Effects of mutual recognition of imputation credits[1]

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Abstract

In both Australia and New Zealand, when tax is paid on corporate income at the company level, dividend recipients can credit this tax against their personal (or institutional) income tax liability. This is referred to as an imputation (or franking) credit. Although both Australian and New Zealand grant imputation credits for tax paid domestically, they do not recognise the imputation credits granted by their trans-Tasman partner. It has been argued that the absence of imputation credit recognition creates a distortion in favour of local investment, to the detriment of both countries. This is particularly an issue for New Zealand, where a large share of foreign investment is sourced from Australia. Both governments have considered the mutual recognition of imputation credits (MRIC).

Conceptual analysis alone cannot determine the net impacts of implementing MRIC on each country. This is because the net impacts depend on relative magnitudes of investment and investors' behavioural responses, and these responses can have positive or negative impacts on each country depending on a range of assumptions.

This paper uses a small, custom-built, international CGE model to analyse the potential impacts of implementing MRIC. The model includes the minimum detail necessary to examine the policy — for example, it includes detailed domestic and international capital and income tax treatments for Australia and New Zealand, and only includes Australia, New Zealand and the Rest of the World as regions. The small size of the model enabled comprehensive sensitivity testing of one million different combinations of 8 behavioural parameters and data items to produce distributions of results for each country. Sensitivity testing is particularly important for the imputation credit policies given uncertainty in the data about capital stocks (Australian and New Zealand statistical agencies report very different amounts) and uncertainty about behavioural responses.

Results show that a unilateral recognition of imputation credits, for example, unilateral recognition by Australia of credits from New Zealand, will improve net returns to capital owners in the recognising country and will induce further capital flows to the newly recognised partner country. To the extent that this capital is not replaced, this will depress wages and decrease tax revenue collections in Australia. Wages and tax revenue will increase in New Zealand, as it becomes a more desirable destination for investment (due to the increased post-tax returns) and its economy expands.

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Effects of mutual recognition of imputation credits

The results suggest that while a trans-Tasman MRIC is likely to yield small gains for both economies taken together, it is unlikely (but possible) to bring gains for each separately. The large number of sensitivity runs indicate that the benefits are likely to accrue to New Zealand, and the costs are likely to be borne by Australia. Key messages from the model results are that:

1. Unilateral imputation credit recognition result in GDP and GNI losses for the recognising country and gains for the partner country.

2. An MRIC policy improves the allocation of trans-Tasman capital, which results in small increases in trans-Tasman GDP and GNI .

3. The costs and benefits of mutual recognition are unlikely to be shared evenly between Australia and New Zealand. Capital back-filling from the Rest of the World can counteract GDP losses, but does not reverse decreases in GNI.

4. In nearly 10 per cent of parameter combinations examined, GDP increased for both economies. GNI increased for both economies in about 5 per cent of the combinations examined.

5. New Zealand is more likely to benefit from the policy than Australia. In about 21 per cent of parameter combinations examined, Australian GNI increases as a result of MRIC. New Zealand GNI increases in 84 per cent of combinations.

6. The tax revenue cost is likely to be larger for Australia than for New Zealand, because credits are granted on inframarginal capital, and the existing stock of Australian owned capital in New Zealand is larger than the stock of New Zealand owned capital in Australia. On average across all the different model runs, about 80 per cent of the trans-Tasman tax revenue cost is borne by Australia.

Australia and New Zealand are among a few countries to have a system of imputation credits. When dividends from previously taxed corporate income are paid to shareholders, they receive an income tax credit for the corporate tax already paid. While Australia and New Zealand provide imputation credits for domestic income streams, neither recognises the imputation credits granted by the other country. For almost twenty years, there has been discussion in both countries about the extent to which this lack of recognition creates a bias toward domestic investment and leads to sub-optimal investment allocation between the two countries.

The business community in particular has suggested that mutual recognition of imputation credits (MRIC) could remove trans-Tasman investment distortions, by enabling capital to flow to the destination where it has the highest marginal product and highest post-tax returns. However, this would be accompanied by income and government revenue changes for two countries.

This paper uses a quantitative model to illustrate the economic impacts of trans-Tasman imputation credit policies. The model — the Small Mutual Recognition of Imputation Credits (SMRIC) model — was developed to assist the joint inquiry undertaken by the Australian and New Zealand Productivity Commissions into the impacts and benefits of further integration of the Australian and New Zealand economies. Submissions to the inquiry revealed that the taxation of company profits is an important issue in the relationship between Australia and New Zealand. However, most submissions did not take into account the interdependent effects that would be triggered by a change to taxation arrangements, and that would determine its ultimate impact. While conceptual analysis was able to illustrate some of the implications of policy, modelling was required to provide insights into the orders of magnitude of the cross-country productive and income effects of the policy. The Australian Productivity Commission therefore decided to build a model that would illustrate and quantify these effects.

A purpose built CGE model was developed that allows the taxes to be implemented as they currently and would apply in each country under mutual recognition of imputation credits. Due to the large uncertainty in the model parameters a detailed sensitivity analysis was undertaken. The model has the advantage that it focuses on the implications for Australian and New Zealand labour and capital incomes, as well as the various sources of government revenue in each country.

Results are decomposed into allocative efficiency and income effects, and by groups (capital owners, owners of other factors, and government revenue impacts) in each country. Mutual recognition is analysed in terms of its two components: Australian recognition of New Zealand's imputation credits, and New Zealand recognition of Australian imputation credits.

The paper consists of four sections. The first section outlines the rationale behind the imputation credit systems as they exist in Australia and New Zealand. The second section details the conceptual framework used to build the model. The third describes the intuition behind the model results, and the mechanisms driving them. The fourth presents conclusions and policy implications. Appendixes contain model data and parameters, as well as the full mathematical detail of the model.

The key insights from the model are that:

1. A unilateral imputation credit recognition policy would decrease fiscal revenue for the country recognising the credits, and increase fiscal revenue for the country whose credits are being recognised.
2. A mutual recognition policy is likely to bring about small, aggregate trans-Tasman efficiency gains by reducing trans-Tasman investment distortions. However, these changes further distort investment away from the rest of the world in favour of the trans-Tasman economies.
3. Due to the relative magnitudes of trans-Tasman investment and likely behavioural responses, a mutual recognition policy is likely to reduce Australian national income

and tax revenues, and increase New Zealand national income and tax revenues. That is, the gains from greater efficiency are unlikely to offset the impact of the fiscal costs for Australia.

Imputation credits in Australia and New Zealand

In Australia and New Zealand, company profits are taxed separately from personal income. When a company earns a profit, this profit is taxed at the respective countries' corporate tax rate (for example, in Australia this rate is 30 per cent). Dividend income is then taxed as shareholders' personal income. The top marginal income tax rate in Australia is 44.9 per cent, and in New Zealand is 33 per cent.

The combination of corporate and personal income taxes results in high effective tax rate on capital incomes in the absence of other policies (up to 61 per cent in Australia and 51 per cent in NZ). This has the potential to increase the cost of capital for firms as investors respond to high tax rates by reducing their supply of capital.

Within each country, this distortion is corrected through the use of imputation credits.[2] When a shareholder receives dividend income from previously taxed corporate income, a tax credit accrues to the shareholder. This credit can then be deducted from the total personal income tax liability. In this way, capital income faces the same effective marginal tax rate as other sources of personal income.[3]

Imputation credits can only be redeemed at the domestic tax office. Thus the imputation credit system reduces the tax rates faced by domestic investors in firms that pay domestic company tax. This creates a price incentive to invest in domestic companies. Under current arrangements, Australian residents have a bias in favour of Australian companies, and likewise for New Zealanders in New Zealand companies. Mutual recognition of imputation credits (MRIC), by removing this trans-Tasman bias, could generate aggregate trans-Tasman efficiency gains as it would allocate capital to more productive uses across the two economies. This efficiency gain could be partially offset by an exacerbation of the investment distortion away from the rest of the world. To the extent that investors redirect their resources away from the rest of the world and towards trans-Tasman economies where they receive a lower pre-tax return (although a higher post-tax return), capital owned by trans-Tasman investors is being used less productively.

While the total trans-Tasman efficiency gains are clear in theory, in practice the magnitude and distribution of the gains are unclear. The distribution and size of the impacts between the two countries, and across groups within each country, depends on the sensitivity of investors to the after tax return in both countries. In the absence of behavioural responses a

2 In Australia, imputation credits are called franking credits. The two terms — imputation and franking credits — describe the same type of tax credit.

3 This is a simplified description of the effect of the policy. For a more detailed description, see PC (2012).

unilateral imputation credit recognition policy involves a pure domestic transfer from government to capital owners; however, behavioural responses induce capital shifts between the countries and the rest of the world that have broader impacts on the distribution of income. These capital movements are the source of the aggregate trans-Tasman efficiency gains, and are also a source of income gains and losses in each economy individually.

The aggregate impact of MRIC is modelled as the combination of two distinct policies: the recognition by the Australian government of credits granted in New Zealand, and recognition by the New Zealand government of credits granted in Australia. The impacts of MRIC are likely to be affected by a range of factors, including (but not limited to) the trans-Tasman capital stocks in each country; the behavioural responses of investors; dividend payout rates and dividends claimed in each country; and projected capital growth rates.

For the remainder of this paper, recognition will be described by categorising one country as the 'source' and the other as the 'destination'. The source country is where the capital owner resides — the income from this capital accrues to the source country. If MRIC is introduced, the source country recognises credits on corporate tax already paid in the destination country (and is thus forgoing tax revenue). The destination country is where the capital is used, and the destination country collects tax revenue on corporate incomes earned in that country.

Model framework

The SMRIC model[4] is designed to illustrate the potential static efficiency, income and tax revenue impacts of imputation credits on the Australian, New Zealand and trans-Tasman economies. It is based on the theoretical frameworks presented in McDougall (1960) and Sørensen and Johnson (2009), and can be considered an extension of the general equilibrium models detailed in Dixon, Parmenter, Powell and Wilcoxen (1992). The model is calibrated almost entirely with data from the GTAP version 7 database (appendix A). It abstracts from any longer term dynamic effects after MRIC is introduced.

The SMRIC model is a stylised model, intended to give illustrative insights into the orders of magnitude of the impacts of MRIC. As there is uncertainty surrounding key data (such as trans-Tasman capital stocks) and parameter values, the model was used to analyse a large number of plausible parameter combinations by varying them simultaneously.

4 Small mutual recognition of imputation credits model.

Model overview

Two factors were particularly important to ensure that the modelling accounted for important features of the mechanisms at work:

- price-responsive behaviour of agents in both countries (households, firms and suppliers of capital); and
- an accurate representation of the mechanisms by which the imputation credits flow to shareholders (thus avoiding the use of imperfect proxy variables, often used in 'off the shelf' modelling exercises).

The SMRIC model is a comparative static general equilibrium model of the global economy, composed of three regions (Australia, New Zealand and the Rest of the World). The model contains the minimum level of detail necessary to illustrate these two drivers of allocative efficiency and national income effects (especially impacts on government revenues for each country) resulting from the policy change.

Allocative efficiency in the SMRIC model is measured through changes in real gross domestic product (GDP). While GDP measures output, it fails to account for the total impacts of changes in income as it does not account for the effects on income earned abroad.

Income in the SMRIC model is measured through changes in real gross national income (GNI). GNI accounts for all the income from factors owned by households (composed of domestic labour, capital and other factor incomes, as well as the income from overseas assets), net of taxes, and income from tax revenue.

Important components of the model are described below. The full model is included in appendix B. The model is implemented in GAMS, which facilitates the large number of simulations used for the sensitivity analysis.

Production and factor demands

Each region produces a single output which is consumed domestically and exported. Output is produced using a regional fixed factor (which includes labour) and capital, which can be sourced domestically and from the other regions. A nested constant elasticity of substitution production technology governs the ability of each region to substitute between the fixed factor and capital, as well as capital sourced from each region. The solution to the first order conditions for the cost minimisation problem faced by each region is used to create the factor demand equations for each region. Each region sells its output at the cost of production.

Final demands

Household income in each region is the sum of the returns to the region-specific factor as well as returns from domestically owned capital used at home and abroad. Households consume the goods that are produced, subject to their budget constraint. The first order conditions for the household optimisation problem are used to generate the household demand equations. Government spending changes in proportion with household consumption (subject to government revenue).

Factor supplies

The specific factor in each region is in fixed supply.

The stock of capital owned by households in each region is fixed and can be allocated across the three regions. The responsiveness of capital supply to changes in relative post-tax returns between regions is governed by an elasticity parameter. When the supply is highly elastic, capital owners are assumed to choose between regions based solely on relative post-tax rates of return. When supply is inelastic, suppliers have a preference for keeping their capital in particular regions, and capital is relatively immobile from the supply side.

Taxes and government revenue

Tax effects are an important aspect of the impacts of the policy on efficiency and incomes. Governments in each region collect revenue from capital income through a corporate income tax, and through taxes on personal income from all factors. In Australia and New Zealand, an imputation credit is granted to residents for corporate tax levied on domestic capital incomes.

For the policy simulations, imputation credits are also allocated to trans-Tasman investors. Any tax revenue lost to the source country government is assumed to translate into a corresponding decrease in GNI.

Results

The simple model structure and macro-accounting foundation of the SMRIC model aids in decomposing what would otherwise be very complex results. The model theory provides an intuitive explanation for the behavioural mechanisms at play in the results, but it fails to give an indication of the orders of magnitude involved, or even the sign of some flows. Quantification is required to assess the direction and orders of magnitude involved.

The SMRIC model was designed to explore a large range of possible input parameters — it was used to produce results for one million simulations, covering a large range of possible

parameter values (appendix A). These sensitivity analyses are important to convey the range of possible impacts on each country of introducing MRIC. The resulting sensitivity ranges provide important insights into which results are uncertain in sign, which are likely to be negative and which are likely to be positive; which results are likely to be small and which are likely to be large.

The following sections explain the results in greater detail, starting with an intuitive explanation without quantification. Results from an example simulation are used to connect these intuitive explanations to the quantitative results for the two unilateral recognition policies. The results for mutual recognition can then be obtained by combining the unilateral results. Finally, the results for MRIC are extended to include the full range of sensitivities examined with the model, resulting in sensitivity ranges and distributions of GDP, GNI and tax revenues for both countries.

Intuitive rationale of the mechanisms at play

Unilateral recognition

The drivers involved are described by analysing the effects of Australian recognition of New Zealand imputation credits.

Australian recognition of New Zealand imputation credits benefits Australian capital owners. When Australia recognises imputation credits for taxes paid in New Zealand, post-tax returns to Australian owners of capital used in New Zealand increase. This increase in relative post-tax returns would cause Australian owners of capital to reallocate their supply of capital away from Australia and the Rest of the World, and towards New Zealand. This quantity response partially moderates the initial increase in returns, as the increase in Australian capital stock in New Zealand is combined with fixed/other factors, which decreases its marginal product and the pre-tax rental rate. The shift of Australian owned-capital away from the Rest of the World in favour of New Zealand lowers the total income collected on Australian investments in the Rest of the World.

The increased supply of capital in New Zealand benefits New Zealand residents. As the stock of capital in New Zealand increases, the marginal product of the fixed factor increases. This manifests as increased returns to the specific factor (for example, an increase in the New Zealand real wage) or an increase in the utilisation of unemployed factors (for example, a decrease in unemployment in New Zealand).

The decreased supply of capital in Australia reduces the income of non-capital-owning Australian residents. As the Australian capital stock contracts, so does Australian output. This decreases the marginal product of the Australian specific factor, and national production.

Tax revenues increase in New Zealand. The additional Australian-owned capital in New Zealand is associated with an increase in the corresponding capital income, which is taxed at the corporate rate. The additional increase in output and returns to the New Zealand fixed factors increase income tax further.

Australian tax revenues decrease. The recognition of New Zealand imputation credits results in a direct loss of tax revenue to the Australian government as residents pay less income tax. Further revenue losses result from decreased corporate tax collections (as some Australian capital owners shift their capital to New Zealand due to the increased relative post-tax return, causing the stock of capital in Australia to contract) and decreased income tax (associated with the decline in returns to the Australian fixed factor). To the extent that Australian-owned capital moves from the Rest of the World to New Zealand, there are further tax revenue reductions, as the full income tax is collected on Rest of the World sourced income but imputation credit recognition reduces net income tax collected on capital incomes coming from New Zealand.

There is an unambiguous net income gain for New Zealand. New Zealand benefits from an increased supply of Australian capital with the resultant output expansion, and New Zealand owners of fixed factors benefit from increased post-tax returns. New Zealand corporate tax revenues increase; and income tax collections increase as a result of the increase in economic activity.

There is an unambiguous net income loss for Australia. The Australian government collects less tax revenue, and the returns to Australian fixed factors decline. Returns to Australian owners of capital used in New Zealand increase but only at a cost to the Australian government's fiscal revenue, while overall the income on holdings of foreign capital fall.

The aggregate improvement in allocative efficiency between Australia and New Zealand translates into small trans-Tasman income gains. These gains are small compared to the country-specific impacts. This is because the trans-Tasman impact is the sum of the New Zealand and Australian impacts, which counteract each other.

This analysis shows that, in aggregate, the unilateral recognition of imputation credits is unambiguously detrimental to the recognising economy, which loses capital and tax income, and beneficial to the partner economy whose capital stock increases.

Bilateral recognition

New Zealand recognition of Australian imputation credits produces the converse effects. The net effect of mutual recognition is approximately equal to the sum of unilateral recognition by each country (as the secondary interaction effects are very small). The sign of the net income effects cannot be determined from the analysis above, since these effects depend on the relative magnitudes of data and responses. Quantification is therefore required to ascertain these effects.

Results from an example simulation

Illustrative results for one set of parameters are detailed in this section to connect the intuitive explanation presented above to the quantitative results produced by the model. The results are not predictions: they illustrate the orders of magnitudes involved in applying the policy in isolation from any other influences, for one set of parameters (appendix A).

Australian recognition of New Zealand imputation credits

Abstracting from any quantity responses, Australia recognises $250 million worth of taxes paid in New Zealand, which accrues to Australian owners of capital that is located in New Zealand, in the form of increased post-tax returns. As part of this 'first round' effect, there are no changes in investment or capital stocks, national outputs and incomes remain fixed for both countries. There is a simple transfer from the Australian government to Australian owners of capital in New Zealand: there is no change in allocative efficiency, and no international transfers.

Behavioural responses

The increase in post-tax returns to Australian capital located in New Zealand causes the Australian-owned capital stock in New Zealand to increase by US$163 million (sourced from both Australian capital used domestically, and Australian capital used in the Rest of the World). The stock of capital in New Zealand expands by less than this (US$97 million), because US$66 million worth of New Zealand and Rest of the World capital located in New Zealand moves to other countries because the influx of Australian capital drives down the return to capital in New Zealand relative to the rest of the world. The capital stock used in Australia contracts by US$41 million (the large movement of capital from Australia to New Zealand is partially offset by backfilling with relatively substitutable capital from the Rest of the World). The total trans-Tasman imputation credits recognised after incorporating behavioural responses are US$263 million.

Australia's domestically-sourced capital contraction is partially offset by an inflow of capital from overseas. The rate of return on capital located in Australia increases as the stock shrinks, and firms substitute away from domestically sourced capital, towards capital from the Rest of the World. Rest of the World capital in Australia increases by US$42 million.

Table 1 **Impacts of Australian recognition of New Zealand imputation credits under an illustrative set of assumptions[a]**

Change US$m, 2012

	Trans-Tasman	*Australia*	*New Zealand*
Specific factor income accruing to households after tax[b]	**33**	**-72**	**105**
Returns to domestically owned and used capital accruing to households after tax	**32**	**-42**	**74**
Imputation credits granted for foreign capital taxes	**263**	**263**	**0**
Returns to domestically owned capital used overseas accruing to households after tax	**-33**	**-32**	**0**
used in Australia	1	na	1
used in New Zealand	-19	-19	na
used in the Rest of the World	-14	-13	-1
Taxes on personal income	**-264**	**-353**	**88**
Total tax collected on personal income	-32	-120	88
imputation credits granted for domestic company tax	31	31	0
imputation credits granted for foreign company tax	-263	-263	0
Company taxes levied on capital used domestically	**-1**	**-18**	**17**
Australian owned	9	-31	40
New Zealand owned	-3	-3	0
Rest of the World owned	-8	16	-23
Gross National Income[c]	***30***	***-254***	***284***

[a] The elasticity of substitution between specific factors and capital is assumed to be 0.85. The elasticity of substitution between capital from different sources are set to 10. [b] Region-specific inputs assumed to be in fixed supply. [c] Gross National Income (GNI) is the sum of the bolded items in the table. Technically, this does not exist for the trans-Tasman column, but is included for completeness.

The shift in capital from Australia to New Zealand has several effects (table 1).

1. The post-tax returns to Australian-owners of capital located in New Zealand increase. The consequent increase in supply of Australian capital to New Zealand and decrease in its marginal productivity moderates this increase in post-tax returns. The imputation credits granted to Australian owners of capital in New Zealand increase their after tax returns by $US 263 million (note that this component is a transfer between the Australian government and Australian taxpayer). This is partially offset by a US $32 million decline in their returns, as the price of Australian capital in New Zealand falls with the increase in supply, leaving a US$231 million increase in the return to Australian capital in New Zealand overall.
2. Returns to specific factors in New Zealand increase. With the inflow of Australian capital, New Zealand firms increase their demand for specific factors, thus increasing their productivity and returns by US$105 million (an increase of less than 0.1 per cent).
3. Conversely, with a reduced capital stock to combine with, returns to Australian specific factors decrease by US$72 million.

4. The increase in Australian-owned capital stock in New Zealand increases New Zealand company tax revenue by US$40 million. This is offset by a loss in company tax revenue in New Zealand on departing capital originating from the Rest of the World (US$23 million).[5]
5. Australian company tax revenues from domestically owned capital decrease (US$31 million), as capital from Australia moves to more productive and higher return uses in New Zealand.[6] This is partially offset by increased company tax on capital inflows from the Rest of the World (US$16 million).
6. The increase in specific factor income in New Zealand increases the corresponding income tax revenue by US$88 million and the increase in corporate tax collected on the increased capital income is US$17 million.
7. The decrease in payments to Australian specific factors (i.e. labour) reduces Australian income tax revenue by US$120 million. US$31 million is saved on credits paid on domestically used capital, and US$263 million is paid through recognised credits on capital in New Zealand. US$18 million in company tax revenues is lost from other foreign capital leaving Australia. This, combined with the $US231 imputation credit cost causes a net decrease in Australian tax revenue of US$370 million.

The net aggregate impacts of these responses are:

- an expansion in New Zealand GNI of US$284 million
- a net contraction in Australian GNI of US$254 million
- a small increase in trans-Tasman GNI of US$30 million. The GNI expansion is about 11 per cent of the size of the gains in GNI that accrue to New Zealand.

New Zealand recognition of Australian imputation credits

The drivers of the results for New Zealand recognising Australian imputation credits are the same when Australia recognises New Zealand imputation credits, only the direction of the capital flow is reversed. The effects are smaller because New Zealand capital plays a smaller role in the Australian economy: foreign capital in Australia comes mainly from the Rest of the World. In the illustrative example the value of Australian imputation credits

5 The increased supply of Australian-owned capital in New Zealand — which, in this scenario, is highly substitutable with other capital — drives down the rate of return in New Zealand. This causes some Rest of the World capital to leave New Zealand in search of more favourable returns elsewhere (including in Australia where returns increase).

6 Note that initially, the marginal product of Australian-owned capital in New Zealand is greater than that of its use in Australia — this is the source of the allocative efficiency gains from a trans-Tasman perspective. However, the marginal product of Australian capital in New Zealand declines due to the increase in its supply. That is, the additional Australian investment in New Zealand lowers its marginal product. When capital is assumed to be perfectly substitutable, the improved allocation of capital across the two economies causes the returns to equalise. Post simulation, the marginal products equate across countries, but are lower than the initial levels in New Zealand.

recognised in New Zealand would be US$163 million before incorporating behavioural responses, and US$171 million after (table 2).

Table 2 **Impacts of New Zealand recognition of Australian imputation credits under an illustrative set of assumptions[a]**

Change US$m, 2012

	Trans-Tasman	*Australia*	*New Zealand*
Specific factor income accruing to households after tax[b]	**-3**	**56**	**-60**
Returns to domestically owned and used capital accruing to households after tax	**30**	**58**	**-28**
Imputation credits granted for foreign capital taxes	**171**	**0**	**171**
Returns to domestically owned capital used overseas accruing to households after tax	**-49**	**-20**	**-30**
used in Australia	-30	na	-30
used in New Zealand	-8	-8	na
used in the Rest of the World	-11	-11	0
Taxes on personal income	**-134**	**72**	**-207**
Total tax collected on personal income	19	77	-58
imputation credits granted for domestic company tax	17	-5	22
imputation credits granted for foreign company tax	-171	0	-171
Company taxes levied on capital used domestically	**1**	**13**	**-13**
Australian owned	2	5	-2
New Zealand owned	6	28	-22
Rest of the World owned	-7	-19	12
Gross National Income[c]	***14***	***180***	***-166***

[a] The elasticity of substitution between specific factors and capital is assumed to be 0.85. The elasticity of substitution between capital from different sources are set to 10. [b] Region-specific inputs assumed to be in fixed supply. [c] Gross National Income (GNI) is the sum of the bolded items in the table. Technically, this does not exist for the trans-Tasman column, but is included for completeness.

Increased returns to New Zealand-owned capital in Australia increase Australia's capital stock by US$46 million, and decrease New Zealand's capital stock by US$34 million.

The net movement of capital toward Australia causes:

1. A net increase in post-tax payments to New Zealand-owned Australian capital of US$141 million (US$171 million less US$30 million)
2. A net increase in payments to Australian specific factors of US$56 million
3. A net decreases in payments to New Zealand specific factors of US$60 million
4. A net increase in Australian tax revenue of US$86 million (US$72 million plus US$13 million)
5. A net decrease in New Zealand tax revenue of US$219 million (US$207 million plus US$13 million).

New Zealand recognition of Australian imputation credits induces a net income decrease of US$166 million for New Zealand, and a net income increase of US$180 million for Australia. From a trans-Tasman perspective, there is a US$14 million increase in GNI.

Combined results for a mutual recognition of imputation credits policy from the example simulation

The income and production impacts of MRIC on Australia and New Zealand are equal to the sum of the two unilateral recognition policies. Since each policy results in unambiguous net national income gains for the destination and unambiguous net national income losses for the source, the difference between the impacts of the two unilateral policies determines the net outcome for each country. Similarly, the net impact on returns to the specific factors, tax revenue collection, and gross domestic product are also determined by the relative sizes of the initial flows and the modelled responses to changing returns to capital across the Tasman.

Combining the unilateral results (tables 1 and 2) gives the illustrative results for mutual recognition of trans-Tasman imputation credits (table 3).

Table 3 **Impacts of mutual recognition of trans-Tasman imputation credits under an illustrative set of assumptions[a]**

Change US$m, 2012

	Trans-Tasman	*Australia*	*New Zealand*
Specific factor income accruing to households after tax[b]	**30**	**-16**	**46**
Returns to domestically owned and used capital accruing to households after tax	**62**	**15**	**46**
Imputation credits granted for foreign capital taxes	**432**	**262**	**170**
Returns to domestically owned capital used overseas accruing to households after tax	**-81**	**-52**	**-30**
used in Australia	-29	na	-29
used in New Zealand	-27	-27	na
used in the Rest of the World	-25	-25	-1
Taxes on personal income	**-396**	**-279**	**-117**
Total tax collected on personal income	-12	-43	31
imputation credits granted for domestic company tax	47	26	21
imputation credits granted for foreign company tax	-432	-262	-170
Company taxes levied on capital used domestically	**0**	**-5**	**4**
Australian owned	12	-26	38
New Zealand owned	3	24	-21
Rest of the World owned	-15	-3	-12
Gross National Income[c]	***46***	***-74***	***120***

[a] The elasticity of substitution between specific factors and capital is assumed to be 0.85. The elasticity of substitution between capital from different sources are set to 10. [b] Region-specific inputs assumed to be in fixed supply. [c] Gross National Income (GNI) is the sum of the bolded items in the table. Technically, this does not exist for the trans-Tasman column, but is included for completeness.

Under the illustrative example parameter values, the effects of Australian recognition of New Zealand imputation credits dominate due to: the size of the initial capital stocks; the relative sizes of the two economies; and the assumed behavioural responses. Australian GNI contracts by US$74 million, and New Zealand GNI increases by US$120 million. Trans-Tasman output increases (US$38 million).

Other impacts are:

- a net increase in returns to Australian and New Zealand owners of capital used overseas of US$211 million (US$262 million in credits less US$52 million in reduced marginal product induced by increased supply) and US$140 million (US$170 million in credits less US$30 million), respectively
- a net increase in payments to New Zealand specific factors of US$46 million, and a net decrease of payments to Australian specific factors of US$16 million
- a net decrease in Australian and New Zealand tax revenue of US$284 million (US$279 million plus US$5 million) and US$113 million (US$117 million less US$4 million) respectively.

Ranges of model results, and sensitivity to alternative input data

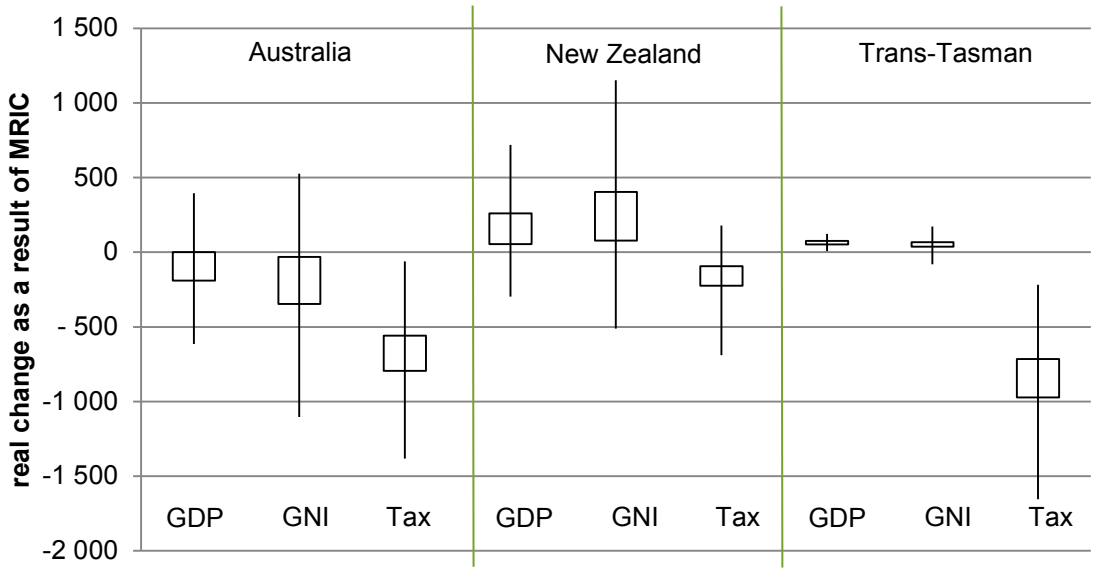
The SMRIC model was used to gain insights into the impacts of parameter values on model results. The relatively small size of the SMRIC model allowed a large number of simulations to be completed, each containing a random combination of parameters from assumed distributions. Compiling the results of all of these simulations gives insights into the distribution of projected income effects of MRIC.

The key insight is that investors respond to post-tax returns on capital. Changes in the tax paid change returns, which change investment behaviour. This change in the allocation of capital in turn changes the returns to the fixed factor. The size of this effect and the distribution across economies depends on the extent to which investors respond to changes in the post-tax returns.

Model sensitivity results

Figure 1 shows the ranges for GDP, GNI and net tax revenue impacts for Australia, New Zealand and the combined economies for the parameter combinations examined. The large range of results reflects the uncertainty about both the data and parameter values. There are small gains for the trans-Tasman economy as a whole and relatively large income changes for the two economies. The extent of the sensitivity test parameter and input variation is detailed in appendix A. This variation reflects uncertainty in data, as well as the potential scope for behavioural responses.

Figure 1 **Real impacts of changes in all parameters[a,b]**



a All parameters are varied simultaneously and are assumed to be uncorrelated. **b.** The diagram shows the ranges in which the results for the 1,000,000 parameter combinations fell. The boxed regions show the central 50 per cent of results (i.e. the 25th and 75th percentiles), while the ends of the tails show the minimum and maximum values. Results in the figure cannot be interpreted as coming from the same simulation; for example, the maximum Australian and New Zealand GDP values are obtained from different simulations.

The results confirm that there are unambiguous trans-Tasman allocative efficiency gains: all values for trans-Tasman GDP are positive (figure 1, right hand panel). Capital moves to where the post-tax returns are highest (trans-Tasman), which removes the domestic distortion in favour of a trans-Tasman neutrality. The key result to observe is that while there are small gains in aggregate, the gains and losses for each country individually can be quite large.

The trans-Tasman allocative efficiency gains are relatively small when compared to the impacts on Australia and New Zealand individually. In a majority of the parameter combinations examined, MRIC results in a net increase in GNI for New Zealand, and a net decrease in GNI for Australia.

The asymmetric GNI results for Australia and New Zealand are driven by differences in the sizes of capital stocks in the two countries, and the responses to increased returns. A situation in which both countries' GNI increases can only be achieved if the costs that Australia incurs by recognising New Zealand credits are more than offset by the benefits resulting from New Zealand recognising Australian credits. Given the initial asymmetries in investment data, this requires a fine balance of differential responses: for example, a limited capital supply response from Australia or markedly lower earnings distributed as

dividends in New Zealand than in Australia. If the response is too strong, the balance can be reversed, such that New Zealand GNI decreases, and Australian GNI increases.

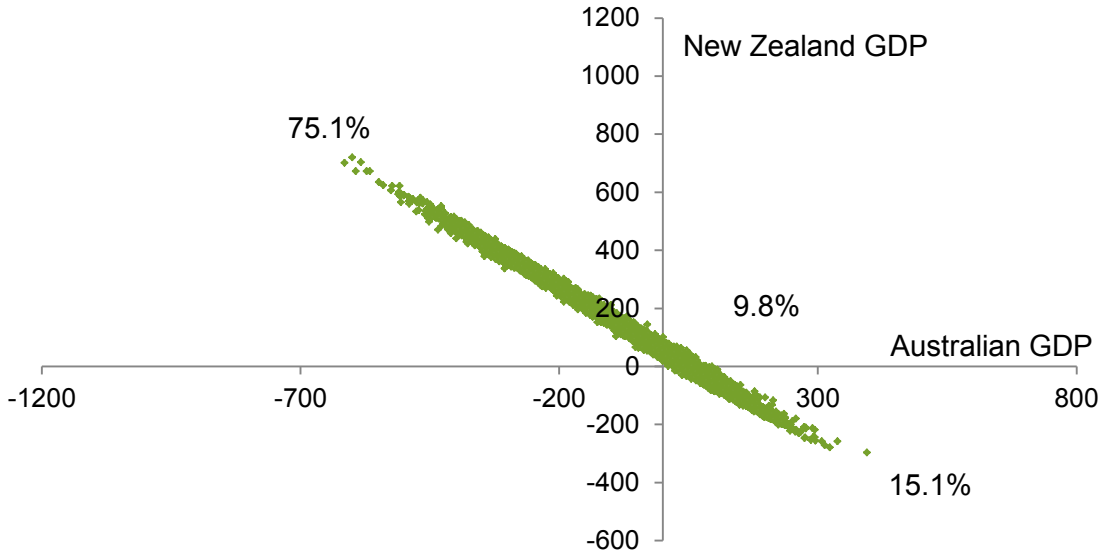
Given the relatively large amount of Australian capital invested in New Zealand, the tax revenue cost of MRIC is in almost all cases larger for Australia than it is for New Zealand. For a small number of parameter combinations, there is a net increase in tax revenue for New Zealand: the increase in revenues from personal taxation (as economic activity expands) and increased corporate tax collections on incoming capital is sufficient to offset the tax cost of the imputation credits granted. That said, in general, MRIC reduces tax income in both countries.

The results indicate that there is a relationship between the gains accruing to one country and the cost imposed on the other (figure 2) — that is, larger increases in GNI for one partner are associated with larger reductions in GNI for the other, the sum of which is the effect of MRIC on the trans-Tasman economy as a whole. While some parameter combinations lead to large increases in GNI for either country, this only happens where there are large losses for the other country – as identified in the second and fourth quadrants in figure 2. In these cases, the costs and benefits for Australia and New Zealand individually are considerably larger than the trans-Tasman allocative efficiency gains. Conversely, some parameter combinations can produce small gains and costs for each country — as identified in the first quadrant. For example, when capital is highly mobile, the changes in prices are relatively small, the trans-Tasman gains are small, the impacts on each country individually are small. The relationship between the results for each country and the trans-Tasman results are expected, since the trans-Tasman results are the sum of the results for each partner.

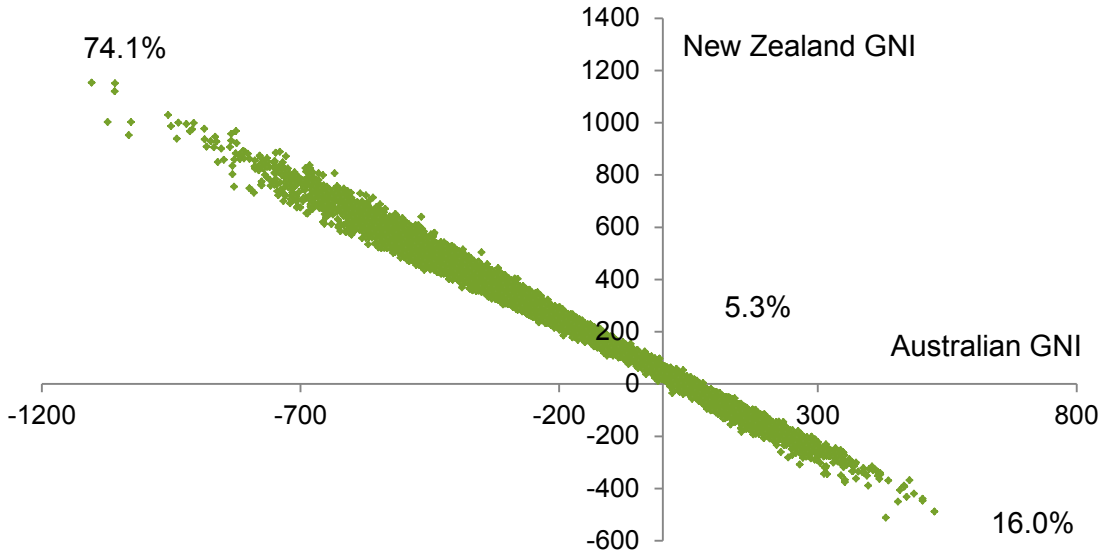
Capital substitutability limits the total change in productive capacity as a result of MRIC: while one country loses trans-Tasman capital, it also attracts capital from the Rest of the World, which limits the contraction in productive factors. However, this inflow of foreign capital does little to stem the net flow of income out of the country (although it provides a small amount of corporate tax revenue to the host government).

Figure 2 **Effects of MRIC on Australian and New Zealand GDP and GNI[a]**

Australian and New Zealand GDP for parameter combinations examined



Australian and New Zealand GNI for parameter combinations examined



a. The percentages in the chart show the percentage of parameter combinations that give results in the relevant quadrants: New Zealand and Australia both expand; New Zealand expands and Australia contracts; Australia expands and New Zealand contracts.

The asymmetric effects on Australia and New Zealand are consistent with intuition, given that the starting point is that Australian investment in New Zealand is largest. From a modelling perspective, Australia can gain if its business sector limits capital movement to New Zealand by limiting its investment response. Australia can then gain from capital inflows from New Zealand. That said, reducing Australia's investment response also reduces the potential gains to New Zealand. Allocative efficiency gains arise as a result of movement in trans-Tasman capital, and to the extent that trans-Tasman capital movement is reduced, so too are the trans-Tasman allocative efficiency gains that can accrue to Australia and New Zealand. In other words, achieving gains for both countries requires a very fine balance, that is, positive outcomes for both countries are predicated on very specific combinations of parameter values and input data.

Policy implications

The SMRIC model is a stylised representation of the Australian, New Zealand and Rest of the World economies, designed to examine the effects of the trans-Tasman recognition of imputation credits. It has been used to examine the allocative efficiency and income implications resulting from the interaction of company and personal income tax interactions with the introduction of imputation credits. The simple and flexible model structure allows the easy examination of the effects of changing parameters and input data, enabling comparison of a range of plausible values of parameters related to dividends; credits claimed; capital supply and demand elasticities; and trans-Tasman capital stock.

The model was able to inform policy analysis in a way that could not be done with conceptual analysis alone. While conceptual analysis could explain certain key mechanisms associated with an MRIC policy (point 1 below), economic modelling was necessary to understand the orders of magnitude involved in the productive, income and cross-country impacts, given that there are a range of influences pulling in different directions (points 2 to 6 below).

MRIC increases post-tax returns to Australian and New Zealand owners of capital in the partner economy. Based on the analysis, the key messages are:

1. Unilateral imputation credit recognition policies result in GDP and GNI losses for the recognising country and gains for the partner country.
2. An MRIC policy improves the allocation of trans-Tasman capital, which results in small increases in trans-Tasman GDP and GNI. The trans-Tasman investment distortion away from the rest of the world is increased.
3. The costs and benefits of mutual recognition are unlikely to be shared evenly between Australia and New Zealand.
4. In 9.8 per cent of parameter combinations examined, GDP increased for both economies. GNI increased for both economies in 5.3 per cent of the combinations examined.

5. New Zealand is more likely to benefit from the policy than Australia. In 21.3 per cent of parameter combinations examined, Australian GNI increases as a result of MRIC. New Zealand GNI increases in 84.0 per cent of combinations.
6. The tax revenue cost is likely to be larger for Australia than for New Zealand, because credits are granted on inframarginal capital, and the existing stock of Australian owned capital in New Zealand is larger than the stock of New Zealand owned capital in Australia. On average across all the different model runs, 80.6 per cent of the trans-Tasman revenue cost is borne by Australia (or, put differently, 80.6 per cent of the total tax credits accrue to Australian capital owners).

Appendix A: data and parameter inputs

Two types of data are required: initial values or economic flows that are based largely on national accounts, and behavioural parameters (which were subjected to extensive sensitivity testing).

Initial database values

The model is parameterised primarily with national accounts and balance of payments data sourced from the Australian Bureau of Statistic (ABS) and Statistics New Zealand (SNZ); additional data were sourced from the GTAP 7 database used by the Australian Productivity Commission (2012). Trans-Tasman foreign investment data were sourced from SNZ. Tax revenues were calculated with top marginal tax rates sourced from the Australian Tax Office (ATO) and the Internal Revenue Department (IRD) New Zealand tax schedules.[7] The Australian and New Zealand macroeconomic data are derived from official statistics. Bilateral incomes on foreign capital are based on shares derived from ANZEA, ABS and SNZ data. Data for the rest of the world are largely sourced from the ANZEA database.

The integrated database is calibrated in US$ and summarised in table 4. The data show that in 2010:

- around 75 per cent of New Zealand's foreign capital income was earned in Australia; 18 per cent of Australia's foreign capital income was earned in New Zealand[8,9]
- New Zealand capital owners accounted for 8 per cent of foreign capital income generated in Australia; Australian capital owners accounted for 58 per cent of foreign capital income generated in New Zealand
- For both Australia and New Zealand, capital incomes sent overseas exceeded capital incomes received from overseas.

7 A possible alternative is to calibrate on tax revenues collected. That said, results are not affected substantially by this approximation.

8 Capital income in this sense is income subject to corporate tax. It excludes some forms of capital income such as foreign income associated with unincorporated enterprises.

9 These data are provided by SNZ. There is significant variation between these data and those published by the ABS. Differences in ABS and SNZ statistics are shown in table 4. The different numbers across sources was part of the motivation for the sensitivity testing.

Table 4 **Basic macroeconomic relationships**

2010 US$m

	Australia	*New Zealand*	*Rest of the World*
Balance of Payments			
Exports	252 948	37 221	257 713
Imports	239 405	35 280	273 197
Trade balance	**13 543**	**1 941**	**-15 484**
Corp. capital income received from o/seas (pre-tax)	20 771	4 078	38 189
Corp. capital income paid to o/seas owners (pre-tax)	-38 277	-7 185	-17 576
Revenue from company tax on foreign capital	8 833	1 572	1 598
Company tax paid o/seas	-2 424	-802	-8 777
Net debt, net remittances, net investment flows	-2 446	395	2 051
Total balance of payments	**-13 543**	**-1 941**	**15 484**
Income and expenditure			
Labour, land income and other taxes	1 023 366	113 743	66 103 272
Domestic corporate capital income	143 468	12 411	10 595 672
Foreign corporate capital income (trans-Tasman)	3 274	2 371	
Foreign corporate capital income (other)	15 073	906	29 412
Revenue from company tax on foreign capital	8 833	1 572	1 598
Net debt, net remittances, net investment flows	-2 446	395	2 051
Gross National Income	**1 191 568**	**131 398**	**76 732 004**
Consumption of domestic production	952 163	96 118	76 458 807
Consumption of imports	239 405	35 280	273 197
Gross National Expenditure	**1 191 568**	**131 398**	**76 732 004**
Gross domestic product (GDP)			
Consumption, Investment, Government spending	1 191 568	131 398	76 732 004
Exports	252 948	37 221	257 713
Imports	239 405	35 280	273 197
GDP (Expenditure side)	**1 205 111**	**133 339**	**76 716 520**
Specific factor income (including taxes)	1 023 366	113 743	66 103 272
Corporate capital income (including taxes)	181 745	19 596	10 613 248
GDP (Income side)	**1 205 111**	**133 339**	**76 716 520**

Behavioural parameters and sensitivity analysis

The SMRIC model was developed to examine whether general conclusions can be drawn, given the large amount of uncertainty surrounding key data (such as trans-Tasman capital stocks) and parameter values. The model was used to analyse a large number of plausible parameter combinations by varying them simultaneously. The sensitivity ranges examined for this analysis are detailed in table 5.

For the purposes of the sensitivity analyses, Australian and New Zealand parameters were allowed to vary separately to allow the impacts of economic asymmetries between the two countries to be explored in the analysis. Parameters were assumed to be uncorrelated. Normal distributions were assigned to all parameters around an 'example value' (these 'example values' were used for the illustrative example simulation detailed in tables 1, 2 and 3) . One million parameter combinations were examined, based on random sampling of the distributions detailed in table 5.

Table 5 **Parameters and data used to construct model result ranges**

	Lower 95% bound	*Upper 95% bound*	*Example value*[f]
Total share of earnings distributed as dividends and credits subsequently claimed[a]			
Australia	0.2	0.3	0.25
New Zealand	0.2	0.3	0.25
Supply responsiveness of capital [b]			
Australia	1.0	6.0	2.5
New Zealand	1.0	6.0	5.0
Capital demand substitutability [c]			
Australia	0.85	10	10
New Zealand	0.85	10	10
Capital incomes (US $m 2010)			
Value of taxable Australian capital incomes in NZ	3 802[e]	4 191[d]	4 191
Value of taxable NZ capital incomes in Australia	1 102[e]	2 382[d]	2 382

[a] Both of these components were combined in a normal distribution such that there was a 95 per cent chance of the combined value being between 0.2 and 0.3. [b] A value of zero would represent a capital supplier unwilling to change the location of their capital supply, while a value of 6 indicates a capital supplier who makes a decision on where to locate their capital based purely on relative returns. Values in excess of 6 roughly converge to infinity. [c] A low value represents differentiation between capital from different countries. A high value represents near perfect substitutability between capital from different countries. [d] Statistics New Zealand unpublished data. [e] Australian Bureau of Statistics cat no. 5206. [f] The example values are used for an illustrative simulation used in the next section to explain the mechanisms and drivers of results, before examining the range of sensitivity results from all the simulations.

Appendix B: Mathematical detail

The SMRIC model includes three regions — Australia, New Zealand and the Rest of the World. Each region produces a unique type of output; firms seek to minimise the cost of production using four factors of production: a factor that is assumed not to relocate (a fixed factor, which includes labour); and three region-specific types of capital that are internationally substitutable. A fixed stock of capital in each region is supplied across regions based on a constant elasticity of transformation.

Incomes from factors less taxes on returns in the destination region (such as payroll and other taxes on labour, and company tax for capital) accrue to the owners of the factors, and this income is then subject to the personal tax rate in the source region. Each region has final demands linked to net income for each of the three types of output, substituting between them based on relative prices.

The remainder of this appendix documents the key variables and equations in the SMRIC model.

The following letters represent sets in the model:

1. r,s,t: region in which output is produced
2. i,j: region from which an input is sourced
3. c: region in which output is consumed

The following terms are parameters in the model:

4. $\theta l(r)$: CES parameter, share of labour in total cost in r
5. $\theta k(r)$: CES parameter, share of all capital in total cost in r
6. $\theta tt(r)$: CES parameter, share of all trans-Tasman capital in total capital cost in r
7. $\theta row(r)$: CES parameter, share of Rest of the World capital in total capital cost in r
8. $\theta aus(r)$: CES parameter, share of Australian capital in total trans-Tasman capital cost in r
9. $\theta nzl(r)$: CES parameter, share of New Zealand capital in total trans-Tasman capital cost in r
10. $\sigma_{LK}(r)$: Substitution elasticity between labour and top-level capital composite in r
11. $\sigma_{RoW}(r)$: Substitution elasticity between trans-Tasman capital composite and Rest of the World capital in r

12. $\sigma_{TT}(r)$: Substitution elasticity between Australian and New Zealand sourced capital in r
13. $\sigma_{KS}(i)$: Capital supply substitution elasticity between regions
14. $plbar(r)$: initial price of labour in r
15. $pkbar(i,r)$: initial price of capital in r sourced from i
16. $p2bar(r)$: initial price of capital composite (Rest of the World and trans-Tasman) in r
17. $p3bar(r)$: initial price of trans-Tasman capital composite (
18. $qcbar(c)$: initial level of output in c
19. $qlbar(r)$: initial labour endowment in region r
20. $qkbar(i,r)$: initial labour endowment, owned by i used in r
21. $\gamma(r) = 1 - \sigma(r)$, where $\sigma(r)$ is the elasticity of substitution between inputs in r
22. $tK(i,r)$: taxes on capital used in r sourced from i, accruing to i
23. $tL(r)$: taxes on labour used in r
24. $tY(r)$: income taxes in r
25. $tC(r,c)$: consumption taxes on r consumed in c, accruing to c
26. $\alpha(r,c)$: Cobb-Douglas consumption parameter for good r consumed in c

The following terms are variables in the model:

27. $Cost(r)$: total cost of production in region r
28. $Cost1(r)$: unit cost of input composite in region r
29. $Cost2(r)$: unit cost of capital composite in region r
30. $Cost3(r)$: unit cost of trans-Tasman capital composite in region r
31. $XRoW(r)$: demand for capital sourced from the Rest of the World used in r
32. $XAus(r)$: demand for capital sourced from Australia used in r
33. $XNzl(r)$: demand for capital sourced from New Zealand used in r
34. $PlD(r)$: wage rate (incl. tax) in region r
35. $PlS(r)$: wage rate (post tax) in region r
36. $QlD(r)$: quantity of labour demanded in region r
37. $PkD(i,r)$: rental rate of capital sourced from i used in r
38. $PkS(i,r)$: post-tax return to capital owned in i supplied to r
39. $QkD(i,r)$: demand for capital sourced from i used in r
40. $QkS(i,r)$: demand for capital sourced from i used in r

41. $PoD(r,c)$: price of output r consumed in region c
42. $PoS(r)$: price of supply in region r
43. $QoD(r,c)$: quantity of output r demanded in region c
44. $QoS(r)$: total quantity of output r
45. $Y(c)$: total incomes in region c
46. $Yd(c)$: disposable household income in region c
47. $Yg(c)$: government revenues in region c

Production side

Firms in region r minimise their cost of production (by sourcing inputs from region i) subject to a constant elasticity of substitution (CES) production function. Based on this optimisation problem, the first order conditions imply cost and input demand functions. Cost functions are nested with three levels: level 1 governs the substitutability between labour and capital; level 2 the substitutability between trans-Tasman capital and rest of the world capital; and level 3 the substitutability between Australian and New Zealand sourced capital.

$$Cost(r) = QoS(r).Cost1(r)$$

$$Cost1(r) = \left[\theta l(r)\left(\frac{PlD(r)}{plbar(r)}\right)^{1-\sigma_{LK}(r)} + \theta k(r)\left(\frac{Cost2(r)}{p2bar(r)}\right)^{1-\sigma_{LK}(r)}\right]^{\frac{1}{1-\sigma_{LK}(r)}}$$

$$Cost2(r) = \left[\theta tt(r)\left(\frac{Cost3(r)}{p3bar(r)}\right)^{1-\sigma_{RoW}(r)} + \theta row(r)\left(\frac{PkD('RoW',r)}{pkbar('RoW',r)}\right)^{1-\sigma_{RoW}(r)}\right]^{\frac{1}{1-\sigma_{RoW}(r)}}$$

$$Cost3(r) = \left[\theta aus(r)\left(\frac{PkD('Aus',r)}{pkbar('Aus',r)}\right)^{1-\sigma_{TT}(r)} + \theta nzl(r)\left(\frac{PkD('Nzl',r)}{pkbar('Nzl',r)}\right)^{1-\sigma_{TT}(r)}\right]^{\frac{1}{1-\sigma_{TT}(r)}}$$

$$QlD(r) = \frac{QoS(r)}{\sum_c qcbar(c)}.\left(\frac{PlD(r)}{plbar(r)}\right)^{-\sigma_{LK}(r)} \times Cost1(r)^{\sigma_{LK}(r)}$$

$$XRoW(r) = \frac{QoS(r)}{\sum_c qcbar(c)} . \left(\frac{PkD('RoW', r)}{pkbar('RoW', r)} \right)^{-\sigma_{RoW}(r)} \times Cost1(f,r)^{\sigma_{LK}(r)} \times Cost2(r)^{\sigma_{RoW}(r) - \sigma_{LK}(r)}$$

$$XAus(r) = \frac{QoS(r)}{\sum_c qcbar(c)} . \left(\frac{PkD('Aus', r)}{pkbar('Aus', r)} \right)^{-\sigma_{TT}(f,r)} \times Cost1(r)^{\sigma_{LK}(r)} \times Cost2(r)^{\sigma_{RoW}(r) - \sigma_{LK}(r)} \times Cost3(r)^{\sigma_{TT}(r) - \sigma_{RoW}(r)}$$

$$XNzl(r) = \frac{QoS(r)}{\sum_c qcbar(c)} . \left(\frac{PkD('Nzl', r)}{pkbar('Nzl', r)} \right)^{-\sigma_{TT}(f,r)} \times Cost1(r)^{\sigma_{LK}(r)} \times Cost2(r)^{\sigma_{RoW}(r) - \sigma_{LK}(r)} \times Cost3(r)^{\sigma_{TT}(r) - \sigma_{RoW}(r)}$$

$$QkD(i,r) = XAus(r)|_{i=Aus} + XNzl(r)|_{i=Nzl} + XRoW(r)|_{i=RoW}$$

Factor supply prices (the post-tax return on capital, and post-tax wage) are defined as the demand prices (the rental rate of capital, and the wage) less taxes:

$$PkS(i,r) = PkD(i,r).(1 - tK(i,r))$$

$$PlS(i) = PlD(r).(1 - tL(r))$$

The supply of output is determined such that suppliers from region r meet the sum of demands from all regions C. Output is region specific. Output in each country is a fixed proportions combination of large and small firm output. The market clearing condition determines the level of output:

$$QoS(r) = \sum_c QoD(r,c)$$

Factor supply side

The market clearing conditions between the demand and supply sides for each factor determine the price.

Labour factor supplies are determined by national capacity constraints. Labour is fixed by country.

$$QlD(r) = qlbar(r)$$

Global capital supplies are governed by a constant elasticity of supply functional firm. Capital owners in each region are assumed to maximise the return to their investment by

allocating a fixed capital stock globally. Changing the elasticity adjusts the preference capital owners have for particular regions. In the extreme cases, (1) capital owners decide between regions based solely on rates of return, without preference for particular regions when the elasticity is large and (2) capital owners desire a fixed portfolio share (reflecting a globally diverse portfolio) of their capital in each region when the elasticity is low.

$$QkD(i,r) = QkS(i,r)$$

$$QkS(i,r) = \frac{(\sum_s qkbar(i,s))\left(\frac{kbar(i,r)}{\sum_s qkbar(i,s)}\right)\left(\frac{PkS(i,r)}{pkbar(i,r) - taxk(i,r)}\right)^{\sigma_{KS}(i)-1}}{\sum_t \left[\left(\frac{kbar(i,t)}{\sum_s qkbar(i,s)}\right)\left(\frac{PkS(i,t)}{pkbar(i,t) - taxk(i,t)}\right)^{\sigma_{KS}(i)-1}\right]}$$

Consumption side

Consumers maximise their CES utility subject to a constrained budget. For the purposes of this simplified example, consumers are treated as having a Cobb–Douglas utility function. The first order conditions imply final demands:

$$QoD(r,c) = \frac{\alpha(r,c).Y(c)}{PoD(r,c)}$$

The supply price is defined as the demand price less consumption taxes:

$$PoS(r) = PoD(r,c).(1 - tC(r,c))$$

National income is the sum of household income and government revenue, such that:

$$Y(c) = Yd(c) + Yg(c)$$

$$Yd(c) = (1 - tY(c)).\left(\sum_f PlD(c).QlD(c) + \sum_r PkD(c,r).Qkd(c,r) - \sum_r tK(c,r).Pkd(c,r).Qkd(c,r)\right)$$

$$Yg(c) = \frac{tY(c)}{1 - tY(c)}.Yd(c) + \sum_{f,i} tK(i,c).Pkd(i,c).Qkd(i,c)$$

Suppliers are assumed not to earn any rents, such that:

$$PoS(r).QoS(r) = Cost(r)$$

The model was specified in the GAMS software, as an MCP. It was solved using the PATH solver.

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