Incorporating International Capital Ownership into the GTAP Model: Results for Asia-Pacific Trade Liberalisation

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June 1999

Abstract

In this paper, some major modifications are made to the existing GTAP structure and database to incorporate a long-run closure in which income earned on endowment commodities accrues to the owners of those endowments. This closure assumes that in the long run all economies grow at a common steady-state rate. In order to ensure valid comparative statics a steady-state database is created in which all economies grow at this common steady-state rate. Once these modifications have been made, the long-run effects of Asia-Pacific trade liberalisation are simulated. It is found that foreign ownership of assets does have a significant effect on the projected outcome of Asia-Pacific trade liberalisation.

1. Introduction

Recent attempts to undertake simple comparative static long-run analysis (Walmsley, 1998 and Francois, MacDonald and Nordström, 1996) using the GTAP model have been frustrated by the need to make certain unrealistic assumptions about the mobility of capital and the allocation of income earned on that capital. In the standard GTAP model the existence of foreign ownership is not considered and therefore the region in which an endowment commodity is located is also implicitly the region of ownership and thus the region to which the income earned accrues. The foreign ownership of capital stocks and of other assets, however, is likely to have a significant affect on the projected long-run effects of a policy shock.

In this paper, some major alterations are made to the GTAP model and database in order to incorporate a long-run closure in which both the foreign ownership of capital and land and the existence of foreign labour are considered. These modifications to the GTAP model and database include the incorporation of equations and data to explain firstly, the way in which saving is allocated across regions for investment purposes; the accumulation of capital stocks by ownership; the foreign ownership of land; the existence of foreign workers and consequently their effect on the allocation of income across consumption, saving and government spending; and to define national income in terms of income earned on endowments owned by permanent residents of the region, rather than income earned on endowments located within the region.

This revised GTAP model and database is then used to determine the long-run effects of Asia-Pacific trade liberalisation. These results, based on the revised GTAP model, are then compared with a similar long-run simulation based on the standard GTAP model. The risk-adjusted long-run closure developed in Walmsley (1998) is used for this purpose. In this closure capital is mobile, however, income earned on endowment commodities is assumed to accrue to the region in which the endowment commodity is located, rather than to the region of ownership. The results show that the inclusion of foreign owned capital can significantly affect the long-run results of Asia-Pacific trade liberalisation, particularly for the Asian economies.

The long-run closure developed for the revised GTAP model assumes that in the long run all economies grow at a common steady-state rate of growth. In order to ensure valid comparative statics a steady-state version of the revised GTAP database must be created. The revised GTAP model and the steady-state database are then used to determine the long-run effects of Asia-Pacific trade liberalisation shock. These results are then compared with those obtained above using the revised GTAP model and the revised GTAP database.

Following the introduction this paper is divided into six sections. Section 2 provides a brief summary of the changes made to the structural form of the GTAP model to track the ownership of endowment commodities. Section 3 examines the changes made to the standard GTAP database to incorporate the foreign ownership of capital, land and labour. Section 4 outlines the long-run closure used in the revised GTAP model and compares it with that developed for the standard GTAP model by Walmsley (1998). The results of the long-run simulations based on the revised GTAP model and database are then compared with the long-run results obtained using the standard GTAP model. In Section 5 the creation of the steady-state database is discussed and the results analysed. Following this the Asia-Pacific trade liberalisation shock is simulated using the revised GTAP model and this steady-state database. These results are then compared with those obtained in Section 4. Section 6 draws general conclusions obtained from the simulations reported.

Wherever possible new variables and coefficients have been added while attempting to maintain the GTAP conventions established in Hertel and Tsingas (1997). Changes to these conventions are however, inevitable with such major modifications to the GTAP structure and database. Additional subscripts have been added to define the location of the endowment commodity and the region of permanent residency of the owner. For example, where i Telephone: +61 3 9904 1711

1. Lower case represent deviations from the base case, while upper case represents the actual values or coefficients.

2. For example, bkp(r,1) is the percentage change in capital stocks located in region r and owned by permanent residents of region 1. In some cases “p” may be lengthened to “perm”. If there is no additional affix the definition of (but not necessarily the equation describing) the variable has not been changed from the standard GTAP model and therefore the region can be interpreted as the location.
2. The Expected Rate of Return Schedule

Expected rates of return are related to current rates of return via the expected rate of return schedule illustrated in percentage change form in Equation 1.

\[
\text{rorelp}(r,t) = \text{rorf}(r,t) - \text{ROREFLEX}(r) \times [\text{kbrown}(r) - \text{avgrow}] \quad \text{Equation 1}
\]

The expected rate of return schedule states that if capital stocks in region \( r \) are expected to grow faster than the global average growth rate of capital (i.e. \( \text{kbrown}(r) > \text{avgrow} \)), then the expected rate of return will be lower than the current rate of return, and visa versa.

Both of these rates of return carry two subscripts reflecting possible differences in the ownership-specific taxes, which are applied to both the expected and current rates of return.

3. Regional Saving Pools

In the current GTAP model, the saving of each region is accumulated into a global saving pool from which investment is then allocated across regions. The inclusion of ownership-specific taxes on the rental price of capital and the division of endowment commodities across regions of ownership preclude the use of this global saving/investment pool. Instead regional saving pools for each region of permanent residency are used to determine investment across regions of location and ownership. In this case the saving of permanent residents (\( q\text{saveperm}(t) \)) of \( t \) must equal the sum across locations \( r \) of all investments undertaken by the permanent residents of \( t \) (\( \text{regionalcgds}(t) \)).

\[
q\text{saveperm}(t) = \sum_r \text{regionalcgds}(t) \quad \text{Equation 2}
\]

\( \text{walraslackp}(t) \) is exogenous (and normally set to zero) for all regions except one (namely, ROW). This acts as a check that Walras’ Law is satisfied in computations.

4. Perceived Risk

Regional saving is allocated across regional investment such that permanent residents of region \( t \) equate their risk-adjusted expected rates of return across regions of asset location. In percentage change form:

\[
\text{rorelp}(r,t) = \text{rorf}(r,t) \quad \text{Equation 3}
\]

where: \( \text{rorelp}(r,t) \) is the percentage change in the expected risk-adjusted rate of return, received by permanent residents of \( t \), on their investments in region \( r \) (\( \text{ROREFREL}(r,t) \)); and

\( \text{rorf}(r,t) \) is the percentage change in the common value of the risk-adjusted rate of return on all investments undertaken by permanent residents of \( t \) (\( \text{ROPERM}(t) \)).

These risk-adjusted expected rates of return are related to the expected rate of return via an endogenously determined ownership- and location-specific risk premium (\( \text{rsklp}(r,t) \)).

\[
\text{ROREFREL}(r,t) \times \text{rorelp}(r,t) = \text{ROEXPL}(r,t) \times \text{rorf}(r,t)
\]

\[ - \text{RISKL}\text{P}(r,t) \times \text{rsklp}(r,t) \]

The level of perceived risk is assumed to depend on both the location of the investment and the permanent residency of the owner and therefore has two subscripts: \( r \) and \( t \) respectively.

Since the risk of which we must take account is the subjective risk, the feeling, that is to say in the mind of the investor, its magnitude very largely depends upon the amount of relevant information that is easily accessible to him. What would be risky to any investor principally depends, in fact upon the degree of ignorance respecting the circumstances and prospects of the investment he is considering......(Keynes3) (italics added).


Thus investors, from different regions, may have different perceptions about the riskiness of a region. In addition these perceptions of risk may alter at different rates as the investor’s share of capital stocks within the region changes or as the region itself grows.

This relationship, labelled the perceived risk schedule, states that the level of risk in each region \( r \) perceived by permanent residents of \( t \) increases as the proportion of their end-of-period capital stock located in region \( r \) and owned by them rises relative to the proportion of global end-of-period capital stock located in region \( r \). This relationship between perceived risk and end-of-period capital stocks is illustrated in Figure 1 and given in the levels in Equation 5.

**Figure 1**

Perceived Risk Schedule

\[
\frac{\text{VKELP}(r,t)/\text{VKEPERM}(t)}{\text{VKELP}(r,t)/\text{VKE}(r)/\text{GLOBKE}} = \frac{\text{RISKL}\text{P}(r,t) \times \text{VKEPERM}(t) \times \text{VKE}(r)/\text{GLOBKE}}{\text{VKELP}(r,t)/\text{VKEPERM}(t)} \quad \text{Equation 5}
\]

\( \text{VKELP}(r,t) \) is the value of end-of-period capital stocks located in region \( r \) and owned by permanent residents of region \( t \), which is equal to beginning-of-period capital stocks plus net investment located in region \( r \) and owned by permanent residents of \( t \).

\( \text{VKEPERM}(t) \) is the value of end-of-period capital stocks owned by permanent residents of \( t \).

\( \text{VKELP}(r,t) \times \text{VKEPERM}(t) \) is therefore the proportion of the portfolio (i.e. end-of-period capital stocks) of permanent residents of \( t \) which are located in region \( r \).

\( \text{GLOBKE} \) is the value of global end-of-period capital stocks.

\( \text{VKE}(r)/\text{GLOBKE} \) is the proportion of global end-of-period capital stocks (i.e. the proportion of the global portfolio) located in region \( r \).

Hence the ratio, 

\[
\frac{\text{VKELP}(r,t) \times \text{VKEPERM}(t)}{\text{VKE}(r)/\text{GLOBKE}}
\]

reflects the specialisation in \( r \) of the portfolio of permanent residents of \( t \) relative to that in the global portfolio. If this ratio is equal to one then permanent residents of \( t \) hold the same proportion of end-of-period capital stocks in region \( r \) as the global portfolio. Alternatively if this ratio is greater (less) than one, then permanent residents of \( t \) hold a higher (lower) proportion of end-of-period capital stocks in region \( r \) than to residents of other regions.
This equation states that the percentage change in income (yperm(t)) earned by the representative permanent resident household of region t is the sum of:

1. Firstly, labour income earned by all permanent residents of region t, who may be currently resident in another region, r.
2. Secondly, capital and land income earned by permanent residents of region t as perceived by permanent residents of t.
3. Thirdly, tax income earned by the government residents of the region in which the tax is levied, although alternative assumptions could be accommodated.

From this equation it is clear to obtain net income.

2.4 Household Behaviour

The existence of foreign workers has implications for the equations describing household behaviour. In particular, the allocation of income to private consumption by permanent residents of a region t on land and capital endowments located in all regions and owned by them, and government consumption and saving (in the region of permanent residency only). The most significant changes is that private consumption in region r can be undertaken by permanent residents of region r and by foreign workers living in region t. An outline of these changes is given below.

1. Rather than there being only one representative household in each region there are now REG representative households for each region representing each of the possible foreign and domestic resident households in each region.
2. Differential taxes may be levied on the private household consumption of each of these representative households. For example, the tax on commodities purchased by foreign household might be incorporated through an additional tax on commodities purchased by foreign household residents in China. As a result, prices on commodities in the region in which the purchase was made and the permanent residency of the purchaser.
3. Income available for consumption by permanent resident of t temporarily residing in region r are assumed to adopt the spending habits of the region of temporary residence. That is, they allocate their income for private expenditure across commodities and domestic and imported goods in the same way as other residents of region r.

With capital, land and labour divided across regions of location and ownership, national income can be properly defined in terms of income earned on endowments owned by permanent residents of region t. National income is generated through the foreign capitalisation of the standard GTAP database.

2.2 The Foreign Ownership of Land and the Existence of Guest Workers

In the previous section the structural form of the equations describing the "behaviour" of households by region of permanent residence, incorporated into the GTAP model, were discussed. In this section the calculation of the initial values of the level variables in the database are discussed. We begin with an 11-region by 8-commodity aggregation of the standard GTAP database.
Foreign Ownership of Capital Stocks

3.1 Data on the Ownership of Capital Stocks

Data on the ownership of capital stocks located in each region are typically derived from domestic and foreign ownership sources. These proportions were also determined using the estimated initial values and the value of capital services (VOALP) in the revised GTAP database. The following observations and assumptions are made concerning the parameters of the perceived risk schedule (RISKNOM) and RISKFLEXLP(r,t): 1. The value of only REG by REG of these variables can be freely determined, the other REG by REG determined by Equation 5. This ensures that the perceived risk schedule holds in the levels. 2. It is assumed that the initial value of the slope parameter (RISKFLEXLP(r,t)) for the perceived risk schedule of permanent residents investing in region r is equal to 0.01. This value is determined arbitrarily but reflects the belief that this curve is relatively flat for permanent residents investing in their own region. 3. It is assumed that the perceived risk on the first dollar of investment does not vary among residents of any given investment location. That is, the perceived risk for all investments in r by permanent residents of region t converges to a common value (RISKNOM(r,t)). This value is approximated by all potential investors (including those from t). 4. The Foreign Ownership of Land and the Existence of Guest Workers

3.1.1 The need to estimate stocks of foreign workers from data on flows; insufficient data — in some cases only data relating to visitors issued could be found; inconsistency of data between importers and exporters of foreign labour; and high levels of illegal foreign workers in some countries. Based on the limited set of data available, a matrix of the proportions of labour by permanent residence was determined. These proportions were then used to determine the share of the wage bill (VOLWAGE(r,t)) due to a permanent resident. Unfortunately this assumption is not very helpful as many workers in particular are not from the less developed economies, as there is a tendency to pay them less for the same work. This allocation could be improved with the division of labour into skilled and unskilled (as is the case in version 5 of the GTAP database).

3.1.2 The Foreign Ownership of Land and the Existence of Guest Workers

The short- and long-run closures developed for the revised GTAP model are similar to those used in the original GTAP model. The results of this simulation are then compared with those obtained in Walmsley (1998) using a long-run closure for the standard GTAP model and the revised GTAP database.
In the revised GTAP model, capital stocks adjust such that the percentage change in the ownership-specific power of the growth rate of capital \( \text{kbgrowlp}(r,t) \) is equal to zero. If commencing from the steady-state database (discussed below) where investment and capital stocks shares are the same, the percentage change in the power of the total growth rate of capital \( \text{kbgrow}(r) \) located in region \( r \) will also equal zero and hence the expected and current rates of return will equate (Equation 12)

\[
\text{rorcplp}(r,t) = \text{rorelplp}(r,t) \quad \text{Equation 12}
\]

### 4.2 The Long-Run Effects of Asia-Pacific Trade Liberalisation

In this section the long-run effects of trade liberalisation within the Asia-Pacific region are determined using the revised GTAP model and database outlined in Sections 2 and 3 respectively. These results are then compared with those obtained using the long-run closure developed in Walmsley (1998) for the standard GTAP model.

#### 4.2.1 The Long-Run Effects of Asia-Pacific Trade Liberalisation using the Revised GTAP Model and Database

The long-run results are depicted in Table 2. The results show that in most of the Asia-Pacific economies (North America and Japan excluded) capital stocks, real gross domestic product and real gross national product rise. In the Rest of World real gross domestic product and gross national product fall.

For the Asia-Pacific region the liberalisation of trade leads to an increase in demand for commodities and output in APEC countries thus causing demand for capital inputs to rise. In the short run, capital stocks within each region are fixed exogenously, so any increase in demand for the services of capital causes its rental price (and thus the current rate of return) to rise. In the long run, capital stocks are no longer fixed. Any increase in demand for domestic goods will increase the demand for and hence the supply of capital.

In the standard GTAP model the short run is defined as that period of time before new investment adds to the total availability of capital for production within regions. In this case investment in each region is determined by allocating global savings to each region in such a way as to equate the expected (possibly risk-adjusted) rates of return across regions. In percentage change form:

\[
\text{ror}(r) = \text{ror}(t)
\]

Equation 9

In the revised GTAP model, the short run is again defined as that period of time before new investment adds to the total availability of capital for production within regions. In this case however, permanent residents of each region allocate their own saving across regions until the ownership-specific risk-adjusted expected rates of return in all regions \( r \) equate to a common risk-adjusted expected rate of return. In percentage change form:

\[
\text{rorcplp}(r,t) = \text{rorcplp}(t)
\]

Equation 10

Total investment \( \text{REGINV}(r) \) undertaken within a region \( r \) is therefore the sum across all regions of permanent residency (t) of investments \( \text{REGINVLP}(r,t) \) undertaken in region \( r \) by permanent residents of t.

In the long run sufficient time has passed for changes in investment to result in changes to regional capital available for production. Thus endogenously determined capital stocks adjust to changes in the demand for capital. In the standard GTAP model, this accumulation effect is determined by setting the current rates of return in the period simulated, equal to the expected rates of return. This accumulation effect reflects the changes in capital stocks necessary for equating rates of return across time.

\[
\text{ror}(r) = \text{ror}(t)
\]

Equation 11

In Walmsley (1998) this was achieved by incorporating a new variable – the power of the growth rate of capital \( \text{kbgrow}(r) \) -- which is set exogenously equal to zero in the long-run closure.

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### Table 1

**Long-Run Closures for Standard GTAP Model and Revised GTAP Model**

<table>
<thead>
<tr>
<th>Standard GTAP Model</th>
<th>Revised GTAP Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>to tx tm tms txs</td>
<td>to tx tm tms txs</td>
</tr>
<tr>
<td>pop</td>
<td>popperm</td>
</tr>
<tr>
<td>psavet</td>
<td></td>
</tr>
<tr>
<td>profitslack incomesslack</td>
<td>profitslack incomesslacklp</td>
</tr>
<tr>
<td>endsslack savesslack</td>
<td>endsslack savesslacklp</td>
</tr>
<tr>
<td>govslack tradslack</td>
<td>govslack tradslack</td>
</tr>
<tr>
<td>ao af afe ava atr</td>
<td>ao af afe ava atr</td>
</tr>
<tr>
<td>qo(\text{&quot;labor&quot;},t) qo(\text{&quot;land&quot;},t)</td>
<td>qo(\text{&quot;labor&quot;},t) qo(\text{&quot;land&quot;},t)</td>
</tr>
<tr>
<td>risk(r)</td>
<td></td>
</tr>
<tr>
<td>\text{kbgrow}(r)</td>
<td>\text{kbgrowlp}(r)</td>
</tr>
<tr>
<td>growavslack</td>
<td>growavslack</td>
</tr>
<tr>
<td>\text{cgdsslack}(r)</td>
<td>walraslp(HAPEC)</td>
</tr>
<tr>
<td>growth</td>
<td>(no longer exists)</td>
</tr>
</tbody>
</table>


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6. If the growth rates of capital \( \text{KBGROWTHLP}(r,t) \) are not equal across all \( r \) and \( t \) (as is the case in the revised GTAP database), fixing the percentage change in the ownership-specific power of the growth rates \( \text{kbgrowlp}(r,t) \) to zero does not necessarily leave to the growth rate \( \text{KBGROWTH}(r) \) in region \( r \) undisturbed and therefore expected and current rates of return may not equate.

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5. As is the case in the risk-adjusted long-run closure developed by Walmsley (1998).
Table 2
The Long-Run Effects of the Asia-Pacific Trade Liberalisation Shock: Revised GTAP Database

<table>
<thead>
<tr>
<th>Region</th>
<th>Real GDP (qgdp)</th>
<th>Real GNP (qgdp)</th>
<th>Current Rate of Return</th>
<th>Expected Rate of Return</th>
<th>Risk-Adjusted Expected Rate of Return</th>
<th>Gross Investment (qgds)</th>
<th>Capital stocks</th>
<th>Welfare (EVPERM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NAM</td>
<td>-0.43</td>
<td>-0.49</td>
<td>2.43</td>
<td>2.98</td>
<td>7.41</td>
<td>-1.13</td>
<td>-1.3</td>
<td>-1.43</td>
</tr>
<tr>
<td>JPN</td>
<td>0.03</td>
<td>-0.38</td>
<td>4.52</td>
<td>5.1</td>
<td>7.5</td>
<td>-2.72</td>
<td>-2.8</td>
<td>-3.66</td>
</tr>
<tr>
<td>AUS</td>
<td>1.62</td>
<td>1.63</td>
<td>3.7</td>
<td>4.09</td>
<td>7.61</td>
<td>4.1</td>
<td>3.62</td>
<td>2.47</td>
</tr>
<tr>
<td>NZL</td>
<td>1.78</td>
<td>3.02</td>
<td>3.88</td>
<td>4.15</td>
<td>7.68</td>
<td>4.75</td>
<td>3.89</td>
<td>8.97</td>
</tr>
<tr>
<td>CHN_HKG</td>
<td>3.86</td>
<td>2.7</td>
<td>5.34</td>
<td>6.27</td>
<td>7.63</td>
<td>6.27</td>
<td>6.51</td>
<td>1.00</td>
</tr>
<tr>
<td>SKOR</td>
<td>7.84</td>
<td>2.9</td>
<td>4.06</td>
<td>5.49</td>
<td>8.28</td>
<td>9.11</td>
<td>9.68</td>
<td>3.02</td>
</tr>
<tr>
<td>TWP</td>
<td>7.49</td>
<td>4.57</td>
<td>2.53</td>
<td>3.43</td>
<td>8.92</td>
<td>9.82</td>
<td>10.04</td>
<td>-0.29</td>
</tr>
<tr>
<td>MYS_SGP</td>
<td>11.09</td>
<td>1.01</td>
<td>3.32</td>
<td>4.65</td>
<td>8.23</td>
<td>15.96</td>
<td>16.65</td>
<td>-8.00</td>
</tr>
<tr>
<td>THA_PHL</td>
<td>35.82</td>
<td>12.48</td>
<td>2.43</td>
<td>3.66</td>
<td>9.66</td>
<td>49.64</td>
<td>50.3</td>
<td>8.31</td>
</tr>
<tr>
<td>HDN</td>
<td>5.35</td>
<td>0.01</td>
<td>1.68</td>
<td>2.52</td>
<td>9.16</td>
<td>8.29</td>
<td>8.45</td>
<td>-5.08</td>
</tr>
<tr>
<td>ROW</td>
<td>-1.68</td>
<td>-0.82</td>
<td>2.39</td>
<td>2.98</td>
<td>7.4</td>
<td>-3.65</td>
<td>-3.73</td>
<td>-1.97</td>
</tr>
<tr>
<td>ROW</td>
<td>-1.68</td>
<td>-0.82</td>
<td>2.39</td>
<td>2.98</td>
<td>7.4</td>
<td>-3.65</td>
<td>-3.73</td>
<td>-1.97</td>
</tr>
</tbody>
</table>

The allocation of capital stocks and investment across ownership depends on the risk premium (\(\text{risk}(r,t)\)), the risk-adjusted expected rate of return (\(\text{reoref}(r,t)\)) and the expected rate of return (\(\text{reore}(r,t)\)). The level of risk perceived by investors as applying to their ownership of end-of-period capital stocks located in region \(r\) depends on firstly, the extent to which a permanent resident investor’s portfolio differs from the average or global portfolio; and secondly, the slope of the perceived risk schedule (\(\text{risk}(r,t)\)) (Equation 5).

Figure 2 demonstrates how the perceived risk schedule can be used to explain the allocation of saving across regions. Investments undertaken by Japanese permanent residents are used for illustrative purposes. The figure is similar to the perceived risk schedule except that the share of end-of-period capital stocks owned by permanent residents \((\text{VKELP}(r,t)/\text{VKEPERM}(t))\) is on the x-axis. Curves are shown for Japanese investment in the Rest of World \((r = \text{ROW})\), in other Asia-Pacific economies \((r = A)\) and in itself \((r = J)\). Changes in the share of global capital located in \(r\) then appear as changes in the location of the schedules.

There are two important aspects of the perceived risk schedule:

1. **The growth effect.** Assuming permanent residents do not alter their portfolios \((\text{ke}(r,t) = \text{ke}_{\text{tot}}(t))\), the risk of investing in region \(r\), as perceived by permanent residents of \(t\), falls with relative increases in the end-of-period capital stocks of the region \(r\) \((\text{ke}(r) - \text{ke}_{\text{tot}} > 0)\). Alternatively, if the shock has a negative effect on the economy of \(r\), so that end-of-period capital stocks there fall relative to global capital stocks, perceived risk associated with assets held in \(r\) will tend to rise. This is depicted in Figure 2 as a shift in the schedule.

2. **The portfolio effect.** This shows the effect on risk of a change in the portfolio of the permanent residents of \(t\); that is, a change in end-of-period capital stocks \((\text{ke}(r,t))\) owned by permanent residents of \(t\) and located in region \(r\) relative to the total end-of-period capital stocks \((\text{ke}_{\text{tot}}(t))\) owned by permanent residents of \(t\). This is depicted in Figure 2 as a movement along the curves – increasing exposure of the portfolio to any region \(r\) results, ceteris paribus, in an increase in perceived risk.

Initially the positive effect of the Asia-Pacific trade liberalisation shock on the end-of-period capital stocks located within the Asia-Pacific economies tends to reduce the perceived risk of the other Asia-Pacific economies, while increasing the perceived risk of the Rest of World (growth effect). Due to the fall in end-of-period capital stocks located in Japan, perceived risk also rises in Japan. As noted above, these changes in risk caused by the ‘growth effect’ are shown in Figure 2 as shifts in the schedules. In the case of investments in Asia-Pacific”, the schedule moves downwards to the right. Conversely, the “in Japan” and “in ROW” schedules move up to the left.

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a. All results here represent percentage deviations from control.
b. Although \(\text{ke}(r,t)\) are all set exogenously equal to zero, differences in end-of-period and beginning-of-period capital stocks in the revised GTAP database mean that \(\text{avgrow}\) is unlikely to equal zero.
The reduction in risk ($\text{risk}(r,t)$) has the effect of increasing the risk-adjusted expected rates of return ($\text{roref}(r,t)$; Equation 4) for the other Asia-Pacific economies and lowering them for Japan and the Rest of World. Investment (or end-of-period capital stocks) will flow towards the higher risk-adjusted expected rates of return in the Asia-Pacific (rightward movements along the curve labelled “in Asia-Pacific” in Figure 2) and away from Japan and the Rest of World (leftward movements along the curves labelled “in Japan” and “in ROW” in Figure 2). This will occur until the percentage changes in the risk-adjusted expected rates of return equate across regions for each permanent resident of $t$ (Equation 3).

Overall Asian investors fail to find sufficient funds to take full advantage of the higher risk-adjusted rates of return. With the exception of Thailand-Philippines, the changes in perceived risk are relatively small. For the owners of capital whose permanent residence is in the Asian economies, and who do not have an existing pool of capital stocks from which funds can be drawn, increases in end-of-period capital stocks are restricted to their own economies (where the slope parameter $\text{RISKFLEXLP}(r,t)$ is relatively low) and in some cases one or two other countries (usually Thailand-Philippines where the risk has fallen substantially).

Capital stocks owned by permanent residents of $t$ is then a weighted sum across regions $r$ of the capital stocks located in region $r$ and owned by permanent residents of $t$. With a large weighting on capital stocks ($\text{kel}(r,t)$ located in region $r$ and owned by permanent residents of $r$ we would expect capital stocks owned by the Asia-Pacific (North America and Japan excluded) economies to rise while capital stocks owned by the Rest of World, North America and Japan are expected to fall. This is not always the case, however. In Taiwan, Malaysia and Indonesia the large decreases in investment elsewhere in the world have resulted in overall declines in their ownership of end-of-period capital stocks.

The increase (decrease) in capital stocks owned by the permanent residents of the region relative to capital stocks located there increases (decreases) income earned and hence real gross national product (relative to real gross domestic product).

In general risk-adjusted rates of return depend inversely on the volume of global saving and investment. In this case global saving decreases (globalcgds) and thus the risk-adjusted expected rates of return are expected to rise. Slight differences in the extent to which they fall are related to the extent to which permanent residents can obtain funds for investing. Hence expected risk-adjusted rates of return tend to rise by less in the Rest-of-World, Japan and North America than in the other Asia-Pacific economies.

4.2.2 A Comparison of the Long-run Effects of Asia-Pacific Trade Liberalisation using the Revised GTAP Model and the Standard GTAP Model

In this section the long-run results of the Asia-Pacific trade liberalisation shock using the revised GTAP model (Table 2) are compared with those obtained in Walmsley (1998) using a risk-adjusted long-run closure for the standard GTAP model (Table 3).

The primary difference between the results obtained in Walmsley (1998) and those obtained using the revised model developed above, is that capital stocks increase much further in the standard GTAP simulations. In the standard GTAP model all income earned on capital stocks located within a region is assumed to accrue to the permanent residents of that region. This income can then be allocated to the production of new capital goods; no concern need be given to the exogenously determined risk premia. In the revised GTAP model, income does not necessarily accrue to the permanent residents of the region in which the income was earned. Instead income will often accrue to foreigners who own the capital. These foreigners will consider carefully the effects on risk before investing more capital into the region. While the level of risk perceived by permanent residents investing in their home region increases only slowly with further investments, investment by permanent residents of other regions may cause risk to increase substantially due to the higher slope parameter of the perceived risk schedule ($\text{RISKFLEXLP}(r,t)$). Thus even though an economy may appear to be a good investment to the permanent residents of that economy, foreigners may not agree.

Table 3
Long-Run Results for APEC Trade Liberalisation: Risk-Adjusted Version of Standard GTAP Model with Standard GTAP Database and Treatment of Assets

<table>
<thead>
<tr>
<th>Regions</th>
<th>Current Rate of Return (rorc)</th>
<th>Capital Stocks (kb)</th>
<th>Real GDP (qgdp)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NAM</td>
<td>1.82</td>
<td>-0.63</td>
<td>-0.20</td>
</tr>
<tr>
<td>JPN</td>
<td>3.08</td>
<td>-0.60</td>
<td>0.92</td>
</tr>
<tr>
<td>AUS</td>
<td>2.50</td>
<td>5.52</td>
<td>2.38</td>
</tr>
<tr>
<td>NZL</td>
<td>2.56</td>
<td>5.65</td>
<td>2.44</td>
</tr>
<tr>
<td>CHN_HKG</td>
<td>3.73</td>
<td>9.12</td>
<td>4.82</td>
</tr>
<tr>
<td>SKOR</td>
<td>3.06</td>
<td>14.25</td>
<td>9.96</td>
</tr>
<tr>
<td>TWN</td>
<td>1.89</td>
<td>12.52</td>
<td>8.49</td>
</tr>
<tr>
<td>MYS_SGP</td>
<td>2.65</td>
<td>20.37</td>
<td>13.18</td>
</tr>
<tr>
<td>THA_PHL</td>
<td>1.91</td>
<td>65.81</td>
<td>44.71</td>
</tr>
<tr>
<td>IDN</td>
<td>1.42</td>
<td>10.19</td>
<td>6.41</td>
</tr>
<tr>
<td>ROW</td>
<td>1.81</td>
<td>-3.17</td>
<td>-1.45</td>
</tr>
</tbody>
</table>

| globalcgds | 1.97 |
| roref(r) = rorgf | 4.51 |

a. Percentage deviation from control.

5. The Steady-State

5.1 The Creation of the Steady-State Database

In the long-run closure outlined above capital stocks adjust to ensure that the growth rate of capital returns to its pre-simulation value in the GTAP database. That is, the powers of the growth rates of capital are all assumed to be exogenous and the percentage changes in them are set to zero. This is equivalent to an assumption that the shock will not affect the growth rate of capital in the long run. This is only true when discussing the very long run or steady state, where the growth rate of capital is determined by the growth rate of the population and technological growth. It is highly unlikely that an Asia-Pacific trade liberalisation shock will permanently affect either the growth rate of the population or technology. Hence the results of this long-run closure represent the move from an initial steady-state position to a new steady-state position in which the effects of the shock are incorporated but where the growth rate of capital has returned to its pre-simulation or steady-state value. It therefore follows that the initial value of growth in the GTAP database should be consistent with this steady-state growth rate of capital. Since the GTAP database is based on a particular year (in this case 1992), it is highly unlikely that the growth rate in the GTAP database is the steady-state growth rate. Therefore there exists an inconsistency between the long-run closure in the GTAP model and the database. This inconsistency is resolved with the creation of a steady-state database. The method used to create this steady-state database is similar to that used in Walmsley (1998).
In order to create a steady-state database, in which growth rates are equal across regions of location and ownership, shocks are imposed on the powers of the growth rates of capital (\(k_{bgrow}(r)\)) by location and ownership. These shocks equate all growth rates to a global average growth rate of 3.1881%. On average, the percentage changes in the risk-adjusted expected rate of return (\(\rho_{ref}(r,t)\)) and the expected rate of return (\(\rho_{ro}(r,t)\)) for each permanent resident of \(t\) (Equation 3).

The allocation of capital stocks and investment across ownership depends on the risk premium (\(\rho_{rsk}(r,t)\)), the risk-adjusted expected rate of return (\(\rho_{ref}(r,t)\)), and the expected rate of return (\(\rho_{ro}(r,t)\)) for each permanent resident of \(t\) (Equation 3).

The reason for this is that the powers of the growth rate of capital (\(k_{bgrow}(r)\)) located in region \(r\) and owned by permanent residents of \(t\) (with a large weight on capital stocks located in region \(r\)) tend to increase for both investments located in other Asian economies and in non-Asian economies ("portfolio effect").

For investments undertaken by the permanent residents of the non-Asian economies, the results are more ambiguous. The final change generally depends on the percentage change in the expected rate of return. For example in China where the expected rate of return falls significantly (-19.67 percent), the proportion increases. In Taiwan and Indonesia, on the other hand, where the expected return only fell by 4.53 percent, the proportion decreases.

Expected rates of return fall significantly in the case of the Asian economies, and are close to unity in the case of the non-Asian economies. The reason for this is that the powers of the growth rate of capital (\(k_{bgrow}(r)\)) located in region \(r\) and owned by permanent residents of \(t\) (with a large weight on capital stocks located in region \(r\)) tend to increase for both investments located in other Asian economies and in non-Asian economies ("portfolio effect").

In the case of own-country investment, the low value of the slope parameter (\(RISKFLEXLP(t,t)\)) prevents the perceived risk of own-country investment from falling (or rising), and thus research suggests that the perceived risk of own-country investment is negative (reflecting the low value of the slope parameter (\(RISKFLEXLP(t,t)\)) by location and ownership).
Kong and South Korea, where both capital stocks by location and by ownership fall in percentage terms relative to the long-run simulation based on the revised GTAP database. In this section we compare the long-run effects of Asia-Pacific trade liberalisation using the revised GTAP model with both the revised GTAP database (Section 5.2) and the steady-state database (Section 5.3). The results for the two simulations are depicted in Table 2 and Table 5 respectively.

### Table 5

<table>
<thead>
<tr>
<th>Region</th>
<th>Real Rate of Return</th>
<th>Risk-Adjusted Rate of Return</th>
<th>Capital Stocks by Location</th>
<th>Capital Stocks by Ownership</th>
</tr>
</thead>
<tbody>
<tr>
<td>NAM</td>
<td>3.38 -0.27</td>
<td>6.64 8.32</td>
<td></td>
<td></td>
</tr>
<tr>
<td>JPN</td>
<td>0.17 0.32</td>
<td>0.09 0.94</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AUS</td>
<td>1.22 4.06</td>
<td>4.35 7.54</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NZL</td>
<td>2.59 8.06</td>
<td>9.10 17.33</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ROW</td>
<td>3.66 4.06</td>
<td>7.54 17.33</td>
<td></td>
<td></td>
</tr>
<tr>
<td>THA/HOL</td>
<td>3.35 5.04</td>
<td>5.34 10.55</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IDN</td>
<td>3.58 12.1</td>
<td>12.3 24.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MYS/SGP</td>
<td>2.76 17.34</td>
<td>12.3 24.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CHN/ROW</td>
<td>1.83 5.04</td>
<td>5.34 10.55</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CHN_HKG</td>
<td>1.83 5.04</td>
<td>5.34 10.55</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Conclusions

In this paper, some major alterations have been made to the GTAP model and database in order to incorporate a long-run closure in which capital and income are defined in terms of income earned on endowment commodities. The model is then used to simulate the long-run effects of an Asia-Pacific trade liberalisation shock. In order to achieve this, it is necessary to consider foreign workers.
Firstly, equations and data relating to the way in which saving is allocated across regions for investment are included. The mechanism used for this allocation must be consistent with both economic theory, that risk-adjusted rates of return should equate across regions, and empirical evidence, that there is a tendency for investors to invest firstly in their home economies. A perceived risk schedule is developed for this purpose. This schedule states that the level of risk perceived by permanent residents of a region rises as the proportion of their end-of-period capital stocks invested within the region rises relative to the proportion of global end-of-period capital stocks invested in that region. Differences in behaviour can be explained by differences in the rate at which this risk rises. Within one’s own region risk rises and falls only slightly as the share of end-of-period capital stocks rises and falls relative to the global share, while risk rises and falls much faster when investing in countries other than one’s own.

Secondly, once a mechanism for allocating saving across regional investment has been included, the ownership of investment and hence capital stocks can be determined. With the ownership of capital stocks well established, any rental income earned on this capital can be appropriately included in the income of the owners of the capital. In this way, changes in welfare can be properly ascertained.

In addition to capital ownership the model also includes the effect on income of foreign ownership of land and foreign labour. The quantities of both foreign and domestic labour and land are, however, determined exogenously, as no equations have been included to describe the flows of these two endowments between regions.

With income now defined in terms of income earned by permanent residents, private expenditure, government expenditure and saving must also be defined in terms of permanent residencies. This has a considerable effect on the treatment of private expenditure as income allocated to private expenditure is then spent in the country of temporary residency of the household. This has a flow-through effect onto many of the demand-side equations in the model. Government expenditure and saving are only affected to the extent that they and income are redefined.

Once the equations had been altered to reflect the behaviour of permanent residents, some initial database values for the year 1992 had to be estimated for endowments, investment, saving and private expenditures. This initial database was estimated using proportions of foreign ownership and foreign workers obtained from various statistical sources. Parameters for the allocation of saving and private expenditure were then estimated by ensuring that the new database was consistent with the behavioural equations in the model.

Finally, a long-run closure was incorporated in which capital stocks responded endogenously to a shock in order to ensure that the growth rate of capital did not change and that expected and current rates of return equated within each region. This closure is similar to the one used in Walmsey (1998).

At this stage the revised GTAP model and database were used to simulate the long-run effects of Asia-Pacific trade liberalisation. These results were then compared with those obtained in Walmsey (1998) where a simple risk-adjusted long-run closure was incorporated into the standard GTAP model to determine the long-run effects of Asia-Pacific trade liberalisation. The results show that the foreign ownership of capital can significantly affect the estimates of the long-run results of trade liberalisation within the Asia-Pacific region. In the case of the revised GTAP model, although a shock may cause the demand for capital to increase, the permanent residents of that region may not have sufficient funds to finance the required increase in capital stocks. If the expected risk-adjusted rates of return are considered adequate, foreigners may be willing to fund the production of these new capital goods; however income earned on these capital goods will accrue to them. This has the effect of increasing real gross national product in the investors’ regions of permanent residence, whereas real gross national product in the region where the capital is located is only marginally affected, through the indirect effect of the increase in capital stocks on labour income and taxes.