The role of modelling in evaluating the Trans-Tasman recognition of imputation credits

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ABSTRACT

Economic models are often used to provide insights into the possible impacts of policy change. Stylised, purpose built models can be useful for providing transparent, replicable and easily understood results that are accessible for policy makers. Perhaps most importantly, custom models can include the policy as it is implemented, without having to rely on the structure of pre-existing models.

As part of the Productivity Commission's Strengthening Trans-Tasman Economic Relations study, the Mutual Recognition of Imputation Credits (MRIC) emerged as an issue important to stakeholders. Conceptual analysis by both the Australian and New Zealand Commissions was only able to illuminate some of the impact that could result from the policy. Staff at the Australian Productivity Commission developed a model to examine the economic efficiency and income transfer implications associated with trans-Tasman imputation credit policies.

This paper details how simple, custom-built models can inform policy analysis, particularly by illustrating the potential impact of policy, and the ranges those results could be expected to take. These concepts are illustrated by applying a purpose-built model to examine trans-Tasman imputation credit policies.

JEL codes: C61, C63, C68, F21, F24, H25, H87

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1 The views expressed in this paper are those of the author and do not necessarily reflect the views of the Productivity Commission.
I. Introduction

Australia and New Zealand both have a system of imputation credits, introduced in the 1980s. When dividends from previously taxed corporate income are paid to shareholders, shareholders receive an income tax credit for the corporate tax already paid. This policy is aimed at removing a distortion that favours equity financing. While Australia and New Zealand both 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 biases investment toward domestic investment and leads to sub-optimal investment allocation.

The business community in particular has suggested that mutual recognition of imputation credits (MRIC) could potentially remove the trans-Tasman investment distortion, by enabling capital to flow where it has the highest marginal product. However, this would be accompanied by significant wealth and government revenue transfers between the two countries.

This paper uses a quantitative model to illustrate the economic impacts of trans-Tasman imputation credit policies. The model was developed to assist a recent 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 more detailed insights into the productive, income an cross-country implications of the policy. The Australian Commission therefore decided to build a model that would illustrate these effects and, to an extent, quantify them.

The model is intuitive and transparent, containing the minimum detail necessary to provide insights into the effects of the policy. The nature of the model allows
analysts to focus on the relevant issues: implementing the taxes as they are applied in each country without the use of proxy variables, and a detailed sensitivity analysis due to the large amount of uncertainty surrounding model parameters.

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 and across countries. Mutual recognition is analysed in terms of its two components: Australia recognises New Zealand’s imputation credits, New Zealand recognises Australia’s imputation credits.

The paper is divided into five sections. Section 1 outlines the rationale behind imputation credit systems as they exist in Australia and New Zealand. Section 2 details the conceptual framework and data used to build a model to evaluate the potential impacts of trans-Tasman imputation credit policies. Section 3 describes the intuition behind the model results, and the mechanisms driving the results. Section 4 presents conclusions and policy implications.

II. 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 in Australia or New Zealand, 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 would result in an 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, reducing their level of investment.²

² Australia has a concessional tax rate on superannuation of 15 per cent, which to an extent would alleviate high effective tax rates on some forms of investment.
Within each country, this distortion is corrected through the use of imputation credits.\(^3\) 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 tax liability that the individual incurs. In this way, capital income faces the same effective marginal tax rate as other sources of personal income.\(^4\)

Imputation credits can only be redeemed with the domestic tax office. Thus the imputation credit system reduces the tax rates faced by domestic investors but maintains relatively high tax rates for foreign shareholders. Mutual recognition of imputation credits (MRIC) could potentially generate aggregate, trans-Tasman efficiency gains, due to the more productive allocation of capital across the two economies in aggregate. However, the distribution and size of the impacts between the two countries, and across groups within each country, is not immediately clear. This was a significant issue for the inquiry, because while the terms of reference required analysis of the ‘joint net benefits’ of reforms, the Commissions considered that it was also important to report the impacts on each country individually.

The aggregate impact of MRIC can be thought of as the combination of two distinct policies: the recognition by Australia of New Zealand imputation credit, and vice versa. 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 one as the ‘destination’. The source country is where the capital owner resides. If MRIC is introduced, the source country recognises credits on corporate tax already paid in the destination country (and is thus

\(^3\) In Australia, imputation credits are called franking credits. The two terms describe the same type of tax credit.

\(^4\) This is a simplified description of the effect of the policy. For a more detailed description, see PC (2012).
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.

**III. Model framework and data**

The model set out in this paper uses publicly available data to gain insights into the efficiency and distributional effects of the trans-Tasman recognition of imputation credits. The aim is to illustrate the impacts of the policy on efficiency and income in both Australia and New Zealand, as well as the trans-Tasman economy as a whole. The quantification is required to understand how the relative magnitudes interact.

Given the uncertainty surrounding key behavioural parameters, the model was used to explore the ranges of outcomes that could result from MRIC. Providing ranges of results improves the usefulness of the insights that can be drawn from modelling, and avoids attaching too much importance to a particular estimate.

**3.2 Model framework**

The SMRIC model 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). It is a stylised model, intended to give illustrative insights into the orders of magnitude of the impacts of MRIC. It does not take account of any longer term dynamic effects of the changes in investment flows after MRIC is introduced.
3.1.1 Model overview

The SMRIC model is simple and transparent, while still providing useful insights into the policies in question. The model was specified to contain the minimum level of detail necessary to illustrate the drivers of allocative efficiency and national income effects (in particular, international revenue transfers) of the policy. Two factors were particularly important to ensure the accuracy of the modelling: 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 built around standard neoclassical economic theory. It is a comparative static general equilibrium model of the global economy, and includes three regions (Australia, New Zealand and the Rest of the World).

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. This is because, among other things, production does not account for effects on income earned abroad, which contributes to the amount of goods and services that can be purchased.

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) and income from tax revenue.

The equations, variables and parameters contained in the model are detailed in the appendix.

3.1.2 Production and factor demands

Each region produces a single output which is consumed domestically, and exported to the remaining regions. Output is produced using a regional fixed factor 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.

3.1.3 Final demands

Household income in each region is the sum of the returns to the region specific factor (which includes labour) as well as returns from capital used domestically 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).

3.1.4 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.

3.1.5 Taxes and government revenue

Taxes have an important impact on the efficiency and income outcomes of the policy in the model. Governments in each region collect revenue from capital income through a corporate tax rate, and through taxes on personal income from
all factors. In Australia and New Zealand, an imputation credit is granted for corporate tax already levied on capital incomes domestically.

For the policy simulations, the imputation credits from the trans-Tasman partner are also credited. Any tax revenue lost to the source country government is assumed to translate into a corresponding decrease in spending, with consequent effects on GNI.

3.2 Data

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).

3.2.1 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 ANZEA 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. 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 1. The data show that in 2010:

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5 A possible alternative is to calibrate on tax revenues collected. That said, results are not affected substantially by this approximation.
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\textsuperscript{6,7}

New Zealand capital owners accounted for 8 per cent of foreign corporate capital income generated in Australia; Australian capital owners accounted for 58 per cent of foreign corporate capital income generated in New Zealand

For both Australia and New Zealand, capital incomes sent overseas exceeded capital incomes received from overseas.

\textsuperscript{6} 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.

\textsuperscript{7} 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 2.
Table 1  Basic macroeconomic relationships
2010 US$m

<table>
<thead>
<tr>
<th></th>
<th>Australia</th>
<th>New Zealand</th>
<th>Rest of the World</th>
</tr>
</thead>
<tbody>
<tr>
<td>Balance of Payments$^a$</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exports</td>
<td>252 948</td>
<td>37 221</td>
<td>257 713</td>
</tr>
<tr>
<td>Imports</td>
<td>239 405</td>
<td>35 280</td>
<td>273 197</td>
</tr>
<tr>
<td><strong>Trade balance</strong></td>
<td><strong>13 543</strong></td>
<td><strong>1 941</strong></td>
<td><strong>-15 484</strong></td>
</tr>
<tr>
<td>Corporate capital income received from o/seas (pre-tax)</td>
<td>20 771</td>
<td>4 078</td>
<td>38 189</td>
</tr>
<tr>
<td>Corporate capital income paid to o/seas owners (pre-tax)</td>
<td>-38 277</td>
<td>-7 185</td>
<td>-17 576</td>
</tr>
<tr>
<td>Revenue from company tax on foreign capital</td>
<td>8 833</td>
<td>1 572</td>
<td>1 598</td>
</tr>
<tr>
<td>Company tax paid o/seas</td>
<td>-2 424</td>
<td>-802</td>
<td>-8 777</td>
</tr>
<tr>
<td>Net debt, net remittances, net investment flows$^b$</td>
<td>-2 446</td>
<td>395</td>
<td>2 051</td>
</tr>
<tr>
<td><strong>Total balance of payments</strong></td>
<td><strong>-13 543</strong></td>
<td><strong>-1 941</strong></td>
<td><strong>15 484</strong></td>
</tr>
</tbody>
</table>

Income and expenditure

|                           |           |             |                   |
| Labour, land income, other taxes and non-corporate capital income | 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)$^c$ | 3 274 | 2 371 |             |
| Foreign corporate capital income (other)$^d$ | 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$^b$ | -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)$^a$

|                           |           |             |                   |
| 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** |

$^a$ Balance of payments and trade figures in the Rest of the World column refer to payments and flows between the Rest of the World and Australia and New Zealand. $^b$ This item used as a balancing item and therefore does not correspond to official data. It aggregates items from the income and capital accounts. $^c$ Trans-Tasman foreign capital income refers to foreign capital income that is earned in one trans-Tasman country and accrues to the other trans-Tasman country. $^d$ This represents gross income after tax received as capital income from overseas. Payments to overseas equity and debt are accounted for in the balance of payments as capital income paid to o/seas owners (pre-tax).
3.2.2 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 therefore 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 2.

For the purposes of the sensitivity analyses detailed later in this paper, 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’. This example is used to illustrate the mechanisms and drivers of the results. The sign, magnitude, and distribution of the income and allocative efficiency impacts are affected differently by each of the parameter sensitivities examined. One million parameter combinations were examined, based on random sampling of the distributions detailed in table 2.
**Table 2  Parameters and data used to construct ranges of model results**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Lower 95% bound</th>
<th>Upper 95% bound</th>
<th>Example values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total share of earnings distributed as dividends and credits subsequently claimed(^a)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Australia</td>
<td>0.2</td>
<td>0.3</td>
<td>0.25</td>
</tr>
<tr>
<td>New Zealand</td>
<td>0.2</td>
<td>0.3</td>
<td>0.25</td>
</tr>
<tr>
<td>Supply responsiveness of capital (^b)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Australia</td>
<td>1.0</td>
<td>6.0</td>
<td>2.5</td>
</tr>
<tr>
<td>New Zealand</td>
<td>1.0</td>
<td>6.0</td>
<td>5.0</td>
</tr>
<tr>
<td>Capital demand substitutability (^c)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Australia</td>
<td>0.85</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>New Zealand</td>
<td>0.85</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Capital incomes (US $m 2010)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Value of taxable Australian capital incomes in New Zealand</td>
<td>3 802(^e)</td>
<td>4 191(^d)</td>
<td>4 191</td>
</tr>
<tr>
<td>Value of taxable New Zealand capital incomes in Australia</td>
<td>1 102(^e)</td>
<td>2 382(^d)</td>
<td>2 382</td>
</tr>
</tbody>
</table>

\(^a\) 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.
IV. Results

The simple model structure and macro-accounting foundation of the SMRIC model aids in decomposing what would otherwise be very complex results. Explaining the logic driving the results provides insights into the mechanics driving the income and allocative efficiency impacts.

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 (section 4.1). Quantification is required to assess the direction and orders of magnitudes involved. Results from the example simulation (for set of parameter values) connects these intuitive explanations to the quantitative results for unilateral recognition (4.2). The results for mutual recognition can then obtained by combining the unilateral results (4.3). 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 revenue for both countries (4.4). The SMRIC model was used to produce results for one million simulations, covering a large range of possible parameter values. These sensitivity analyses are important to convey the range of possible impacts on each country of introducing MRIC.

4.1 Intuitive rationale of the behavioural mechanisms at play

4.1.1 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 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 income.

Tax revenues increase in New Zealand. The additional Australian-owned capital in New Zealand is associated with an increase in the corresponding 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 the capital stock contracts) and decreased income tax (associated with the decline in returns to the Australian fixed factor).

There is an unambiguous net income gain for New Zealand. New Zealand benefits from an increased supply of Australian capital, 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 these income gains are not large enough to offset the lost tax revenue and specific factor income.

The aggregate improvement in allocative efficiency 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.

4.1.2 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.

4.2 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 assumed parameter set (detailed in table 2).
4.2.1 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 owners of Australian 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 in aggregate, and there is a simple transfer from Australian taxpayers to Australian owners of capital in New Zealand.

Behavioural responses complicate this story; these effects are reported in table 3. The increase in post-tax returns to Australian capital located in New Zealand causes 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 Rest of the World capital). 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 Australian capital increases as the stock shrinks, and firms substitute away from domestically sourced capital, towards rest of the world capital. The net effect is that Rest of the World capital used in Australia increases by US$42 million.
Table 3  Impacts of Australian recognition of New Zealand imputation credits under an illustrative set of assumptions\textsuperscript{a}

<table>
<thead>
<tr>
<th>Change US$m, 2012</th>
<th>Trans-Tasman</th>
<th>Australia</th>
<th>New Zealand</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specific factor income accruing to households after tax\textsuperscript{b}</td>
<td>33</td>
<td>-72</td>
<td>105</td>
</tr>
<tr>
<td>Returns to domestically owned and used capital accruing to households after tax</td>
<td>32</td>
<td>-42</td>
<td>74</td>
</tr>
<tr>
<td>Imputation credits granted for foreign capital taxes</td>
<td>263</td>
<td>263</td>
<td>0</td>
</tr>
<tr>
<td>Returns to domestically owned capital used overseas accruing to households after tax</td>
<td>-33</td>
<td>-32</td>
<td>0</td>
</tr>
<tr>
<td>used in Australia</td>
<td>1</td>
<td>na</td>
<td>1</td>
</tr>
<tr>
<td>used in New Zealand</td>
<td>-19</td>
<td>-19</td>
<td>na</td>
</tr>
<tr>
<td>used in the Rest of the World</td>
<td>-14</td>
<td>-13</td>
<td>-1</td>
</tr>
<tr>
<td>Taxes on personal income</td>
<td>-264</td>
<td>-353</td>
<td>88</td>
</tr>
<tr>
<td>Total tax collected on personal income</td>
<td>-32</td>
<td>-120</td>
<td>88</td>
</tr>
<tr>
<td>imputation credits granted for domestic company tax</td>
<td>31</td>
<td>31</td>
<td>0</td>
</tr>
<tr>
<td>imputation credits granted for foreign company tax</td>
<td>-263</td>
<td>-263</td>
<td>0</td>
</tr>
<tr>
<td>Company taxes levied on capital used domestically</td>
<td>-1</td>
<td>-18</td>
<td>17</td>
</tr>
<tr>
<td>Australian owned</td>
<td>9</td>
<td>-31</td>
<td>40</td>
</tr>
<tr>
<td>New Zealand owned</td>
<td>-3</td>
<td>-3</td>
<td>0</td>
</tr>
<tr>
<td>Rest of the World owned</td>
<td>-8</td>
<td>16</td>
<td>-23</td>
</tr>
<tr>
<td>Gross National Income\textsuperscript{c}</td>
<td>30</td>
<td>-254</td>
<td>284</td>
</tr>
<tr>
<td>Gross Domestic Product</td>
<td>24</td>
<td>-139</td>
<td>163</td>
</tr>
</tbody>
</table>

\textsuperscript{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. \textsuperscript{b} Region-specific inputs assumed to be in fixed supply. \textsuperscript{c} Gross National Income (GNI) is the sum of the bolded items in the table.

The shift in capital from Australia to New Zealand has several effects.

1. The post-tax returns to Australian-owners of New Zealand capital increase. The consequent increase in supply of Australian capital to New Zealand and decrease in marginal productivity moderates this increase. The imputation credits granted to Australian owners of capital in New Zealand increase their after tax returns by $US 263 million. This is partially offset by a US $32 million in their returns, as the marginal productivity of Australian capital in New Zealand falls as the amount of that capital increases, 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 the returns to those factors. The net increase in
payments to the New Zealand specific factors in this simulation is US$105 million (an increase in specific factor incomes of under 0.1 per cent).

3. Conversely, with a reduced capital stock to combine with, returns to the specific factor in Australia decrease by US$72 million.

4. The increased value of 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).\(^8\)

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. 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 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 impacts of these responses are:

- a net increase of US$163 million in New Zealand real GDP, due the increased capital stock and productivity of the fixed factor
- an expansion in New Zealand GNI of US$284 million.

\(^8\) The increased supply of Australian capital — which, in this scenario, is highly substitutable with other capital — drives down the rate of return. 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).
- a net contraction in Australian GNI of US$254 million and GDP of US$139 million
- a small increase in trans-Tasman GDP of US$24 million and 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.
4.2.2 New Zealand recognition of Australian imputation credits

Table 4  Impacts of New Zealand recognition of Australian imputation credits\textsuperscript{a}

<table>
<thead>
<tr>
<th>Change US$m, 2012</th>
<th>Trans-Tasman</th>
<th>Australia</th>
<th>New Zealand</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specific factor income accruing to households after tax\textsuperscript{b}</td>
<td>-3</td>
<td>56</td>
<td>-60</td>
</tr>
<tr>
<td>Returns to domestically owned and used capital accruing to households after tax</td>
<td>30</td>
<td>58</td>
<td>-28</td>
</tr>
<tr>
<td>Imputation credits granted for foreign capital taxes</td>
<td>171</td>
<td>0</td>
<td>171</td>
</tr>
<tr>
<td>Returns to domestically owned capital used overseas accruing to households after tax</td>
<td>-49</td>
<td>-20</td>
<td>-30</td>
</tr>
<tr>
<td>used in Australia</td>
<td>-30</td>
<td>na</td>
<td>-30</td>
</tr>
<tr>
<td>used in New Zealand</td>
<td>-8</td>
<td>-8</td>
<td>na</td>
</tr>
<tr>
<td>used in the Rest of the World</td>
<td>-11</td>
<td>-11</td>
<td>0</td>
</tr>
<tr>
<td>Taxes on personal income</td>
<td>-134</td>
<td>72</td>
<td>-207</td>
</tr>
<tr>
<td>Total tax collected on personal income</td>
<td>19</td>
<td>77</td>
<td>-58</td>
</tr>
<tr>
<td>imputation credits granted for domestic company tax</td>
<td>17</td>
<td>-5</td>
<td>22</td>
</tr>
<tr>
<td>imputation credits granted for foreign company tax</td>
<td>-171</td>
<td>0</td>
<td>-171</td>
</tr>
<tr>
<td>Company taxes levied on foreign used domestically</td>
<td>1</td>
<td>13</td>
<td>-13</td>
</tr>
<tr>
<td>Australian owned</td>
<td>2</td>
<td>5</td>
<td>-2</td>
</tr>
<tr>
<td>New Zealand owned</td>
<td>6</td>
<td>28</td>
<td>-22</td>
</tr>
<tr>
<td>Rest of the World owned</td>
<td>-7</td>
<td>-19</td>
<td>12</td>
</tr>
<tr>
<td>Gross National Income\textsuperscript{c}</td>
<td>14</td>
<td>180</td>
<td>-166</td>
</tr>
<tr>
<td>Gross Domestic Product</td>
<td>13</td>
<td>106</td>
<td>-93</td>
</tr>
</tbody>
</table>

\textsuperscript{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. \textsuperscript{b} Region-specific inputs assumed to be in fixed supply. \textsuperscript{c} Gross National Income (GNI) is the sum of the bolded values in the table.

The drivers of the results for New Zealand recognising Australian imputation credits are the same as those identified above, when Australia recognises New Zealand imputation credits. 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. The value of Australian imputation credits recognised in New Zealand would be US$163 million before incorporating behavioural responses, and US$171 million after.

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)


New Zealand recognition of Australian imputation credits produces a transfer of income of around US$166 million from New Zealand to Australia. From a trans-Tasman perspective, there is a US$14 million increase in income. Trans-Tasman GDP increases by US$13 million.
4.3 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 income gains for the destination and unambiguous income losses for the source, the difference between the impacts of the two unilateral policies determines whether each country will experience a net income increase as a result of MRIC. 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 changes in returns to trans-Tasman capital.

Combining the unilateral results shown in tables 3 and 4 produce the illustrative results for MRIC in table 5.
### Table 5  Impacts of mutual recognition of trans-Tasman imputation credits

<table>
<thead>
<tr>
<th></th>
<th>Trans-Tasman</th>
<th>Australia</th>
<th>New Zealand</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specific factor income accruing to households after tax</td>
<td>30</td>
<td>-16</td>
<td>46</td>
</tr>
<tr>
<td>Returns to domestically owned and used capital accruing to households after tax</td>
<td>62</td>
<td>15</td>
<td>46</td>
</tr>
<tr>
<td>Imputation credits granted for foreign capital taxes</td>
<td>432</td>
<td>262</td>
<td>170</td>
</tr>
<tr>
<td>Returns to domestically owned capital used overseas accruing to households after tax</td>
<td>-81</td>
<td>-52</td>
<td>-30</td>
</tr>
<tr>
<td>used in Australia</td>
<td>-29</td>
<td>na</td>
<td>-29</td>
</tr>
<tr>
<td>used in New Zealand</td>
<td>-27</td>
<td>-27</td>
<td>na</td>
</tr>
<tr>
<td>used in the Rest of the World</td>
<td>-25</td>
<td>-25</td>
<td>-1</td>
</tr>
<tr>
<td>Taxes on personal income</td>
<td>-396</td>
<td>-279</td>
<td>-117</td>
</tr>
<tr>
<td>Total tax collected on personal income</td>
<td>-12</td>
<td>-43</td>
<td>31</td>
</tr>
<tr>
<td>imputation credits granted for domestic company tax</td>
<td>47</td>
<td>26</td>
<td>21</td>
</tr>
<tr>
<td>imputation credits granted for foreign company tax</td>
<td>-432</td>
<td>-262</td>
<td>-170</td>
</tr>
<tr>
<td>Company taxes levied on capital used domestically</td>
<td>0</td>
<td>-5</td>
<td>4</td>
</tr>
<tr>
<td>Australian owned</td>
<td>12</td>
<td>-26</td>
<td>38</td>
</tr>
<tr>
<td>New Zealand owned</td>
<td>3</td>
<td>24</td>
<td>-21</td>
</tr>
<tr>
<td>Rest of the World owned</td>
<td>-15</td>
<td>-3</td>
<td>-12</td>
</tr>
<tr>
<td>Gross National Income</td>
<td>46</td>
<td>-74</td>
<td>120</td>
</tr>
<tr>
<td>Gross Domestic Product</td>
<td>38</td>
<td>-33</td>
<td>71</td>
</tr>
</tbody>
</table>

*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.

Under an MRIC scenario with the 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. There is a net transfer of income from Australia to New Zealand (Australian GNI contracts by US$74 million, and New Zealand GNI increases by US$120 million) and 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.
4.4 Sensitivity ranges and distribution of model results

Each of these policies has a different income implication for Australia and New Zealand. The relative magnitude of the impacts flowing from those policies is affected by parameters (detailed in table 2), whose true values are unknown.

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.

4.4.1 Model sensitivity results

Figure 1 shows the ranges for GDP, GNI and net tax revenue impact for Australia, New Zealand and the combined economies for the parameter combinations (table 5) examined in this paper. 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 transfers between the two economies.
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 marginal product is highest.

The trans-Tasman allocative efficiency gains are relatively small when compared to the results for Australia and New Zealand individually. In a majority of the parameter combinations examined, MRIC results in a net increase in GDP and GNI for New Zealand, and a net decrease in GDP and GNI for Australia. The GDP effect is, in general, smaller than the GNI effect, due to foreign capital back-filling and displacement — that is, capital from the rest of the world replaces (displaces) capital that is sent to (received from) the trans-Tasman partner (limiting the change in productivity capacity), but the additional (reduced) incomes associated with these flows accrue to the rest of the world.

The asymmetric GNI results for Australia and New Zealand are driven, to a large extent, by differences in the sizes of capital stocks in the two countries, and their capital responses. A situation in which both countries’ GDP and 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. However, 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 as a result of MRIC, and that the productive and income impacts are distributed differently (figure 2) — that is, larger increases in GDP/GNI for one partner are associated with larger reductions in GDP/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 GDP or 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. 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.
Figure 2 also shows that the potential changes in income (GNI) for each country are less concentrated than the productive impacts (GDP). Capital substitutability always serves as a limit to the total change in productive capacity as a result of MRIC: while one country loses trans-Tasman capital, the resulting decrease in trans-Tasman capital supply will attract capital from the Rest of the World, which limits the productive contraction. However, this inflow of foreign capital (while providing a small amount of corporate tax revenue to the host government) does little to stem the net flow of income out of the country. As a result, the range of GDP changes is smaller, and more closely concentrated towards the centre of the distribution of results, while the GNI changes are more dispersed, with a larger proportion of results in the tails.
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 larger than the converse. From a modelling perspective, Australia can gain if its business
sector limits income transfers to New Zealand by having a small investment response to the higher post-tax returns in New Zealand. Australia can then gain from the greater capital inflow from New Zealand. That said, reducing Australia’s investment response (and corresponding losses) 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.

V. Conclusions and 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 was able to illuminate certain key messages associated with an MRIC policy (point 1 below), economic modelling was able to illustrate potential productive, income and cross-country impacts that otherwise would have remained unclear (points 2 to 6 below).

Based on the sensitivities examined in this paper, 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 results in small increases in trans-Tasman GDP and GNI, brought about by improved allocation of trans-Tasman capital by reducing income tax revenues, which increases returns to relevant investors.

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

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. 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, 80.6 per cent of the trans-Tasman revenue cost is borne by Australia.
Appendix: Model structure

The SMRIC model includes three regions — Australia, New Zealand and the Rest of the World. Each region produces a unique type of output (seeking to minimise the cost of production) using four factors of production: a factor that is assumed not to relocate (aggregate labour); and three region-specific sourced factors that are internationally substitutable (capital). Capital owners substitute supply between regions based on a constant elasticity of transformation, subject to a fixed total capital supply. There are two types of firms in each country: firms that have access to global equity finance and firms that do not. Regional output is a fixed-proportion combination of the output of both firm types.

Incomes from factors less taxes on returns in the destination region (such as payroll for 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. The residual disposable income can be spent on consumption. Each region has final demands 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:
1. \(\theta_l(r)\): CES parameter, share of labour in total cost in \(r\)
2. \(\theta_k(r)\): CES parameter, share of all capital in total cost in \(r\)
3. \(\theta_{tt}(r)\): CES parameter, share all trans-Tasman capital in total capital cost in \(r\)
4. \(\theta_{row}(r)\): CES parameter, share Rest of the World capital in total capital cost in \(r\)
5. \(\theta_{aus}(r)\): CES parameter, share Australian capital in total trans-Tasman capital cost in \(r\)
6. \(\theta_{nz}(r)\): CES parameter, share New Zealand capital in total trans-Tasman capital cost in \(r\)
7. $\sigma_{LK}(r)$: Substitution elasticity between labour and top-level capital composite in $r$
8. $\sigma_{RoW}(r)$: Substitution elasticity between trans-Tasman capital composite and Rest of the World capital in $r$
9. $\sigma_{TT}(r)$: Substitution elasticity between Australian and New Zealand sourced capital in $r$
10. $\sigma_{KS}(i)$: Capital supply substitution elasticity between regions
11. $p\bar{L}(r)$: initial price of labour in $r$
12. $p\bar{k}(i, r)$: initial price of capital in $r$ sourced from $i$
13. $p2\bar{K}(r)$: initial price of capital composite (Rest of the World and trans-Tasman) in $r$
14. $p3\bar{K}(r)$: initial price of trans-Tasman capital composite
15. $q\bar{c}(c)$: initial level of output in $c$
16. $q\bar{l}(r)$: initial labour endowment in region $r$
17. $q\bar{k}(i, r)$: initial labour endowment, owned by $i$ used in $r$
18. $\gamma(r) = 1 - \sigma(r)$, where $\sigma(r)$ is the elasticity of substitution between inputs in $r$
19. $tK(i, r)$: taxes on capital used in $r$ sourced from $i$, accruing to $i$
20. $tL(r)$: taxes on labour used in $r$
21. $tY(r)$: income taxes in $r$
22. $tC(r, c)$: consumption taxes on $r$ consumed in $c$, accruing to $c$
23. $\alpha(r, c)$: Cobb-Douglas consumption parameter for good $r$ consumed in $c$

The following terms are variables in the model:
1. $Cost(r)$: total cost of production in region $r$
2. $Cost1(r)$: unit cost of input composite in region $r$
3. $Cost2(r)$: unit cost of capital composite in region $r$
4. $Cost3(r)$: unit cost of trans-Tasman capital composite in region $r$
5. $XRoW(r)$: demand for capital sourced from the Rest of the World used in $r$
6. $XAus(r)$: demand for capital sourced from Australia used in $r$
7. $XNZl(r)$: demand for capital sourced from New Zealand used in $r$
8. $PLD(r)$: wage rate (incl. tax) in region $r$
9. $PLS(r)$: wage rate (post tax) in region $r$
10. $Q_{LD}(r)$: quantity of labour demanded in region r
11. $P_{kD}(i, r)$: rental rate of capital sourced from i used in r
12. $P_{kS}(i, r)$: post-tax return to capital owned in i supplied to r
13. $Q_{kD}(i, r)$: demand for capital sourced from i used in r
14. $Q_{kS}(i, r)$: demand for capital sourced from i used in r
15. $P_{oD}(r, c)$: price of output r consumed in region c
16. $P_{oS}(r)$: price of supply in region r
17. $Q_{oD}(r, c)$: quantity of output r demanded in region c
18. $Q_{oS}(r)$: total quantity of output r
19. $Y(c)$: total incomes in region c
20. $Yd(c)$: disposable household income in region c
21. $Yg(c)$: 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.

\[
\text{Cost}(r) = QoS(r).\text{Cost1}(r)
\]

\[
\text{Cost1}(r) = \left[ \theta l(r) \left( \frac{P_{LD}(r)}{p_{lbar}(r)} \right)^{1-\sigma_{LK}(r)} + \theta k(r) \left( \frac{\text{Cost2}(r)}{p_{2bar}(r)} \right)^{1-\sigma_{LK}(r)} \right]^{\frac{1}{1-\sigma_{LK}(r)}}
\]

\[
\text{Cost2}(r) = \left[ \theta tt(r) \left( \frac{\text{Cost3}(r)}{p_{3bar}(r)} \right)^{1-\sigma_{RoW}(r)} + \theta row(r) \left( \frac{P_{kD}(\text{RoW}', r)}{pkbar(\text{RoW}', r)} \right)^{1-\sigma_{RoW}(r)} \right]^{\frac{1}{1-\sigma_{RoW}(r)}}
\]
\[
\text{Cost}_3(r) = \left[ \theta_{aus}(r) \left( \frac{\text{PkD}('Aus', r)}{\text{pkbar}('Aus', r)} \right)^{1-\sigma_{TT}(r)} + \theta_{nzl}(r) \left( \frac{\text{PkD}('Nzl', r)}{\text{pkbar}('Nzl', r)} \right)^{1-\sigma_{TT}(r)} \right]^{1/(1-\sigma_{TT}(r))}
\]

\[
\text{QID}(r) = \frac{QoS(r)}{\sum_c q_{cbar}(c)} \left( \frac{\text{PlD}(r)}{\text{plbar}(r)} \right)^{-\sigma_{LK}(r)} \times \text{Cost}_1(r)^{\sigma_{LK}(r)}
\]

\[
\text{XRoW}(r) = \frac{QoS(r)}{\sum_c q_{cbar}(c)} \left( \frac{\text{PkD}('RoW', r)}{\text{pkbar}('RoW', r)} \right)^{-\sigma_{RoW}(r)} \times \text{Cost}_1(f, r)^{\sigma_{LK}(r)}
\]

\[
\text{XAus}(r) = \frac{QoS(r)}{\sum_c q_{cbar}(c)} \left( \frac{\text{PkD}('Aus', r)}{\text{pkbar}('Aus', r)} \right)^{-\sigma_{TT}(f, r)} \times \text{Cost}_1(r)^{\sigma_{LK}(r)}
\]

\[
\text{XNzl}(r) = \frac{QoS(r)}{\sum_c q_{cbar}(c)} \left( \frac{\text{PkD}('Nzl', r)}{\text{pkbar}('Nzl', r)} \right)^{-\sigma_{TT}(f, r)} \times \text{Cost}_1(r)^{\sigma_{LK}(r)}
\]

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:

\[
\text{PkS}(i, r) = \text{PkD}(i, r). (1 - tK(i, r))
\]

\[
\text{PlS}(i) = \text{PlD}(r). (1 - tL(r))
\]

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:

\[
\text{QoS}(r) = \sum_c QoD(r, c)
\]
**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.

\[ QkD(i, r) = QkS(i, r) \]

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

**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:

\[ QoD(r, c) = \frac{a(r, c) \cdot Y(c)}{PoD(r, c)} \]

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

\[ PoS(r) = PoD(r, c) \cdot (1 - tC(r, c)) \]

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

\[ Y(c) = Yd(c) + Yg(c) \]
\[
Y_d(c) = (1 - tY(c)). \left( \sum_f PId(c). Qld(c) \right. \\
\hspace{1.5cm} \left. + \sum_r Pkd(c, r). Qkd(c, r) - \sum_r tK(c, r). Pkd(c, r). Qkd(c, r) \right)
\]

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

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 problem. It was solved using the PATH solver.