting higher-cost domestic suppliers. The removal of these costs was modelled as capital augmenting technical change on foreign-owned capital, which is equivalent to an *increase* in the productivity of capital.
- *Rent-creating barriers faced by foreign firms*. Rent-creating barriers — such as screening requirements — are assumed to restrict competition, by restricting entry by new foreign firms into services industries. This allows incumbent firms to price above marginal cost.[6] The removal of these barriers was modelled as a *reduction* in a rent in excess of normal returns to foreign-owned capital.

6 Firm-specific factors earn a quasi-rent as a result of monopolistic competition. This 'rent' accrues as a return to other factors not explicitly recorded in national accounts, such as know-how or branding. This is accounted for in Gross Operating Surplus (GOS) as a return to capital.

Box E.3 **CIE calculation of barriers**

The CIE used FDI Regulatory Restrictiveness Index (FRRI) data produced by the OECD (2006) to calculate its shocks. The FRRI attempts to quantify the level of restrictions placed on FDI investment by sector for different countries. Four types of measures are covered by the FRRI (these components are listed in the table below). The highest score for a measure is 1 (the measure fully restricts foreign investment in the sector) and the lowest is 0 (there are no regulatory impediments to FDI in the sector). The total FRRI score for each sector is obtained by adding the scores for all four types of measures.

Table **Coefficients on FDI restrictions used in OECD (2006)**

	Scores
Foreign equity limits	
No foreign equity allowed	1
1–19 % foreign equity allowed	0.6
20–34% foreign equity allowed	0.4
35–49 % foreign equity allowed	0.3
50–74% foreign equity allowed	0.2
75–99% foreign equity allowed	0.1
Screening and Approval	
Investor must show economic benefits	0.2
Approval unless contrary to national interest	0.1
Notification	0.05
Other Restrictions	
Board of directors/Managers	
majority must be nationals or residents	0.1
at least 1 must be national or resident	0.05
must be locally licensed	0.025
Movement of people	
no entry	0.1
less than one year	0.075
one to two years	0.05
three to four years	0.025
Input and Operational Restrictions	
domestic content must be more than 50%	0.1
other	0.05
Total[a]	**Between 0 and 1**

[a] If foreign equity is banned, then the other criteria become irrelevant, so that the Index is at 1.0. The Index is also capped at 1.0.

(Continued next page)

Box E.3 (continued)

The CIE calculated its barriers by:

- estimating a statistical relationship between the FDI to GDP ratio and each component of the FRRI, based on data for 2006
- using this estimate to project how each country's FDI stock changes if the component barriers were removed
- converting the projected changes in FDI stocks to a price equivalent using price elasticities of capital derived from historical data.

Screening barriers were modelled as rent-creating barriers, while equity and operational restrictions were modelled as cost-escalating barriers.

This modelling has not been updated to account for recent revisions to the FRRI index.

Sources: OECD (2006); CIE (2010).

Some adjustments were made to the CIE shocks to better reflect the barriers faced by trans-Tasman investors.[7] First, shocks applying to the financial services sector were removed to reflect the fact that the New Zealand financial sector is substantially owned by Australian firms, and all Australian banks currently have a presence in New Zealand (Bollard 2011). Thus, removing barriers affecting Australian capital in the New Zealand financial services sector is unlikely to lead to any increase in the amount of Australian capital in the New Zealand financial services sector.

Second, judgemental adjustments were made to account for the fact that the rent-creating barriers that exist in Australia and New Zealand are likely to be less costly for trans-Tasman investors than for other foreign investors (owing to the close proximity and similar cultural heritage of Australia and New Zealand). This is supported by the high level of trans-Tasman FDI in both countries. The Commission has assumed that the costs of the barriers in Australia and New Zealand to the other trans-Tasman country are 10 percent of the costs that other foreign firms face.

7 The Commission has not reduced the rent-creating barrier shocks for Australia to reflect changes in the Australian FRRI that have occurred since 2006. This is because the criteria used to calculate the index were updated in 2010, and the CIE shocks were derived using the previous version of the FRRI, which is not directly comparable with the 2010 version. If it were the case that Australia's FRRI would have also decreased under the old criteria, then the shocks used for this simulation would overestimate the size of the Australian barriers.

Three different scenarios that reduced the barriers to commercial presence were modelled to illustrate the effects of reducing barriers on services.

- A reduction in trans-Tasman barriers to FDI in all services industries (except the banking sector).
- A reduction in trans-Tasman barriers to FDI in communications industries.
- A reduction in the barriers to FDI in communications industries irrespective of where the FDI originates.

A reduction in the barriers to commercial presence in the communications industry was modelled separately as an example of the magnitude of gains in a sector that provides services to households as well as intermediate input services to businesses. The barriers that were removed are summarised in table E.12.

Table E.12 **Estimated barriers to commercial presence**

	Rents on foreign capital		*Cost-increasing effects*	
	Australia	*New Zealand*	*Australia*	*New Zealand*
	% of the return to foreign capital	% of the return to foreign capital	% of the return to foreign capital	% of the return to foreign capital
Trans-Tasman barriers				
Barriers to services[a]	0.9	0.9	2.4	0.9
Barriers to communications	0.5	0.5	4.5	3.1
Barriers with all partners				
Barriers to communications[b]	0.9	1.3	1.1	1.2

[a] Weighted average of barriers for all services industries. [b] The weighted average of barriers for all foreign countries in the communications sector is smaller than the equivalent trans-Tasman barriers because relatively low barriers are assumed to apply to capital owned by USA and Europe in both Australia and New Zealand.

Source: Australian Commission estimates based on CIE (2010).

Preferential barriers to services

Removing the barriers to Australian commercial presence in New Zealand services, reduces the rental rate of capital of Australian capital located in New Zealand. The reduction in the cost of this source of capital leads to an increase in its level. While, some of this Australian-owned capital crowds out existing capital owned by New Zealand and the Rest of the World, the majority adds to the stock of capital employed in New Zealand, leading to an increase in New Zealand GDP. The bulk of the Australian-owned capital which flows into New Zealand originates from Australia, but some originates from the Rest of the World. While some capital owned by the Rest of the World and New Zealand flows into Australia, there is still a small reduction in the amount of capital employed in Australia and a reduction in Australian GDP. This reflects, in part, the assumption of fixed global capital.[8]

The same mechanism applies when barriers to New Zealand commercial presence in Australia are reduced. However, the effects are smaller because Australia's share of New Zealand's capital stock is much larger than New Zealand's share of Australia's capital stock.

The net allocative effect of removing trans-Tasman barriers to commercial presence is a relatively large increase in capital in New Zealand and a negligible decrease in capital in Australia. This results in an increase in New Zealand GDP of 0.13 percent and a decrease in Australian GDP of 0.01 percent (table E.13).

Table E.13 **Effects on GDP and GNI of eliminating barriers to commercial presence[a]**

	Australia	*New Zealand*
	% changes	% changes
GDP		
Preferential		
Remove trans-Tasman barriers to FDI — all services	-0.01	0.13
Remove trans-Tasman barriers to FDI — communications	–	0.01
Non-preferential		
Remove barriers to FDI all countries — communications	0.11	0.22
GNI		
Preferential		
Remove trans-Tasman barriers to FDI — all services	–	0.07
Remove trans-Tasman barriers to FDI — communications	–	0.01
Non-preferential		
Remove barriers to FDI all countries — communications	0.06	0.10

[a] Capital owned by each region is assumed to be fixed but able to move between regions to illustrate the allocative effects while abstracting from capital accumulation effects. **–** less than 0.005.

Source: Australian Commission estimates.

When the increase in returns to Australian capital in New Zealand are considered, Australian GNI (which includes income from Australian-owned capital) does not change. For New Zealand, the change in New Zealand GNI is smaller than it is for GDP because of the increased capital stock owned by Australia and related

8 There are broad similarities between removing trans-Tasman barriers to commercial presence and the trans-Tasman mutual recognition of imputation credits. The Commission has not modelled the latter using the ANZEA model, because the model's treatment of tax policy is not sufficiently detailed.

returns paid to Australian capital owners. New Zealand GNI also grows because labour incomes in New Zealand increase with a greater capital stock.

There is significant uncertainty surrounding the size of barriers to commercial presence in Australia and New Zealand. For this reason, results were also obtained for simulations where rent-creating and cost-escalating barriers for both Australia and New Zealand were varied by plus/minus 50 percent (table E.14). Increasing (decreasing) the trans-Tasman barriers to commercial presence leads to an increase (decrease) in New Zealand GNI of 0.04 percent. Australian GNI does not change noticeably.

Table E.14 **Sensitivity analysis: changes in barriers**[a]

	Australia			*New Zealand*		
	Low **[b]**	*Mid*	*High* **[c]**	*Low* **[b]**	*Mid*	*High* **[c]**
	%	%	%	%	%	%
GDP	-0.01	-0.01	**–**	0.07	0.13	0.20
GNI	**–**	**–**	**–**	0.03	0.07	0.11

a Capital owned by each region is assumed to be fixed but able to move between regions to illustrate the allocative effects while abstracting from capital accumulation effects. **b** 'Low' represents the results when the barriers to commercial presence are reduced by 50 percent. **c** 'High' represents the results when the barriers to commercial presence are reduced by 50 percent. **–** less than 0.005.

Source: Australian Commission estimates based on CIE (2010).

Preferential barriers to Communications

The New Zealand economy gains more strongly than Australia's as a result of removing of trans-Tasman barriers to FDI in communications (table E.13). The share of communications capital in Australia and New Zealand are relatively similar, but Australia contributes a much larger share of New Zealand's foreign-owned capital. Reducing the cost for incumbent foreign capital by removing cost-escalating barriers (and attracting more capital by removing rent-creating barriers) creates proportionately larger gains for New Zealand.

Non-preferential barriers to Communications

Trans-Tasman telecommunications FDI is a small share of the total capital stock for both Australia and New Zealand (less than 1 percent in both countries). However, the total stock of foreign-owned telecommunications capital is 3.2 percent for New Zealand and 1.2 percent for Australia. Given the much larger base of foreign-owned capital in telecommunications, reductions in relevant barriers from all sources have the potential to provide larger economy-wide gains (table E.13).

E.4 Sensitivity analysis

Sensitivity to closure settings

Model results are sensitive to closure settings. This section examines the effects of alternative treatments of capital on model results. Other closure assumptions — such as assuming that government expenditure changes as a fixed proportion of government income — are not reported as they were found to have a less significant impact on model results.

Four closure settings were examined, each allowing capital to adjust with a further degree of flexibility than the previous closure:

- C1 — capital used or owned by each region can move between industries within an economy to seek the highest return, but cannot move across borders. This capital closure was used for the 'labour migration' results presented in section E.3. (This approach does not attempt to include capital accumulation gains). This closure is used in most GTAP applications.
- C2 — the amount of capital owned by each region is fixed (thus total world capital is also fixed), but capital owned by each region can move between regions and industries to seek the highest return available. This capital closure was used for all simulation results presented in section E.3 aside from the labour migration simulation. (This approach does not attempt to proxy capital accumulation gains but rather only focuses on allocative effects).
- C3 — The amount of capital owned by each region can increase (or decrease), such that the ratio of investment to capital stock located in each region remains the same. Capital owned by each region can move between regions and industries to seek the highest return available. (This approach proxies capital accumulation gains).[9]
- C4 — the amount of capital owned by each region can increase (or decrease), such that the rate of return for capital owned by each region remains the same as in the base. Under this closure, the world capital stock can change and capital owned by each region can move between regions and industries to seek the highest return available. (This approach proxies capital accumulation gains).

[9] This closure is similar to the fixed savings rate closure employed by Francois, McDonald and Nordstrom (1995). However, C3 also allows for capital mobility and includes bilateral capital ownership, which are both excluded by Francois, McDonald and Nordstrom (1995); see Verikios and Hanslow (2009) for a clear exposition of Francois, McDonald and Nordstrom (1995).

Alternative capital closures have different effects on GDP and GNI. This is because GDP includes incomes earned by the capital used in a country, even if that capital is foreign-owned. In contrast, GNI only includes capital income that accrues to a country. Therefore, an increase in the stock of capital that occurs in response to a change in the rates of return produces an increase in GDP in the country where the productive capital stock has increased. All other things equal, the increase in the country's GNI is smaller if the new capital is sourced from abroad.

The effects of alternative capital closures on the results of the 'removing MFN tariffs', 'trans-Tasman migration' and 'reducing barriers to commercial presence' simulations are assessed in the remainder of this section.

'Removing MFN tariffs' simulation

When the stock of capital owned by a region is permitted to grow (C3 and C4), removing tariffs in Australia and New Zealand results in larger increases in GNI and GDP than when the level of capital owned by regions is assumed to be fixed (table E.15).

The mechanism behind this result is relatively intuitive. Removing tariffs improves returns to capital in Australia and New Zealand, as capital is allocated to more productive uses. This translates into a relatively large increase in returns to capital in C1, and progressively smaller increases in returns in C2, C3 and C4 because restrictions on international capital mobility and global capital accumulation are relaxed gradually.

Table E.15 **Effects of removing MFN tariffs on GDP and GNI under alternative capital closures**

	Australia		*New Zealand*		*Rates of return*[a]
	GDP	*GNI*	*GDP*	*GNI*	
	%	%	%	%	%
1 K stock fixed globally and in each economy	0.08	0.09	0.09	0.09	(0.01) – 1.17
2 K stock fixed globally, mobile across economies[b]	**0.30**	**0.14**	**0.40**	**0.17**	**0.22**
3 Variable global K, fixed investment/capital ratio	0.33	0.19	0.61	0.44	0.17
4 Variable global K stock, fixed rates of return	0.46	0.41	0.93	0.82	0

[a] Changes in regional rates of return, which vary across regions in closure 1, but are modelled as the same across regions in other closures.[b] Closure used for results presented in the body of the report.

Source: Australian Commission estimates.

Under C1 (where capital used cannot move between regions), GDP and GNI increase by a smaller amount than under the other closures. This is because increased returns are prevented from attracting additional capital into New Zealand or Australia. Changes in returns to capital vary across countries (between -0.01 and 1.17 percent):

- rates of return to capital increase by 0.89 percent in Australia and 1.17 percent in New Zealand
- rates of return in other countries increase if they export goods and services to Australia or decrease if they compete with Australian exports.

When the world capital stock is assumed to be fixed but can be reallocated across countries (C2), Australian and New Zealand GDP increase because they attract capital from the Rest of the World (whose capital stock decreases 0.01 percent). This adjustment occurs until rates of return are the same in across the world. GNI for Australia and New Zealand increase less than GDP, because returns paid to owners of infra-marginal capital in the Rest of the World have increased and because of the marginal increase in capital sourced from abroad. Australian and New Zealand GNI also grow because labour productivity increases when combined with the greater capital stocks, which increase real wages.

Under C4, Australian and New Zealand capital stocks increase, producing increases in GDP of 0.46[10] and 0.93 percent, respectively. In this closure, capital is assumed to be created in each region to maintain the global rate of return at its initial level (the creation of additional capital is not explicitly linked to any increase in savings or investment). Thus, the supply of capital by each region (related to GNI) increases to satisfy the demand for capital by firms in the region (as indicated by GDP). The stocks of capital owned by Australia and New Zealand increase by 1.0 and 1.8 percent, respectively, while the world capital stock increases by 0.003 percent.

In C3, capital expansion is constrained by the requirement that investment (part of final demand) expand proportionately to match the increase in capital stock, creating a rising opportunity cost to creating new capital: the investment expansion diverts resources away from other parts of final demand (such as consumption and exports), which can increase more when capital expansion at the initial rate of return is unconstrained (C4). The opportunity cost in C3 limits the overall capital expansion, and a higher rate of return is obtained with the increasing cost of capital. The C3 results are larger than the C2 result, because global capital

[10] This result is similar to that obtained in PC (2010), which was 0.56 percent. The result in this study is smaller because the initial tariffs are lower.

expansion is still possible, provided it is accompanied by increased investment relative to the base case.[11] Thus, C3 produces results that are between those for C2 and C4.

'Trans-Tasman migration' simulation

Alternative capital closures have a limited effect on the model results of the 'trans-Tasman migration' simulation (table E.16). The most noticeable result is that the decrease in New Zealand GNI and GDP is amplified when capital stocks are allowed to decrease (C3 and C4). This occurs because the capital stock owned by New Zealand can now decrease in response to the lower returns received in New Zealand, further reducing production and income. Under closure 1, New Zealand-owned capital cannot be reallocated; its returns decrease as a result.

Table E.16 **Effects of trans-Tasman migration on GDP and GNI under alternative capital closures**

	Australia		*New Zealand*		*Rates of return*[a]
	GDP	*GNI*	*GDP*	*GNI*	
	%	%	%	%	%
1 K stock fixed globally and in each economy[b]	**0.01**	**0.01**	**-0.07**	**-0.08**	**(0.07) – 0.01**
2 K stock fixed globally, mobile across economies	0.01	0.01	-0.06	-0.08	–
3 Variable global K, fixed investment/capital ratio	0.02	0.02	-0.09	-0.12	–
4 Variable global K stock, fixed rates of return	0.02	0.01	-0.12	-0.12	0

[a] Changes in regional rates of return, which vary across regions in closure 1, but are modelled as the same across regions in other closures.[b] Closure used for results presented in the body of the report. **–** less than 0.005.

Source: Australian Commission estimates.

'Reducing barriers to commercial presence' simulation

Alternative capital closures have a significant effect on the model results of the 'eliminating barriers to commercial presence' simulation (table E.17).

As discussed in section E.3, removing barriers to commercial presence was modelled with four shocks of varying sizes; the removal of rent-creating barriers on Australian investment in New Zealand dominates the other shocks.

[11] That said, it is recognised that the investment in the database is not necessarily consistent with the capital stock.

Table E.17 **Effects of eliminating barriers to commercial presence on GDP and GNI under alternative capital closures**

	Australia		*New Zealand*		*Rates of return*[a]
	GDP	*GNI*	*GDP*	*GNI*	
	%	%	%	%	%
1 K stock fixed globally and in each economy	–	–	–	0.04	0.00 – 0.04
2 K stock fixed globally, mobile across economies[b]	**-0.01**	**–**	**0.13**	**0.07**	**–**
3 Variable global K, fixed investment/capital ratio	–	0.01	0.04	-0.06	–
4 Variable global K stock, fixed rates of return	0.01	0.03	0.07	-0.04	0

[a] Changes in regional rates of return, which vary across regions in closure 1, but are modelled as the same across regions in other closures.[b] Closure used for results presented in the body of the report. **–** less than 0.005.

Source: Australian Commission estimates.

When capital stocks are fixed globally but are mobile across economies (C2), removing the barriers to commercial presence results in an increase in the returns to Australian capital in New Zealand. This would lead to an increase in the quantity of Australian-owned capital in New Zealand (diverted from both Australia and the Rest of the World) and an increase in New Zealand GDP. For New Zealand, the change in GNI is smaller than it is for GDP because of the increased capital stock owned by Australia and related returns paid to Australian capital owners. New Zealand GNI still grows because labour incomes in New Zealand increase with a greater capital stock.

When capital stocks owned by regions are not fixed (closures 3 and 4), there is still an increase in GDP for New Zealand, but GNI decreases by approximately 0.05 percent (table E.17). Under C4, removing the barriers to commercial presence increases the returns to Australian-owned capital in New Zealand, which leads Australia to increase the size of the capital stock it owns by 0.1 percent. In contrast, returns to New Zealand-owned capital in New Zealand decrease, as producers have substituted towards Australian-owned capital. This causes New Zealand to reduce its stock of locally owned capital by 0.3 percent, which reduces New Zealand GNI. However, GDP in New Zealand still increases, as the amount of capital used in New Zealand increases by 0.2 percent. The net increase results from the increase in Australian-owned capital used in New Zealand which is greater than the decrease in New Zealand- and Rest of the World-owned capital used in New Zealand.

Sensitivity to parameters

Sensitivity analysis is also used to examine the sensitivity of model results to changes in parameters (such as elasticities and cost shares). Varying combinations of parameters shows the likely range of results. When a number of parameters need to be varied, comprehensive sensitivity analysis can be time consuming, as it requires a large number of simulations.

One of the key reasons for using the ANZEA model in the current study was the relative ease with which sensitivity analysis could be performed. CGE models are typically large and may take a long time to solve. The ease of solving the ANZEA model, its simplified and more transparent structure, and its easily modified core make the process of performing sensitivity analysis more straightforward than comparable models (such as GTAP and G-Cubed).[12] Reduced simulation times allow more detailed sensitivity analyses to be conducted within reasonable timeframes. For the version of the ANZEA model used, a simulation takes less than half the time required to solve a comparable GTAP simulation.

A comprehensive sensitivity analysis examining a range of input parameters simultaneously (for example, via Monte Carlo simulation) would require several thousand simulations for each scenario, which is impractical.[13] As an alternative, the Commissions have used a technique called Gaussian Quadrature (box E.4), which reduces the number of simulations required.

Central values and ranges of the model parameters varied in the sensitivity analysis are presented in table E.18. The parameters chosen were those whose estimates are judged to be most uncertain or judged most likely to affect results.[14] The parameters of interest are varied by +/- 50 percent, assuming both a uniform and a triangular distribution (box E.5). Any of the assumptions underlying the Gaussian Quadrature analysis can be varied for further modelling.

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[12] G-Cubed is a multi-region, multi-sector, dynamic CGE model that accounts for some financial effects on the real economy. It does this by distinguishing between financial and physical capital. ‘Financial capital is perfectly mobile between sectors and from one region to another, and is driven by forward-looking investors who respond to arbitrage opportunities. Physical capital, in contrast, is perfectly immobile once it has been installed.’ (McKibbin and Wilcoxen 1999, p. 2).

[13] The Commission was able to use Monte Carlo simulation to conduct a sensitivity analysis of the SMRIC model (detailed in supplementary paper G) because this model solves relatively quickly compared to the ANZEA model.

[14] These parameters do not affect migration results much. Other parameters (including database values) are likely to affect these results more. This latter factor has not been investigated in the context of the study.

Box E.4 **Gaussian Quadrature for sensitivity analysis**

CGE results are sensitive to a range of parameters (such as elasticities and cost shares). A lot of uncertainty characterises the levels of these parameters. Varying key parameters can provide insights into the robustness and range of results. Gaussian Quadrature (GQ) is one approach for conducting sensitivity analysis.

The GQ approach treats key parameters as random variables with associated distributions. Based on distributions assumed for the parameters, the GQ approach produces estimates of means and standard deviations of model results. These means and standard deviations can then be used to derive confidence intervals.

The mean and standard deviation of a known probability distribution can be calculated from first principles if the distribution takes a simple form. If the distribution is unknown or takes a complicated form, then an approximation may be required. The distributions of CGE model results are generally unknown and would be complex if they were known. For the ranges presented in the study, a uniform distribution was chosen to reflect the lack of knowledge about the properties of the parameter values; this produces larger ranges in model results than alternative assumptions, such as triangular or normal distributions. Sensitivity analysis using the triangular distribution was also undertaken and is presented in table E.19.

The 'low' and 'high' results presented in this section represent a 95 percent confidence interval of the model results. This is conditional on all other assumptions incorporated in the model, and does not reflect uncertainty regarding the functional forms in the model, model closure, other parameter values, or the specifications of shocks and scenarios.

The GQ approach has been used in various CGE applications (Beckman and Hertel 2009; Hertel et al. 2003; Piet 2002). A more detailed explanation of the GQ approach is presented in Arndt (1996).

Source: Arndt (1996).

Table E.18 **Parameters varied in the sensitivity analysis**

Substitution elasticity	*Number of parameters*	*Mean value*[a]	*Ranges examined*
Armington[b]	57	2.51	+/- 1.26
Factor substitution[c]	25	1.27	+/- 0.64
Capital source[d]	25	5.00	+/- 2.50

[a] Parameters in the database vary by a number of dimensions (such as commodity, source region and destination region). Values presented in this table reflect weighted averages across all indices. [b] Import-domestic substitution. Elasticities of substitution across different sources are parameterised as twice the value of the import-domestic elasticities. [c] Substitution between labour, capital and land. [d] Substitution between capital sourced from different countries.

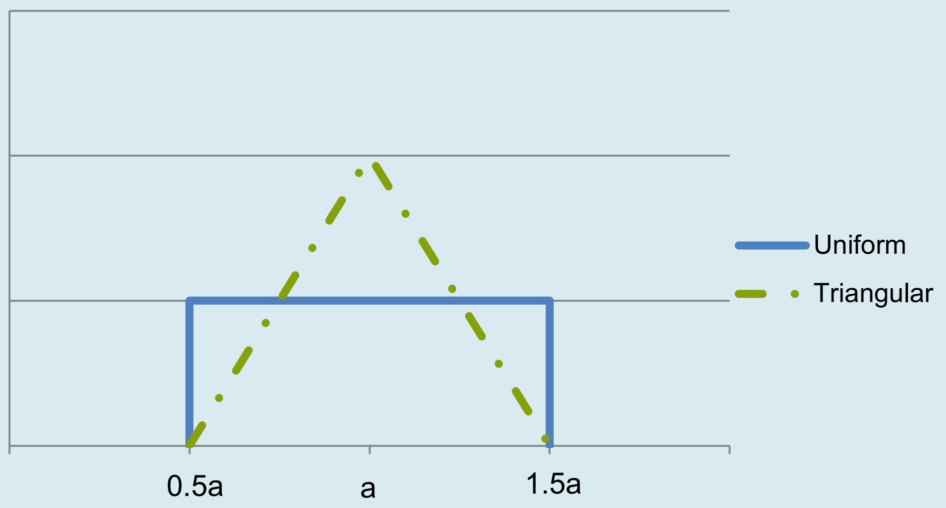
Box E.5 **Uniform and triangular probability distributions**

Parameters were varied using both a uniform and triangular distribution. For both distributions, the lower and upper bounds were set equal to +/- 50 percent of the parameter's database value (described as the point 'a' in the figure below).

With a uniform distribution, the probabilities associated with each possible value between the lower and upper bounds are all equal (figure below). With a triangular distribution, the probabilities associated with values close to the mean (the original database value) are higher than values that are relatively close to the lower or upper bounds.

Assuming a uniform distribution produces wider ranges in results than assuming a triangular distribution.

Figure **Uniform and triangular probability distributions**



The sensitivity of model results is presented in table E.19. For the majority of simulations, the signs of the results do not change as parameter values are varied. The exceptions are:

- the New Zealand GNI result under the 'Australian productivity improvement' simulation
- the Australian GNI result under the 'New Zealand productivity improvement' simulation.

Table E.19 **Sensitivity analysis: effects on GNI**

Percentage changes relative to base

	Australia			*New Zealand*		
	Low	*Mid*	*High*	*Low*	*Mid*	*High*
Uniform distribution	%	%	%	%	%	%
Multilateral tariff removal[a]	0.09	0.14	0.18	0.10	0.17	0.23
Asian growth[b]	0.02	0.07	0.11	0.00	0.06	0.12
Increase in migration[c]	0.01	0.01	0.01	-0.08	-0.08	-0.08
Remove barriers to FDI						
Trans-Tasman — all services[d]	0.00	0.00	0.00	0.06	0.07	0.08
Trans-Tasman — telecommunications[e]	0.00	0.00	0.00	0.01	0.01	0.01
Multilateral — telecommunications[f]	0.02	0.06	0.09	0.07	0.10	0.14
Australian productivity improvement[g]	1.09	1.12	1.15	-0.03	-0.01	0.00
New Zealand productivity improvement[h]	0.00	0.00	0.00	1.14	1.17	1.21
Triangular distribution						
Multilateral tariff removal[a]	0.10	0.14	0.17	0.12	0.17	0.21
Asian growth[b]	0.04	0.07	0.09	0.02	0.06	0.09
Increase in migration[c]	0.01	0.01	0.01	-0.08	-0.08	-0.08
Remove barriers to FDI						
Trans-Tasman — all services[d]	0.00	0.00	0.00	0.06	0.07	0.07
Trans-Tasman — telecommunications[e]	0.00	0.00	0.00	0.01	0.01	0.01
Multilateral — telecommunications[f]	0.03	0.06	0.08	0.08	0.10	0.13
Australian productivity improvement[g]	1.10	1.12	1.14	-0.03	-0.01	0.00
New Zealand productivity improvement[h]	0.00	0.00	0.00	1.15	1.18	1.20

[a] Reduction in all Australian and New Zealand tariff rates to zero. [b] 10 percent growth in Asian economies. [c] 0.13 percent decrease in the supply of labour in New Zealand and a 0.02 percent increase in the supply of labour in Australia. [d] Removal of trans-Tasman barriers to commercial presence for all services as defined in CIE (2010). [e] Removal of trans-Tasman barriers to commercial presence in telecommunications. [f] Removal of all Australian and New Zealand barriers to commercial presence in telecommunications. [g] 1 percent improvement in primary factor productivity in Australia. [h] 1 percent improvement in primary factor productivity in New Zealand.

Source: Australian Commission estimates.

As would be expected, results obtained using the triangular distribution display a smaller spread than results obtained using the uniform distribution. Aside from the labour migration simulation results and commercial presence and New Zealand productivity improvement simulation results for Australia, the GNI results for simulations are noticeably different when parameters are varied.

The contribution of different elasticities to the range of results obtained through sensitivity analysis varies between simulations (table E.20 and E.21). The Armington elasticities contribute most to the range of results for the 'multilateral tariff removal' and 'Asian growth' simulations.

- For the ‘multilateral tariff removal’ simulation, assuming a relatively high level of substitutability between imports and domestically produced goods results in countries purchasing relatively more imports when tariff barriers are removed. This allows additional resources to be diverted to more productive uses, increasing GNI.
- For the ‘Asian growth’ simulations, assuming a relatively high level of substitutability between imports and domestic production leads to smaller changes in GNI for Australia and New Zealand. This is because Asian countries crowd Australian and New Zealand exports out of international markets to a greater extent, reducing the positive effect of Asian growth on Australian and New Zealand GDP. Indeed, the change in New Zealand GDP becomes negative with a large enough Armington elasticity.

Table E.20 **Relative contributions of different elasticities to the range of GNI results for Australia[a]**

			Proportion of standard deviation attributable to parameters regulating:		
	Mid GNI result	*Standard deviation*	*Armington*	*Factor substitution*	*Capital source*
	%	%	%	%	%
Multilateral tariff removal	0.14	0.02	88.3	6.7	5.0
Asian growth	0.07	0.02	74.0	7.3	18.6
Remove barriers to trans-Tasman FDI — all services	–	–	28.5	57.8	13.7
New Zealand productivity improvement	–	–	44.8	16.9	38.3

[a] Explanations of simulations are presented in table E.19. – less than 0.005.

Source: Australian Commission estimates.

Table E.21 **Relative contributions of different elasticities to the range of GNI results for New Zealand[a]**

			Proportion of standard deviation attributable to parameters regulating:		
	Mid GNI result	*Standard deviation*	*Armington*	*Factor substitution*	*Capital source*
			%	%	%
Multilateral tariff removal	0.17	0.03	83.9	2.0	14.1
Asian growth	0.06	0.03	77.5	0.7	21.8
Remove barriers to trans-Tasman FDI — all services	0.07	–	34.9	63.4	1.7
Australian productivity improvement	-0.01	0.01	38.7	25.3	36.0

[a] Explanations of simulations are presented in table E.19. – less than 0.005.

Source: Australian Commission estimates.

The factor substitution elasticity has the biggest impact on the range of results in the 'reducing barriers to commercial presence' simulation (equal to 58 and 63 percent of the standard error for Australia and New Zealand respectively).

- Increasing the ease with which capital and labour can be substituted, results in more Australian-owned capital flowing to New Zealand. This leads to a decrease in Australian GDP and GNI and an increase in New Zealand GDP and GNI.

For the 'productivity improvement' simulation, the Armington, factor substitution and capital source elasticities make similar contributions to the range of results.

- assuming a relatively high level of substitutability between goods from different countries leads to more exports of the more productive country crowding out the exports of the trans-Tasman partner in international markets and the domestic production of the trans-Tasman partner. This decreases the GDP result for the trans-Tasman partner.
- assuming high values for the substitutability between capital from different sources and the substitutability between labour and capital leads to more capital flowing to the country experiencing the productivity improvement from the trans-Tasman partner. This increases the GDP result for the more productive country and decreases the GDP result for the trans-Tasman partner.

Appendix E.1: Industries and regions

Table E.22 **Industries in the ANZEA model database[a]**

Number	*Industry*	*Number*	*Industry*
1	Paddy rice	30	Wood products
2	Wheat	31	Paper products, publishing
3	Cereal grains nec	32	Petroleum, coal products
4	Vegetables, fruit, nuts	33	Chemical, rubber, plastic products
5	Oil seeds	34	Mineral products nec
6	Sugar cane, sugar beet	35	Ferrous metals
7	Plant-based fibres	36	Metals nec
8	Crops nec	37	Metal products
9	Cattle, sheep and goats, horses	38	Motor vehicles and parts
10	Animal products nec	39	Transport equipment nec
11	Raw milk	40	Electronic Equipment
12	Wool, silk-worm cocoons	41	Machinery and equipment nec
13	Forestry	42	Manufactures nec
14	Fishing	43	Electricity
15	Coal	44	Gas manufacture, distribution
16	Oil	45	Water
17	Gas	46	Construction
18	Minerals nec	47	Trade
19	Bovine meat products	48	Transport nec
20	Meat products nec	49	Water transport
21	Vegetable oils and fats	50	Air transport
22	Dairy products	51	Communication
23	Processed rice	52	Financial services nec
24	Sugar	53	Insurance
25	Food products nec	54	Business services nec
26	Beverages and tobacco products	55	Recreational and other services
27	Textiles	56	Pub Admin, Defence, Educ., Health
28	Wearing apparel	57	Dwellings
29	Leather products		

a Industries 1 to 14 form the agricultural sector, 15 to 18 the mining sector, 19 to 42 the manufacturing sector, and 43 to 57 the services sector.

Table E.23 **Regions in the ANZEA database**

Number	*Region*	*Number*	*Region*
1	Australia	14	India
2	New Zealand	15	Rest of Asia
3	China	16	Canada
4	Hong Kong	17	USA
5	Japan	18	Mexico
6	Korea	19	Brazil
7	Taiwan	20	Rest of America
8	Indonesia	21	European Union
9	Malaysia	22	Russia
10	Philippines	23	Rest of Europe
11	Singapore	24	South Africa
12	Thailand	25	Rest of Africa
13	Bangladesh		

Appendix E.2: The ANZEA model and database

This appendix outlines the model's database structure and describes the model's core equation system. This model is an extension of a global model developed for policy analysis. The exposition is technical, but allows a referee to form a clear view of differences between the approach used in developing the ANZEA model and the approach used in other global CGE models such as the GTAP model.

The model is described in levels in this paper but is implemented in percentage changes using GEMPACK software. The appendix first presents some notation conventions, before detailing the model database. The third section of the appendix presents the core equations that are required to solve for the equilibrium.

Conventions

The following sets are used in the description of the model and database.

- COM(1,…,*m*): Commodities (indexed by *i* or *j*)
- REG(1,…,*n*): Regions (indexed by *r* or *s*)
- USER(COM,hou,gov,inv): Users (indexed by *u*)
- SRC(dom,imp): Sources (indexed by *s*)
- FAC(lab,cap,land): Factors of production (indexed by *f*)
- NCF(lab,land): Non-capital factors (indexed by *f*)
- MCOM(1,…,*h*): Margin commodities (indexed by *j* or *m*)
- NCOM(1,…,*k*): Non-margin commodities (NCOM=COM–MCOM)

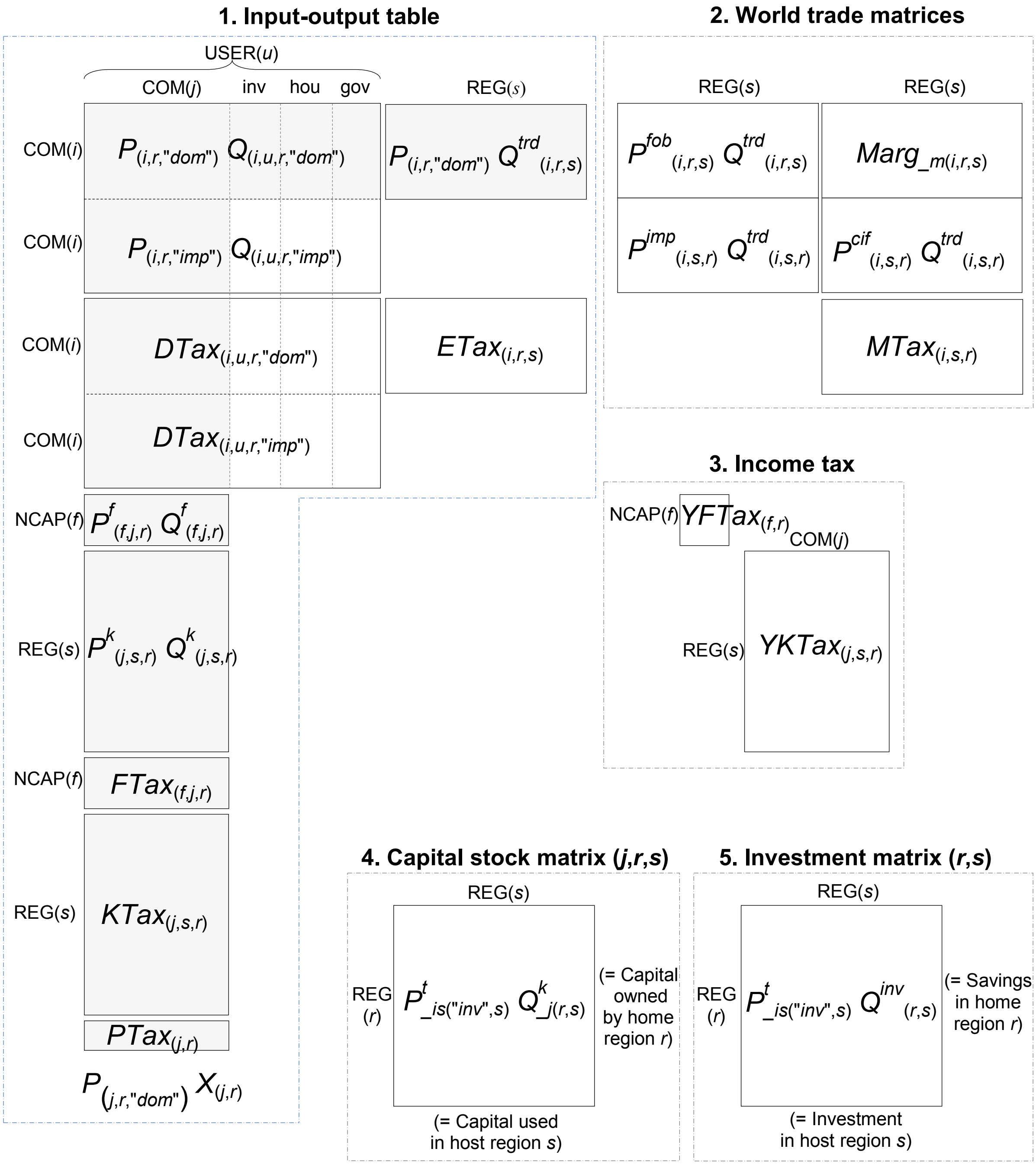
Database

The basic structure of the model's database is illustrated in figure E.1, which shows the database for a representative region *r*. It has five components: a national input-output table; bilateral trade matrices; factor income tax tables; a bilateral capital stock matrix at the industrial level; and an investment matrix at the national level.

The input-output, world trade and factor income tax data are taken from the GTAP version 7 database. The bilateral capital stock and investment matrices are compiled with additional data from various sources.[15]

15 The additional data used include *Balance of Payments Statistics 2005* (IMF 2005); GDyn database (Ianchovichina and Walmsley 2012) and Lakatos and Walmsley and Chappuis (2011).

Figure E.1 **Database structure for a representative region (*r*)**



Each component of the database consists of a number of boxes, representing matrices or vectors. The elements in these matrices and vectors are values, expressed in US dollars, representing certain economic activities portrayed in the model. To link the database with the model structure, these values are expressed in terms of the relevant variables in the core model. In most cases, these values can be presented as the product of a price variable and a quantity variable, which are defined in the model's core equation system.

Input-output table

This component consists of the following eight matrices and one vector:

- the purchases of domestically produced and imported goods by domestic users at basic prices ($P_{(i,r,s)}Q_{(i,u,r,s)}$)
- indirect taxes/subsidies on these purchases ($DTax_{(i,u,r,s)}$)
- the exports of goods to each destination region ($P_{(i,r,"dom")}Q^{trd}_{(i,r,s)}$)
- taxes/subsidies on exports ($ETax_{(i,u,r,s)}$)
- the purchases of non-capital factors of production at basic prices ($P^{f}_{(f,j,r)}Q^{f}_{(f,j,r)}$)
- the purchases of capital at basic prices ($P^{k}_{(j,s,r)}Q^{k}_{(j,s,r)}$)
- taxes on non-capital factor purchases ($FTax_{(i,u,r,s)}$)
- taxes on capital purchases ($KTax_{(i,u,r,s)}$).

The row vector is the production tax on industry's outputs ($PTax_{(i,u,r,s)}$).

Unlike the standard GTAP database, this database incorporates bilateral foreign capital stocks. Therefore, the capital income part of the input-output table is extended to include a capital owner dimension. Capital income, generated in a region, is received by owners of capital across the world. This allows factor taxes to be levied on each region's owned capital stock.

World trade matrices

In Part 2 of the database, there are five boxes showing how the values of exports are turned into the values of imports. The first box is a matrix showing the freight on board (FOB) values of exports ($P^{fob}_{(i,r,s)}$ $Q^{trd}_{(i,r,s)}$), which is equal to the domestic basic value of exports ($P_{(i,r,"dom")}$ $Q^{trd}_{(i,r,s)}$) plus export taxes (ETax). The FOB export matrix plus the export margin matrix ($Marg_{\_m(i,r,s)}$) gives the cost, insurance and freight (CIF) import matrix ($P^{cif}_{(i,r,s)}$ $Q^{trd}_{(i,r,s)}$). The CIF import matrix plus the import tariff matrix (MTax) gives the domestic basic value import matrix ($P^{imp}_{(i,r,s)}$ $Q^{trd}_{(i,r,s)}$), which can then be purchased by domestic users.

Income tax tables

This part of the database has an income tax vector for non-capital factors ($YFTax_{(f,r)}$) and a capital income tax matrix ($YKTax_{(j,s,r)}$). The former is a region-specific tax while the latter is an industry-specific tax, which is levied on individual owner regions. This extension in income tax data is needed for modelling foreign investment barriers in selected industries.

Capital stock matrix

Unlike the GTAP model in which each region owns the capital it uses, this model introduces foreign capital ownership and extends the capital stock data from a vector to a three dimensional matrix with bilateral capital stock ownership at the industry level. It can be seen in figure E.1 that firms in an industry of each region can source capital from not only their own regions but also from any foreign region in the world. This extension allows an analysis of the type of service trade liberalisation that involves foreign commercial presence with bilateral foreign capital investment in service sectors.

Part 4 of figure E.1 shows only the capital stock matrix from a home-host region dimension. From this dimension, it can be seen that the column total, or the sum of the matrix over home regions (*r*), gives the capital stock used in each host region (*s*). On the other hand, the row total, or the sum of the matrix over host regions (*s*), gives the capital stock owned by each home region (*r*).

Investment matrix

To be consistent with the capital stock data, investment data must also be extended from one vector in the standard GTAP database to a two-dimensional matrix. Its structure, as shown in Part 5 of figure E.1, is a home-host region matrix. This is a matrix of bilateral investment across the world. As world investment must be equal to world saving in equilibrium, this matrix also gives bilateral saving flows. Therefore, it can be shown that the column sum of the matrix over home regions (*r*) should be equal to total investment in host regions, consistent with the investment value in the regional input-output tables, while the row sum of the matrix over host regions (*s*) gives the total savings in home regions (*r*). Moreover, a region's total investment (column sum), net of its total saving (row sum), gives the value of net foreign investment inflow required by this region in equilibrium.

Core equation system

Included in the core system are only those variables and equations that are essential for solving the model's general equilibrium solution. The core system excludes other non-essential variables, such as price indices and quantity aggregates, which do not affect the model's solution.

The separation of essential from non-essential variables allows the number of equations in the core system to be reduced significantly. Moreover, these equations can be arranged in a simpler and cleaner structure, which is more accessible to model users. Such a structure can also be used as a powerful platform for developing new and more sophisticated extensions or add-on modules. This is because each component of the core system is clearly defined and can be easily replaced by an alternative component or linked with an added extension.

There are 33 equations in the core system, which are organised in four sections: (i) demands for imports and domestic goods, (ii) industrial demands for factors, (iii) regional supplies of factors and (iv) final users' expenditure. Most equations are used to define an endogenous variable. The names of the variables are described by the equation titles and aim to be self-explanatory. The equations specifying optimal behaviour are highlighted by boxes in the series of equations (see below), which are typically followed by a number of equations that define the variables used in those behavioural functions.

Demand for imports and domestic goods (equations 1–9)

The demand for imports in each region is determined in a two-tier Armington function. First, each region purchases imports from source regions in the rest of the world to form an import composite under a lower tier Constant Elasticity of Substitution (CES) demand function (equation 1). The import composite is then allocated to individual domestic users in an upper tier CES demand function, together with domestically produced goods to form another composite good, which is used in production and final consumption (equation 6).

(1) CES demand of region s for import i from region r

$$Q^{trd}_{(i,r,s)} = CES\ (P^{imp}_{(i,r,s)},\ P_{(i,s,\text{"}imp\text{"})},\ Q_{\_u(i,s,\text{"}imp\text{"})}) \qquad (i \in \text{COM};\ r,s \in \text{REG})$$

where $P_{(i,s,\text{"}imp\text{"})}$ is a CES price index for composite import i in region s

$$P_{(i,s,\text{"}imp\text{"})} = CES\ (P^{imp}_{(i,r_1,s)},\ \ldots\ ,\ P^{imp}_{(i,r_n,s)}) \qquad (i \in \text{COM};\ r \in \text{REG})$$

(2) The domestic basic prices of import *i* from region *r* to region *s*

$$P^{imp}_{(i,r,s)} = P^{cif}_{(i,r,s)} * (1 + t^{imp}_{(i,r,s)}) \qquad (i \in COM;\ r,s \in REG)$$

where $t^{imp}_{(i,r,s)}$ is the rate of an import tariff.

(3) The *CIF* price of import *i* from region *r* to region *s*

$$P^{cif}_{(i,r,s)} = P^{fob}_{(i,r,s)} + P^{mrg}_{(i,r,s)} \qquad (i \in COM;\ r,s \in REG)$$

where $P^{mrg}_{(i,r,s)}$ is the unit cost of margin service.

(4) The *FOB* price of export *i* from region *r* to region *s*

$$P^{fob}_{(i,r,s)} = P_{(i,r,\text{"dom"})} * (1 + t^{exp}_{(i,r,s)}) \qquad (i \in COM;\ u \in USER\ r,s \in REG)$$

where $t^{exp}_{(i,r,s)}$ is the rate of an export tax.

(5) Regional user demands for composite import *i*

$$Q_{\_u(i,r,s)} = \sum_u Q_{(i,u,r,s)} \qquad (i \in COM;\ r \in REG;\ s \in SRC)$$

(6) CES demand for good *i* from source *s* by user *u* in region *r*

$$Q_{(i,u,r,s)} = CES\ (P^t_{(i,u,r,s)},\ P^t_{\_s(i,u,r)},\ Q_{\_s(i,u,r)}) \qquad (i \in COM;\ u \in USER;\ r \in REG;\ s \in SRC)$$

where $P^t_{\_s(i,u,r)}$ is a CES price index for composite *i* of a domestically produced good and an import composite for user *u* in region *r*,

$$P^t_{\_s(i,u,r)} = CES\ (P^t_{(i,u,r,\text{"dom"})},\ P^t_{(i,u,r,\text{"imp"})}) \qquad (i \in COM;\ r \in REG)$$

(7) Purchasers' price of good *i* from source *s* for user *u* in region *r*

$$P^t_{(i,u,r,s)} = P_{(i,r,s)} * (1 + t^{dom}_{(i,u,r,s)}) \qquad (j \in COM;\ u \in USER;\ ;\ r \in REG;\ s \in SRC)$$

where $t^{dom}_{(i,u,r,s)}$ is the rate of an indirect tax.

(8) Demands for composite good *i* by user *u* in region *r*

$$Q_{\_s(i,u,r)} = \begin{cases} Leontief\ (X_{(u,r)}) & (i,\ u \in COM;\ r \in REG) \\ CDE\ (V_{(u,r)},\ P^t_{\_s(i_1,u,r)},\ \ldots,\ P^t_{\_s(i_n,u,r)})^{16} & (i \in COM;\ u{=}hou;\ r \in REG) \\ f\ (V_{(u,r)},\ P^t_{\_s(i,u,r)}) & (i \in COM;\ u{=}gov;\ r \in REG) \\ Leontief\ (V_{(u,r)}\ /\ P^t_{\_is(u,r)}) & (i \in COM;\ u{=}inv;\ r \in REG) \end{cases}$$

(9) Purchases' price index for composite goods for user *u* in region *r*

$$P^t_{\_is(u,r)} = \sum_i \frac{Q_{\_s(i,j,r)}}{Q_{\_is(u,r)}} P^t_{\_s(i,u,r)} \qquad (u \in USER;\ r \in REG).$$

16 Following GTAP, regional household demand is a Constant Differences of Elasticity (CDE) function.

Industrial demands for factors (equations 10–17)

Firms in a regional industry purchase required intermediate inputs under a Leontief demand function (equation 8) and primary factors of production under a CES demand function (equation 11). In the model, firms in an industry can source their capital demands from all regions. This is specified in a second tier CES demand function for capital (equation 13).

With given prices of inputs and factors, firms choose an optimal combination of inputs and factors to minimise the cost of producing a given output. This output is determined by the domestic and foreign demands for the good produced in the industry (equation 9). Under constant return to scale production technology, the basic price of the output in that industry is just the unit cost of all inputs and factor services, used in production, plus a production tax (equation 16).

(10) Output of industry *j* in region *r*

$$X_{(j,r)} = \begin{cases} Q_{\_u(j,r,\text{"dom"})} + \sum_s Q^{trd}_{(j,r,s)} & (j \in \text{NCOM}; r \in \text{REG}) \\ Q_{\_u(j,r,\text{"dom"})} + \sum_s Q^{trd}_{(j,r,s)} + Q^{mexp}_{(j,r)} & (j \in \text{MCOM}; r \in \text{REG}) \end{cases}$$

(11) The export of margin good *m* from region *r*

$$Q^{mexp}_{(m,r)} = CES\left(P_{(m_1,r,\text{"dom"})}, \ldots, P_{(m_h,r,\text{"dom"})}, Q^{mexp}_{\_irs\ (m)}\right) \quad (m \in \text{MCOM}; r \in \text{REG})$$

(12) CES demand for factor *f* used in industry *j* in region *r*

$$Q^{f}_{(f,j,r)} = CES\left(P^{tf}_{(f,j,r)}, P^{tf}_{\_j(j,s)}, X_{(j,r)}\right) \quad (f \in \text{FAC}; j \in \text{COM}; r \in \text{REG})$$

where $P^{tf}_{\_f(j,s)}$ is CES price index for composite factor in industry *j* in region *s*

$$P^{tf}_{\_f(j,s)} = CES\left(P^{tf}_{(\text{"land"},j,r)}, P^{tf}_{(\text{"cap"},j,r)}, P^{tf}_{(\text{"lab"},j,r)}\right) \quad (j \in \text{COM}; s \in \text{REG})$$

(13) The purchasers' price of non-capital factor *f* in industry *j* of region *r*

$$P^{tf}_{(f,j,r)} = P^{f}_{(f,j,r)} * (1 + t^{f}_{(f,j,r)}) \quad (f \in \text{NCF}; j \in \text{COM}; r \in \text{REG})$$

where $t^{f}_{(f,j,r)}$ is the rate of a non-capital factor tax.

(14) CES demand of industry *j* of host region *s* for capital from home region *r*

$$Q^{k}_{(j,r,s)} = CES\left(P^{tk}_{(j,r,s)}, P^{tf}_{(\text{"cap"},j,s)}, Q^{f}_{(\text{"cap"},j,s)}\right) \quad (j \in \text{COM}; r,s \in \text{REG})$$

where $P^{tf}_{(\text{"cap"},j,s)}$ is a CES price index for composite capital stock used in region *s*,

$$P^{tf}_{(\text{"cap"},j,s)} = CES\left(P^{tk}_{(j,r_1,s)}, \ldots, P^{tk}_{(j,r_n,s)}\right) \quad (j \in \text{COM}; s \in \text{REG})$$

(15) The purchasers' price of capital from region *r* used in industry *j* in region *s*

$$P^{tk}_{(j,r,s)} = P^{k}_{(j,r,s)} * (1 + t^{k}_{(j,r,s)}) \quad (j \in \text{COM}; r,s \in \text{REG})$$

where $t^{k}_{(j,r,s)}$ is the rate of a factor tax on capital.

(16) The basic rental price of capital, used in industry *j* of host region *s*

$$P^f_{("cap",j,s)} = \sum_{r} \frac{Q^k_{(j,r,s)}}{Q^f_{("cap",j,r)}} P^k_{(j,r,s)} \qquad (j \in COM;\ s \in REG).$$

(17) Basic price for the output of industry *j* in region *r* (zero pure profit condition)

$$P_{(j,r,"dom")} = \left(\frac{Q\_{is(j,r)}}{X_{(j,r)}} P^t\_{is(j,r)} + \frac{Q^f\_{f(j,r)}}{X_{(j,r)}} P^{tf}\_{f(j,r)} \right) (1 + t^p_{(j,r)}) \qquad (j \in COM;\ r \in REG)$$

where $t^p_{(j,r)}$ is the rate of a production tax.

Regional supplies of factors (equations 18–24)

The regional household is the owner of primary factors of production: land, labour and capital. Land is an industry- and region-specific factor. Land supply is determined in a Constant Elasticity of Transformation (CET) supply function, which implies that land can be transformed between different uses to a limited extent (equation 17). Labour is assumed to be mobile across industries but not between regions (equation 18) so that industrial wage rates will be equalised in equilibrium (equation 19).

In a comparative static context, it is assumed that capital stock, owned by a region, can be reallocated in other regions to maximise the rate of return for its owners (equation 20). In equilibrium, the rates of return to a home region's capital stock will be equalised across all host regions (equation 21).

(18) CET supply of land in industry *j* in region *r* (market equilibrium condition (MEC) for industrial land)

$$Q^f_{("land",j,r)} = CET\ (P^f_{("land",j,r)},\ P^{tf}\_{j("land",s)},\ X^{land}_{(r)}) \qquad (j \in COM;\ r \in REG)$$

where $X^{land}_{(r)}$ is the exogenously given endowment of land owned by region *r* and $P^{tf}\_{j("land",s)}$ is a CET price index for land in region *s*,

$$P^{tf}\_{j("land",s)} = CET\ (P^{tf}_{("land",j_1,s)},\ \ldots,\ P^{tf}_{("land",j_m,s)}) \qquad (f \in FAC;\ s \in REG)$$

(19) Supply of labour in region *r* (MEC for regional labour)

$$X^{lab}_{(r)} = \sum_{j} Q^f_{("lab",j,r)} \qquad (r \in REG)$$

(20) The basic prices of labour equalisation

$$P^f_{("lab",j,r)} = W_{(r)} \qquad (j \in COM;\ r \in REG)$$

where $W_{(r)}$ is equilibrium wage rate in region *r*.

(21) Supply of capital by home region *r* (MEC for regional capital)

$$X^k_{(r)} = \sum_{s} Q^k\_{j(r,s)} = \sum_{s}\sum_{j} Q^k_{(j,r,s)} \qquad (r \in REG)$$

(22) Rate of return to capital

$$R_{(j,r,s)} = \frac{P^{kt}_{(j,r,s)}}{P^{t}_{\_is("inv",s)}} \qquad (j\in\text{COM};\ r,s\in\text{REG})$$

(23) Global allocation rule for regional capital stocks

$$R_{(j,r,s)} = R_{\_\boldsymbol{js(r)}} \qquad (j\in\text{COM};\ r,s\in\text{REG})$$

where $R_{\_js(r)}$ is the equilibrium rate of return to capital owned by home region *r*.

(24) The rental price of capital, net of income tax

$$P^{kt}_{(j,r,s)} = P^{k}_{(j,r,s)}\ (1 - t^{kt}_{(j,r,s)} - t^{fdi}_{(j,r,s)}) \qquad j\in\text{COM};\ r,s\in\text{REG})$$

where $t^{kt}_{(j,r,s)}$ is the rate of a tax on capital income and $t^{fdi}_{(j,r,s)}$ is introduced as a tax-equivalent of barrier to foreign capital in host regions' service industries.

Final users' expenditure (equations 25–35)

There are three final users in the model: household, government and investor. Their expenditures are shown in equation 24. Household and government expenditures are equal to their income net of savings. Investment expenditure is equal to total domestic savings plus net foreign investment (NFI) inflow.

It is assumed in the model that regional savings can be invested across all regions, including the home region, to maximise its expected rates of return (equation 31). This optimal behaviour implies that, in equilibrium, all regional expected rates of return will be equalised (equation 32). These bilateral investment flows must be constrained by regional investment (equation 33). This requires the host region's net foreign investment inflow to adjust independently.

(25) Final expenditure of user *u* (*hou*, *gov*, *inv*) in region *r*

$$V_{(u,r)} = \begin{cases} Y^{hou}_{(r)} * (1 - s^{hou}_{(r)}) & (u=hou;\ r\in\text{REG}) \\ Y^{gov}_{(r)} * (1 - s^{gov}_{(r)}) & (u=gov;\ r\in\text{REG}) \\ V^{sav}_{(r)} + V^{NFI}_{(r)} & (u=inv;\ r\in\text{REG}) \end{cases}$$

where $s^{hou}_{(r)}$ and $s^{gov}_{(r)}$ are household and government saving rates; and $V^{NFI}_{(r)}$ is the inflow of net foreign investment (NFI).

(26) Total saving in region *r*

$$V^{sav}_{(r)} = Y^{hou}_{(r)}\ s^{hou}_{(r)} + Y^{gov}_{(r)}\ s^{gov}_{(r)}$$

(27) Post-income tax price for factor *f* in region *r*

$$P^{ft}_{(f,r)} = \begin{cases} P^{f}_{\_j(f,r)} * (1 - t^{ft}_{(f,r)}) & (f \in \text{NCF};\ r \in \text{REG}) \\ \sum_{j} \sum_{s} s^{kt}_{(j,r,s)} P^{kt}_{(j,r,s)} & (f = cap;\ r \in \text{REG}) \end{cases}$$

where $t^{ft}_{(f,r)}$ is the rate of an income tax on non-capital factor services and $s^{kt}_{(j,r,s)}$ is the rental share of capital from region *r* used in industry *j* of region *s*.

(28) Household disposable income

$$Y^{hou}_{(r)} = \sum_{j} (P^{ft}_{("land",j,r)} X^{land}_{(j,r)}) + P^{ft}_{\_j("lab",r)} X^{lab}_{(r)} + \sum_{s} (P^{kt}_{\_j(r,s)} Q^{k}_{\_j(r,s)}) \quad (r \in \text{REG})$$

where $P^{kt}_{\_j(r,s)}$ is the rental price of capital from region *r* to region *s*.

(29) Government income from tax revenue

$$Y^{gov}_{(r)} = (\textit{Total Tax Revenue}) \qquad (r \in \text{REG})$$

(30) Capital stock at the end of period

$$X^{ke}_{(r,s)} = Q^{k}_{\_j(r,s)} * (1 - r^{dep}_{(s)}) + Q^{inv}_{(r,s)} \qquad (r,s \in \text{REG})$$

where $r^{dep}_{(s)}$ is the rate of capital depreciation.

(31) Real investment from region *r* to region *s*

$$Q^{inv}_{(r,s)} = V^{inv}_{(r,s)} / P^{t}_{\_is("inv",s)} \qquad (r,s \in \text{REG})$$

(32) Market equilibrium condition (MEC) for world savings

$$\sum_{r} V^{sav}_{(r)} = \sum_{r} \sum_{s} V^{inv}_{(r,s)}$$

(33) Expected rates of return equalisation

$$R^{e}_{(r,s)} = R_{\_js(r)} \left(\frac{X^{ke}_{(r,s)}}{Q^{k}_{\_j(r,s)}} \right)^{-r_{(r)}} \qquad (r,s \in \text{REG})$$

where $\gamma_{(r)}$ is a parameter that controls the sensitivity of capital growth to change in the expected rate of return.

(34) Global allocation rule for regional savings

$$R^{e}_{(r,s)} = R^{e}_{\_rs} \qquad (r,s \in \text{REG})$$

where $R^{e}_{\_rs}$ is the general equilibrium rate of return for the world as a whole.

(35) Market equilibrium condition (MEC) for host region real investment

$$\sum_{i} Q_{\_s(i,\text{"}inv\text{"},r)} = \sum_{s} Q^{inv}_{(s,r)} \qquad (r \in \text{REG})$$

Note that $V^{NFI}_{(r)}$ has to adjust to satisfy this constraint.[17]

There are 35 equations in the core system. All of them are used to define uniquely an endogenous variable, except seven equations. In these seven equations, five of them are market equilibrium conditions: equations 18, 19, and 21 for land, labour and capital, and equations 32 and 35 for savings and investment, respectively. The remaining two are global allocation rules for regional capital stocks and savings: equations 23 and 34.

In addition to the 28 defined endogenous variables, there are seven endogenous variables that are not defined by any equations (appear only on the right hand side of equations). They include factor prices and rate of return to capital owner regions ($P^{f}_{(\text{"}land\text{"},j,r)}$, $W_{(r)}$, $P^{k}_{(j,r,s)}$ and $R_{\_js(r)}$); and world expected rate of return to investment, inter-regional investment, and regional net foreign investment inflows ($R^{e}_{\_rs}$, $V^{inv}_{(r,s)}$ and $V^{NFI}_{(r)}$). It can be seen that each of these undefined variable corresponds to one of the seven equations for market equilibrium conditions or global allocation rules. These undefined variables can be seen as general equilibrium variables: each of them needs to be independently adjusted to clear a corresponding market or to satisfy a global allocation rule, specified above.

17 It is worth checking that net foreign investment inflow equals the difference between a region's investment and its savings: $V^{NFI}_{(r)} = \sum_{s} V^{inv}_{(s,r)} - \sum_{s} V^{inv}_{(r,s)}$.

Appendix E.3: Industry results

Table E.24 **Effects on value-added of eliminating Australian and New Zealand tariffs, industry results**

	Australia			*New Zealand*		
	Average tariff	*% changes*	*US$ million*[a]	*Average tariff*	*% changes*	*US$ million*[a]
Paddy rice	0.0	1.1	–	0.0	1.7	–
Wheat	0.0	0.9	23	0.0	1.3	–
Cereal grains nec	0.0	0.6	4	0.0	1.3	–
Vegetables, fruit, nuts	1.0	0.2	11	0.0	0.8	10
Oil seeds	0.7	0.8	4	0.0	1.4	–
Sugar cane, sugar beet	0.0	0.6	–	0.0	0.6	–
Plant-based fibres	0.0	0.5	5	0.0	0.6	–
Crops nec	0.0	0.7	4	0.2	2.4	3
Cattle, sheep and goats, horses	0.0	1.0	15	0.0	1.8	4
Animal products nec	0.0	0.8	7	0.0	1.1	4
Raw milk	0.0	0.6	2	0.0	1.5	1
Wool, silk-worm cocoons	0.2	0.6	9	0.0	1.1	2
Forestry	0.3	-0.1	-1	0.1	0.4	2
Fishing	0.1	0.2	4	0.0	0.1	–
Coal	0.0	0.4	39	0.0	0.2	–
Oil	0.0	0.5	10	0.0	0.3	–
Gas	0.0	0.5	9	0.0	0.4	–
Minerals nec	0.1	1.2	158	0.0	0.7	–
Bovine meat products	0.0	1.6	107	0.0	2.1	76
Meat products nec	0.4	0.5	15	0.9	1.6	12
Vegetable oils and fats	0.7	0.9	6	0.3	0.7	4
Dairy products	3.3	0.7	42	1.0	1.6	66
Processed rice	0.0	1.2	4	0.0	2.0	–
Sugar	0.0	1.5	15	0.0	0.6	4
Food products nec	1.7	0.4	57	3.0	0.2	4
Beverages and tobacco products	2.5	0.6	54	4.6	-0.1	-2
Textiles	4.4	-3.1	-96	2.3	-2.7	-26
Wearing apparel	7.5	-6.2	-239	7.1	-7.8	-60
Leather products	4.0	0.1	1	2.7	0.5	1
Wood products	3.6	-1.1	-13	3.5	-0.9	-10
Paper products, publishing	2.6	-0.2	-10	0.6	0.1	2
Petroleum, coal products	0.0	0.4	16	2.2	-0.1	-1
Chemical, rubber, plastic products	2.8	-0.5	-56	1.7	-0.1	-2
Mineral products nec	4.0	-0.7	-3	2.6	0.2	–
Ferrous metals	3.1	-0.8	-15	1.5	-0.4	-1
Metals nec	0.8	4.1	637	1.1	3.0	29
Metal products	5.1	-1.6	-38	2.9	-1.8	-10

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Table E.24 (continued)

	Australia			*New Zealand*		
	Average tariff	*% changes*	*US$ million*[a]	*Average tariff*	*% changes*	*US$ million*[a]
Motor vehicles and parts	3.5	-0.8	-113	4.3	-3.0	-40
Transport equipment nec	0.8	2.7	43	0.6	5.5	31
Electronic Equipment	0.8	3.0	93	0.4	2.4	30
Machinery and equipment nec	3.2	-1.3	-147	2.6	-1.4	-36
Manufactures nec	2.8	-0.2	-11	6.9	-4.1	-38
Electricity	0.0	1.1	48	0.0	0.6	7
Gas manufacture, distribution	0.0	0.8	2	0.0	0.0	0
Water	0.0	0.5	20	0.0	0.6	–
Construction	0.0	0.6	486	0.0	1.0	90
Trade	0.0	0.4	436	0.0	0.5	87
Transport nec	0.0	0.4	72	0.0	0.9	11
Water transport	0.0	0.6	15	0.0	1.1	10
Air transport	0.0	0.8	95	0.0	1.8	42
Communication	0.0	0.4	34	0.0	0.7	13
Financial services nec	0.0	0.5	61	0.0	0.5	7
Insurance	0.0	0.5	54	0.0	0.6	8
Business services nec	0.0	0.4	99	0.0	0.6	33
Recreational and other services	0.0	0.6	129	0.0	0.7	27
Pub Admin, Defence, Educ., Health	0.0	-0.6	-795	0.0	-0.9	-164
Dwellings	0.0	0.4	252	0.0	0.4	34

[a] Results are in 2004 US$. **–** less than 0.5.

Source: Australian Commission estimates.

Table E.25 **Effects on value-added of productivity improvement in trans-Tasman partner, industry results[a]**

	Australia[b]		*New Zealand[c]*	
	% changes	*US$ million[a]*	*% changes*	*US$ million[a]*
Paddy rice	-0.05	–	-0.31	–
Wheat	-0.06	-1.5	-0.35	–
Cereal grains nec	-0.04	-0.3	-0.27	–
Vegetables, fruit, nuts	-0.02	-0.9	-0.13	-1.8
Oil seeds	-0.05	-0.2	-0.21	–
Sugar cane, sugar beet	-0.02	0.0	-0.03	–
Plant-based fibres	-0.05	-0.5	-0.08	–
Crops nec	-0.04	-0.2	-0.26	-0.3
Cattle, sheep and goats, horses	-0.08	-1.2	-0.32	-0.6
Animal products nec	-0.05	-0.4	-0.15	-0.6
Raw milk	-0.09	-0.3	-0.29	-0.1
Wool, silk-worm cocoons	-0.08	-1.2	-0.49	-0.7
Forestry	-0.05	-0.2	-0.12	-0.7
Fishing	0.00	0.0	-0.06	-0.1
Coal	-0.02	-1.6	-0.23	-0.3
Oil	-0.01	-0.2	-0.14	–
Gas	-0.02	-0.3	-0.19	–
Minerals nec	-0.05	-6.0	-0.15	-0.1
Bovine meat products	-0.15	-10.2	-0.40	-14.5
Meat products nec	-0.03	-0.8	-0.25	-2.0
Vegetable oils and fats	-0.04	-0.3	-0.08	-0.4
Dairy products	-0.11	-7.0	-0.30	-12.5
Processed rice	-0.04	-0.1	-0.62	–
Sugar	-0.06	-0.6	-0.02	-0.1
Food products nec	-0.01	-2.2	-0.15	-3.3
Beverages and tobacco products	-0.02	-1.5	-0.05	-0.7
Textiles	-0.09	-2.8	-0.26	-2.5
Wearing apparel	-0.03	-1.3	-0.14	-1.1
Leather products	-0.12	-1.1	-0.39	-1.0
Wood products	-0.07	-0.8	-0.06	-0.7
Paper products, publishing	-0.03	-1.3	-0.22	-3.7
Petroleum, coal products	-0.01	-0.3	-0.09	-0.6
Chemical, rubber, plastic products	-0.06	-7.0	-0.31	-7.0
Mineral products nec	0.02	0.1	0.05	0.1
Ferrous metals	-0.04	-0.8	-0.29	-0.9
Metals nec	-0.20	-31.4	-0.84	-8.2
Metal products	-0.02	-0.4	-0.21	-1.2

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Table E.25 (continued)

	Australia		New Zealand	
	% changes	*US$ million*[a]	*% changes*	*US$ million*[a]
Motor vehicles and parts	0.01	1.2	-0.03	-0.4
Transport equipment nec	-0.07	-1.2	-0.21	-1.2
Electronic Equipment	-0.01	-0.2	-0.28	-3.5
Machinery and equipment nec	-0.05	-5.7	-0.27	-7.2
Manufactures nec	-0.02	-1.3	-0.06	-0.5
Electricity	-0.06	-2.5	-0.20	-2.2
Gas manufacture, distribution	-0.05	-0.1	-0.24	-0.1
Water	-0.01	-0.4	-0.16	–
Construction	0.06	46.1	0.23	19.9
Trade	0.00	-0.4	-0.03	-5.2
Transport nec	-0.02	-3.7	-0.18	-2.2
Water transport	-0.03	-0.8	-0.16	-1.5
Air transport	-0.04	-4.2	-0.12	-2.8
Communication	-0.02	-1.5	-0.09	-1.6
Financial services nec	-0.02	-2.1	-0.14	-1.8
Insurance	-0.02	-1.9	-0.14	-1.9
Business services nec	-0.01	-1.6	-0.10	-5.1
Recreational and other services	-0.02	-4.1	-0.08	-2.7
Pub Admin, Defence, Educ., Health	-0.01	-8.9	-0.03	-6.4
Dwellings	-0.01	-7.1	-0.09	-8.0

a Results are in 2004 US$. **c** Effects on Australian value-added when New Zealand productivity improves. **b** Effects on New Zealand value-added when Australian productivity improves. **–** less than 0.5.

Source: Australian Commission estimates.

Table E.26 **Effects of Asian growth on value-added, industry results**

	Australia		*New Zealand*	
	% changes	*US$ million*[a]	*% changes*	*US$ million*[a]
Paddy rice	-3.5	-1	-3.1	–
Wheat	0.3	9	0.2	–
Cereal grains nec	2.2	17	0.2	–
Vegetables, fruit, nuts	-0.5	-21	-1.5	-20
Oil seeds	1.6	8	0.9	–
Sugar cane, sugar beet	0.4	0	0.0	0
Plant-based fibres	0.9	8	0.3	–
Crops nec	-0.7	-4	-1.8	-2
Cattle, sheep and goats, horses	0.6	9	0.2	–
Animal products nec	1.0	8	1.7	7
Raw milk	0.4	1	0.5	–
Wool, silk-worm cocoons	-0.8	-11	-0.7	-1
Forestry	0.4	1	1.5	9
Fishing	0.3	6	0.4	1
Coal	1.0	97	1.1	1
Oil	-1.4	-29	-1.5	–
Gas	-0.9	-15	0.0	0
Minerals nec	3.0	384	0.6	–
Bovine meat products	0.7	47	0.1	3
Meat products nec	-0.1	-2	-0.2	-2
Vegetable oils and fats	-0.5	-3	0.0	0
Dairy products	0.5	31	0.6	25
Processed rice	-2.4	-8	-4.7	–
Sugar	1.0	11	0.2	2
Food products nec	0.3	40	0.4	8
Beverages and tobacco products	0.4	36	0.3	4
Textiles	-1.7	-53	-2.0	-20
Wearing apparel	-0.9	-34	-1.1	-9
Leather products	-2.2	-20	-3.0	-8
Wood products	-0.3	-4	-0.3	-3
Paper products, publishing	0.0	0	0.2	3
Petroleum, coal products	0.8	31	0.9	6
Chemical, rubber, plastic products	-0.5	-60	-0.4	-8
Mineral products nec	-0.4	-2	-0.1	–
Ferrous metals	-0.5	-9	-0.6	-2
Metals nec	0.6	95	0.1	1
Metal products	-0.4	-10	-0.7	-4

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Table E.26 (continued)

	Australia		New Zealand	
	% changes	*US$ million*[a]	*% changes*	*US$ million*[a]
Motor vehicles and parts	-0.4	-62	-0.7	-10
Transport equipment nec	-0.5	-9	0.2	1
Electronic Equipment	-2.4	-75	-2.1	-25
Machinery and equipment nec	-1.0	-110	-1.3	-35
Manufactures nec	-0.8	-47	-0.5	-4
Electricity	0.4	16	0.1	1
Gas manufacture, distribution	0.2	–	-0.1	–
Water	0.2	8	0.1	–
Construction	-0.2	-124	0.2	20
Trade	0.1	167	0.1	21
Transport nec	0.2	35	0.3	3
Water transport	0.7	18	1.6	15
Air transport	0.6	65	0.9	21
Communication	0.2	20	0.2	4
Financial services nec	0.2	31	0.2	2
Insurance	0.2	21	0.2	2
Business services nec	0.1	19	0.1	6
Recreational and other services	0.3	68	0.4	13
Pub Admin, Defence, Educ., Health	0.1	154	0.1	24
Dwellings	0.3	182	0.2	15

[a] Results are in 2004 US$. **–** less than 0.5.

Source: Australian Commission estimates.

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