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Journal of Policy Modeling 27 (2005) 941–959
Journal of Policy Modeling

Interpretation of results from CGE models such as GTAP

Philip D. Adams *

Centre of Policy Studies, Building 11E, Monash University, Vic. 3800, Australia

Received 1 May 2004; received in revised form 1 January 2005; accepted 1 June 2005
Available online 25 July 2005

Abstract

Interpretation of results from a CGE model like GTAP is not easy. The objective of this paper is to outline a general strategy, which is always available as a starting point, and is often suggestive of more detailed, simulation-specific interpretations. The strategy focuses first on macroeconomic variables, then on structural variables such as industry output.

At the core of our general strategy is a model of the model. Stylised models assist in identifying the principal theoretical mechanisms that underlie the projections from the full model.

In the penultimate section of the paper, the power of the general strategy is demonstrated with an application to a GTAP simulation of the effects of trade liberalisation.

JEL classification: C68

Keywords: CGE modelling; Interpretation; Tariff reform

1. Introduction

There are four basic tasks in model-based analysis:

1. derivation of the model's theoretical structure;
2. calibration;

* Tel.: +61 3 9905 5094; fax: +61 3 9905 2426.
E-mail address: philip.adams@buseco.monash.edu.au.

0161-8938/$ – see front matter © 2005 Published by Elsevier Inc. on behalf of Society for Policy Modeling.
doi:10.1016/j.jpolmod.2005.06.002

3. simulation design and solution;
4. interpretation of results.

This paper deals with the fourth task—interpretation.

Interpretation is concerned with explaining in a logical sequence the projections from a model. At each point in a properly constructed sequence of explanation, the results are explained by drawing on results that have been explained earlier and/or values in the calibrated database and/or aspects of the underlying theory. Proper interpretation assists in the checking of the model's implementation. It also enhances the credibility of the analysis and provides economic insights that are not obvious from a casual inspection of the results.

The interpretation of results in terms of a logical sequence of connections is not an easy task, and is often made more difficult by a requirement that economists not familiar with details of the model readily understand the interpretation. The objective of this paper is to outline a general strategy for interpreting macroeconomic results from a CGE model such as GTAP.[1] A general strategy is useful because it is available as a starting point and it is often suggestive of more detailed, simulation-specific interpretations.

At the core of our general strategy is a stylised model of the model.[2] Stylised models assist both in identifying the principal theoretical mechanisms that underlie the projections from the full model and in highlighting important elements of the database. They can also be used to conduct sensitivity analysis, indicating the variability of projections from the main model to changes in data and other inputs.

The rest of this paper is organised as follows. The general strategy is outlined in Section 2, and the stylised macroeconomic model is derived in Section 3. In Section 4, the power of the general strategy is demonstrated with an application to a GTAP simulation of the effects of APEC trade liberalisation. Concluding remarks are in Section 5.

2. A general strategy

Our general strategy has two main steps. The first is to identify the first point of impact of the exogenous shock. In the case of a unilateral cut in one country's tariff protection against imports (the focus of our worked example in Section 4), the first points of impact are increased demand for imports at the expense of domestic products and a reduction in the real cost of fixed factors.[3]

[1] Our strategy focuses on macroeconomic variables rather than on detailed structural variables such as industry output. Typically, consideration of the macropicture leads to a better understanding of the microdetail. For example, understanding what happens to aggregate private consumption is a key to understanding the response of consumption-oriented industries such as dwelling services. Similarly, understanding what happens to the real exchange rate is the key to understanding the response of trade-exposed industries.

[2] Stylised models are used extensively at the Centre of Policy Studies to facilitate "back-of-the-envelope" explanations. A recent example is (Dixon & Rimmer, 2002, Section 7.2). The usefulness of stylised models and "back-of-the-envelope" explanations is discussed in detail in Dixon, Parmenter, and Powell (1984).

[3] In typical comparative-static closures of single-country CGE models like GTAP, one of labour or capital is fixed, but not both. For example, in a long-run comparative-static closure labour is typically fixed and capital is variable. With labour fixed the real wage rate can vary. With Capital Variables, the real cost of capital (or the rate of return on capital) is fixed.

The second step is to use a stylised model to explain the outcomes for factor quantities and for real factor prices. From these, explanations normally follow for the major components of real GDP from the income and expenditure sides, and for other macroeconomic variables such as the real exchange rate, price indexes and the balance on trade account.

3. A stylised macroeconomic model

The stylised macroeconomic model developed in this section has a multi-country dimension with each variable and coefficient having a regional index. However, there is no explicit modelling of the linkages between each of the economies. Instead, just as in a single-country model, each economy is modelled in isolation, with allowance for exogenous changes in the positions of foreign-demand schedules for exports and foreign-supply schedules for imports as well as for changes in the global rate of return on capital. We adopt the single-country approach for the sake of simplicity. A fully endogenous explanation of trade in goods, services and financial instruments is complex and adds relatively little to the insights that can be gained from a model that excludes them.

Equations of the stylised model are shown in Table 1. Eq. (1) defines real GDP at market prices in region r ($Y^{MP}(r)$) as the sum of real consumption ($C(r)$), real investment ($I(r)$), real government consumption ($G(r)$) and the net volume of trade ($X(r) - M(r)$).

Eq. (2) is region r's production function. It relates real GDP at factor cost ($Y^{FC}(r)$)[4] to inputs of labour ($L(r)$) and capital ($K(r)$), with an allowance for changes in all-factor technical efficiency. $A(r)$ is the technological-change term. An increase in $A(r)$ implies technological deterioration. A decrease implies technological improvement. In writing (2), and elsewhere in the stylised model, we ignore the existence of agricultural land.

The relationship between real GDP at market prices and real GDP at factor cost is given in Eq. (3). On the right-hand side of (3) the first product is the value of GDP at factor cost. The second product is the value of indirect taxes net of subsidies—$Y^{TAX}(r)$ and $P^{TAX}(r)$ are the quantity index and the price index to which the ad valorem rate of tax, $T(r)$ is applied. Later, we assume that import taxes are the only form of indirect taxation imposed in each region. Thus $T(r)$ is taken to be the average ad valorem rate of import tariff applied in region r and $Y^{TAX}(r)$ and $P^{TAX}(r)$ are the quantity and before-tariff CIF price of imports.

Eq. (4) is the economy's consumption function, relating the value of private consumption ($P^{C}(r) \times C(r)$) to the value of GDP at market prices via the average propensity to consume (Ω). Eq. (5) explains the value of government consumption. It is analogous to Eq. (4), with $\Gamma(r)$ being the government's average propensity to consume.

Eq. (6) relates the volume of imports to the general level of activity ($Y^{MP}(r)$), to the real exchange rate (RER(r)) and (negatively) to the power of the average rate of tariff, $(1+T(r))$. An increase in the real exchange rate (a real appreciation) with all else unchanged signals a decline in competitiveness of traded-goods industries in region r and hence an increase in imports.

[4] GDP at factor cost is the total cost of primary factors. It is equal to market-price GDP less indirect taxes net of subsidies.

Eq. (7) is region r's export equation. Exports are inversely related to the real exchange rate and to $Y_W(r)$, an exogenous variable representing the general level of activity in the countries to which region r sells.

Eq. (8) determines economy r's investment, by setting the ratio of investment to capital in the solution year to the exogenous variable $\Phi(r)$.

Table 1
A stylised macromodel useful for analysing results from GTAP

Levels equations

$$Y^{MP}(r) = C(r) + I(r) + G(r) + (X(r) - M(r)) \tag{1}$$

$$Y^{FC}(r) \times A(r) = F_Y(L(r), K(r)) \tag{2}$$

$$P^{MP}_{GDP}(r) \times Y^{MP}(r) = P^{FC}_{GDP}(r) \times Y^{FC}(r) + P^{TAX}(r) \times Y^{TAX}(r) \times T(r) \tag{3}$$

$$P^{C}(r) \times C(r) = \Omega(r) \times P^{MP}_{GDP}(r) \times Y^{MP}(r) \tag{4}$$

$$P^{G}(r) \times G(r) = \Gamma(r) \times P^{MP}_{GDP}(r) \times Y^{MP}(r) \tag{5}$$

$$M(r) = F_M\left(Y^{MP}(r), \mathrm{RER}(r), \frac{1}{1+T(r)}\right) \tag{6}$$

$$X(r) = F_X(-\mathrm{RER}(r)) \times Y_W(r) \tag{7}$$

$$I(r)/K(r) = \Phi(r) \tag{8}$$

$$\mathrm{RER}(r) = \frac{P^{MP}_{GDP}(r)}{\Theta(r) \times P_W(r)} \tag{9}$$

$$P^{MP}_{GDP}(r) = F_{P_{GDP}}(P^{FC}_{GDP}(r), T(r), P^{TAX}(r)) \tag{10}$$

$$\mathrm{TOT}(r) = \frac{1}{F_{TOT}(X(r)) \times P_W(r)} \tag{11}$$

$$\frac{P^{C}(r)}{P^{MP}_{GDP}(r)} = \frac{1}{F_{P_C}(\mathrm{TOT}(r))} \tag{12}$$

$$\frac{P^{G}(r)}{P^{MP}_{GDP}(r)} = \frac{1}{F_{P_G}(\mathrm{TOT}(r))} \tag{13}$$

$$\frac{K(r)}{L(r)} = F_{KL}\left(\frac{\mathrm{RP_L}(r)}{\mathrm{RP}_K(r)}\right) \tag{14}$$

$$\mathrm{RP_L}(r)^{S_L(r)} = \frac{\mathrm{RP_K}(r)^{-S_K(r)}}{A(r)} \tag{15}$$

$$\mathrm{RP_L}(r) = \mathrm{RW}(r) \times F_{\mathrm{RP_L}}\left(\frac{1}{TOT(r), (1+T(r)}\right) \tag{16}$$

Table 1 (*Continued*)

Levels equations

$$\mathrm{RP_K}(r) = \mathrm{ROR}(r) \times F_{\mathrm{RP_K}}\left(\frac{1}{TOT(r),(1+T(r))}\right) \tag{17}$$

Linearised equations in the percentage changes of variables

$$y^{\mathrm{mp}}(r) = S_{\mathrm{C}}(r) \times c(r) + S_{\mathrm{I}} \times i(r) + S_{\mathrm{G}}(r) \times g(r) + (S_{\mathrm{X}}(r) \times x(r) - S_{\mathrm{M}}(r) \times m(r)) \tag{1′}$$

$$y^{\mathrm{fc}}(r) = S_{\mathrm{L}}(r) \times l(r) + S_{\mathrm{K}}(r) \times k(r) - a(r) \tag{2′}$$

$$y^{\mathrm{mp}}(r) = S_{\mathrm{FC}}(r) \times y^{\mathrm{fc}}(r) + S_{\mathrm{T}}(r) \times y^{\mathrm{tax}}(r) \tag{3′}$$

$$c(r) = \omega(r) + (p^{\mathrm{mp}}_{\mathrm{gdp}}(r) + y^{\mathrm{mp}}(r)) - p^{\mathrm{c}}(r) \tag{4′}$$

$$g(r) = \gamma(r) + (p^{\mathrm{mp}}_{\mathrm{gdp}}(r) + y^{\mathrm{mp}}(r)) - p^{\mathrm{g}}(r) \tag{5′}$$

$$m(r) = y^{\mathrm{mp}}(r) + \sigma_{\mathrm{M}} \times (\mathrm{rer}(r) - S_{\mathrm{T}}(r) \times t(r)) \tag{6′}$$

$$x(r) = \sigma_{\mathrm{X}}(r) \times \mathrm{rer}(r) + y_{\mathrm{W}}(r) \tag{7′}$$

$$i(r) - k(r) = \phi(r) \tag{8′}$$

$$\mathrm{rer}(r) = p^{\mathrm{mp}}_{\mathrm{gdp}}(r) - (\theta(r) + p_{\mathrm{W}}(r)) \tag{9′}$$

$$p^{\mathrm{mp}}_{\mathrm{gdp}}(r) = S_{\mathrm{FC}}(r) \times p^{\mathrm{fc}}_{\mathrm{gdp}}(r) + S_{\mathrm{T}}(r) \times p^{\mathrm{tax}}(r) \times t(r) \tag{10′}$$

$$\mathrm{tot}(r) = \frac{1}{\sigma_{\mathrm{X}}(r)} \times x(r) + f_{\mathrm{X}}(r) - p_{\mathrm{W}}(r) \tag{11′}$$

$$p^{\mathrm{c}}(r) = p^{\mathrm{mp}}_{\mathrm{gdp}}(r) - S_{\mathrm{X}}(r) \times \mathrm{tot}(r) \tag{12′}$$

$$p^{\mathrm{g}}(r) = p^{\mathrm{c}}(r) + \eta(r) \tag{13′}$$

$$k(r) - l(r) = \sigma_{\mathrm{KL}}(r) \times (rp_{\mathrm{L}}(r) - rp_{\mathrm{K}}(r)) \tag{14′}$$

$$\mathrm{rp_L}(r) = \frac{-S_{\mathrm{K}}(r)}{S_{\mathrm{L}}(r)} \times \mathrm{rp_K}(r) - a(r) \tag{15′}$$

$$\mathrm{rp_L}(r) = \mathrm{rw}(r) - S_{\mathrm{X}}(r) \times \mathrm{tot}(r) + S_{\mathrm{T}}(r) \times t(r) \tag{16′}$$

$$\mathrm{rp_K}(r) = \mathrm{ror}(r) - S_{\mathrm{X}}(r) \times \mathrm{tot}(r) + S_{\mathrm{T}}(r) \times t(r) \tag{17′}$$

Eq. (9) defines the real exchange rate as the ratio of the price of GDP in the domestic economy (a proxy for local production costs) to the average price of GDP in region r's trading partners ($P_{\mathrm{w}}(r)$), converted to domestic currency via the nominal exchange rate $\Theta(r)$). The exchange rate is expressed as domestic currency per unit of foreign currency.

Eq. (10) relates the price of GDP at market prices to the price of GDP at factor cost, to the ad valorem rate of indirect tax, and to the price to which the tax rate is applied.

Eq. (11) relates the terms of trade (TOT(r)) (i.e., the price of exports relative to the price of imports) negatively to the volume of exports and to the average price of imports paid by region r ($P_{\mathrm{W}}(r)$). $F_{\mathrm{TOT}}\{\}$ is a positive increasing function of $X(r)$. Eq. (11) is consistent with region r being a small country with respect to imports, but facing a downward-sloping demand curve for its exports.

Eq. (12) shows the relationship between the terms of trade and the ratio of the price of private consumption to the price of GDP at market prices. $F_{P_{\mathrm{C}}}\{\}$ is a positive increasing function of TOT(r). Changes in $(P^{\mathrm{C}}(r)/P^{\mathrm{MP}}_{\mathrm{GDP}}(r))$ will often be associated with changes in the terms of trade. A terms-of-trade improvement reduces the price of total domestic final expenditure (which includes imports but not exports) relative to the market price of output (which includes exports but not imports).[5] Eq. (13) explains the ratio of the price of government consumption to the price of GDP in a way that is analogous to the explanation of the price of private consumption relative to the price of GDP in Eq. (12).

Eq. (14) connects relative factor inputs to relative factor prices. $\mathrm{RP}_{\mathrm{L}}(r)$ is the real price of labour, defined as the nominal wage rate relative to the price of GDP at factor cost (the price of output). $\mathrm{RP}_{\mathrm{K}}(r)$ is the real price of capital, defined as the nominal rental on capital relative to the price of GDP at factor cost. Under (14), an increase in the real price of labour relative to the real price of capital will cause an increase in the capital intensity of the economy. Notice that with perfect competition, the real price of labour is equivalent to the marginal product of labour and that the real price of capital is equivalent to the marginal product of capital.

The relationship between real factor prices is given in Eq. (15). It is derived from the geometric-average form[6]:

$$P^{\mathrm{FC}}_{\mathrm{GDP}}(r) = (P_{\mathrm{L}}(r) \times A(r))^{S_{\mathrm{L}}(r)} \times (P_{\mathrm{K}}(r) \times A(r))^{S_{\mathrm{K}}(r)}, \tag{18}$$

where $S_{\mathrm{L}}(r)$ and $S_{\mathrm{K}}(r)$ reflect the shares of labour and capital in the economy ($S_{\mathrm{L}}(r) + S_{\mathrm{K}}(r) = 1$), and $P_{\mathrm{L}}(r)$ and $P_{\mathrm{K}}(r)$ are the nominal wage rate and the nominal rental on capital. To obtain (15), divide both sides of (18) by the factor-cost price of GDP, redefine in terms of real prices, and then re-arrange.

Eq. (16) explains the real price of labour as a function of the real wage rate (RW(r)) (i.e., the nominal wage rate deflated by the price of consumption), the inverse of the terms of trade, and one plus the ad valorem rate of indirect taxes less subsidies. In deriving (16), we

[5] Note that imports of private consumption goods comprise only a fraction of total imports and so not all terms-of-trade changes will lead to changes in the price of private consumption goods relative to the GDP deflator. Moreover, private consumption is only one part of total domestic final expenditure (GNE). Consequently, changes in the price of labour, say, may affect the prices of other GNE components more than the price of private consumption, leading to a change in the price of consumption relative to the GDP deflator even when there has been no change in the terms of trade.

[6] At this point the equation numbering might appear confusing. This is because the equations of the model listed in Table 1 are numbered consecutively and the equations in the text follow on from the number of the final model equation, namely Eq. (17).

Table 2
Coefficients and parameters in the percentage change form of the stylised model

Symbol	Description
$S_C(r)$	Share of private consumption in GDP at market prices
$S_I(r)$	Share of investment in GDP at market prices
$S_G(r)$	Share of public consumption in GDP at market prices
$S_X(r)$	Share of exports in GDP at market prices
$S_M(r)$	Share of imports in GDP at market prices
$S_L(r)$	Share of the cost of labour in GDP at factor cost
$S_K(r)$	Share of the cost of capital in GDP at factor cost
$S_{FC}(r)$	Share of the cost of factors (labour and capital) in market-price GDP
$S_T(r)$	Share of indirect taxes less subsidies in market-price GDP
$\sigma_M(r)$	Average domestic/imported substitution elasticity.
$\sigma_X(r)$	Price elasticity of world demand for region r's exports (negative parameter)
$\sigma_{KL}(r)$	Capital/labour substitution elasticity

note that the real price of labour equals:

$$\frac{P_L(r)}{P^{FC}_{GDP}(r)} = \frac{P_L(r)}{P^C(r)} \times \frac{P^C(r)}{P^{MP}_{GDP}(r)} \times \frac{P^{MP}_{GDP}(r)}{P^{FC}_{GDP}(r)}. \tag{19}$$

On the right hand side of (19), $P_L(r)/P^C(r)$ is the real wage rate (RW(r)), $P^C(r)/P^{MP}_{GDP}(r)$ is a function of the inverse of the terms of trade (see Eq. (12)) and $P^{MP}_{GDP}(r)/P^{FC}_{GDP}(r)$equals (1+$T(r)$) (see Eq. (10)).

In deriving (17), note that the real rental price of capital equals:

$$\frac{P_K(r)}{P^{FC}_{GDP}(r)} = \frac{P_K(r)}{P^I(r)} \times \frac{P^I(r)}{P^{MP}_{GDP}(r)} \times \frac{P^{MP}_{GDP}(r)}{P^{FC}_{GDP}(r)}, \tag{20}$$

where $P^I(r)$ is the price of investment. On the right-hand-side of (20), $P_k(r)/P^I(r)$ can be interpreted as the economy's rate of return, ROR(r). The second term, like the corresponding term in (19), responds to changes in the inverse of the terms of trade.[7] The final term is equivalent to (1+$T(r)$).

The linearised percentage change forms of Eqs. (1)–(17) are given in the second part of Table 1 as Eqs. (1′)–(17′). Lower-case letters identify percentage changes in variables written in the corresponding upper-case letters. Coefficients and parameters in the linearised model are given in Table 2. The derivations of the linear forms are generally straightforward but some explanation is necessary.

Eq. (3′) is derived by substituting Eq. (10′) into the percentage change form of Eq. (3).

Eq. (6′) is an implication of the CES form for domestic/import substitution, with $\sigma_M(r)$ representing the average domestic/import substitution elasticity. Omitting the regional index for sake of brevity, note that the percentage change in (1+$T(r)$) is:

$$\frac{100\Delta T}{1+T} = \frac{100\Delta T}{1+T} \times \frac{T}{T} = t \times \frac{T}{1+T} = t \times \frac{T \times P^{FC}_{GDP} Y^{FC}_{GDP}}{(1+T) \times P^{FC}_{GDP} Y^{FC}_{GDP}} = tS_T, \tag{21}$$

[7] Footnote 5, which relates to consumption goods, applies in an analogous way to investment goods.

where as noted in Table 2, S_T(r) is the share of indirect taxes net of subsidies in GDP at market prices.

In Eqs. (7′) and (11′), $\sigma_X(r)$ is a negative parameter, representing the price elasticity of world demand for exports. Eq. (11′) also contains a shift variable, $f_X(r)$ that allows for exogenous shifts in the foreign-currency price of exports in region r.

For Eq. (12′), notice that from the expenditure side of GDP we can write:

$$p^{mp}_{gdp}(r) = S_C(r) \times p^c(r) + S_G(r) \times p^g(r) + S_I(r) \times p^i(r) + (S_X(r) \times p^x(r) - S_M(r) \times p^m(r)).$$

To obtain (12′), we assume that the prices of private consumption, public consumption and investment move together, i.e.,

$$p^c(r) = p^g = p^i(r),$$

and that trade is initially balanced, i.e.,

$$S_X(r) = S_M(r).$$

Thus,

$$p^{mp}_{gdp}(r) = p^c(r) + S_X(r) \times (p^x(r) - p^m(r)) = p^c(r) + S_X(r) \times \text{tot}(r). \tag{22}$$

In Eq. (13′), $\eta(r)$ is an exogenous shift variable that allows for changes in the ratio of the price of government consumption to the price of private consumption. Eq. (14′) is an implication of the CES form for capital/labour substitution:

$$\frac{K(r)}{L(r)} = \left(\frac{P_L(r) \times P^{FC}_{GDP}(r)}{P_K(r) \times P^{FC}_{GDP}(r)} \right)^{\sigma_{KL}(r)}, \tag{23}$$

where $\sigma_{KL}(r)$ is a positive parameter, representing the capital/labour substitution elasticity.

Our starting point for Eq. (16′) is Eq. (19). Eq. (19) implies that the percentage change in real price of labour is the sum of: (a) the percentage change in the real wage rate (rw(r)), (b) the percentage change in the ratio of the consumption price to the market-price GDP deflator and (c) the percentage change in the ratio of the market-price GDP deflator to the factor-cost GDP deflator. Component (b) is explained by Eq. (12′) and component (c) is explained by Eq. (10′). The derivation of Eq. (17′) from Eq. (20) is analogous to the derivation of (16′) from (19).

Table 3 lists the variables in the linearised form of the stylised macromodel. The number of variables (31) exceeds the number of Eq. (17) by 14. Thus, 14 variables

Table 3
Percentage change variables of the stylised model

Symbol	Description	Naturally exogenous (X)/endogenous (N)	Short-run	Long-run
$y^{mp}(r)$	Real GDP at market prices	N		
$c(r)$	Real private consumption	N		
$i(r)$	Real investment	N		
$g(r)$	Real public consumption	N		
$x(r)$	Real exports	N		
$m(r)$	Real imports	N		
$y^{fc}(r)$	Real GDP at factor cost	N		
$l(r)$	Employment		N	X
$k(r)$	Capital stock		X	N
$a(r)$	All factor technical efficiency	X		
$y^{tax}(r)$	Quantity of flow to which indirect taxes are attached.	X		
$p^{tax}(r)$	Price of flow to which indirect taxes are attached.	X		
$\omega(r)$	Ratio of private consumption to GDP	X		
$\gamma(r)$	Ratio of public consumption to GDP	X		
$p^{mp}_{gdp}(r)$	GDP price (market prices)	N		
$\theta(r)$	Nominal exchange rate (domestic per foreign)	X (numeraire)		
tot(r)	Terms of trade	N		
$p_w(r)$	Average foreign-currency price of imports	X		
$f_X(r)$	Shift in foreign-currency price of exports	X		
$p^c(r)$	Price of private consumption	N		
$p^g(r)$	Price of government consumption	N		
$\eta(r)$	Ratio government to private consumption prices	X		
rer(r)	Real exchange rate	N		
$y_w(r)$	Average GDP change - region r's trading partners.	X		
ror(r)	Rate of return on capital		N	X
ϕ(r)	Ratio of investment to capital in solution year	X		
$t(r)$	*Ad valorem* rate of indirect tax	X		
$p^{fc}_{gdp}(r)$	GDP price (factor cost)	N		
$rp_l(r)$	Real price of labour	N		
$rp_k(r)$	Real price of capital	N		
rw(r)	Real wage rate		X	N

must be set exogenously. Table 3 shows the exogenous/endogenous status of each variable that has a natural classification. Twelve variables are shown as naturally exogenous; in general, the model cannot explain changes in these variables. The nominal exchange rate is one such variable. It acts as the numeraire, namely, it determines the general price level.[8] This leaves two more variables to be made exogenous. In short-run comparative-static simulations, the capital stock and real wage rate are typically exogenous, allowing the model to determine values for employment and the rate of return on capital. In long-run comparative-static simulations, employment and the rate of return are exogenous, allowing the model to determine values for capital and the real wage rate.

[8] The choice of numeraire is arbitrary. Natural alternatives to the exchange rate as the numeraire are the price of consumption or one of the GDP deflators.

Table 4
Regional aggregation of GTAP used for this paper

Identifier	Countries in region
1. NAM	*North America* (United States, Canada and Mexico)
2. JPN	Japan
3. AUS	Australia
4. NZL	New Zealand
5. CHINA	China (includes Hong Kong)
6. SKOR	South Korea
7. TWN	Taiwan
8. MYS_SGP	Malaysia and Singapore
9. THA_PHL	Thailand and the Philippines
10. IDN	Indonesia
11. ROW	Rest of the World

4. Interpretation: GTAP projections of the effects of APEC liberalisation

4.1. GTAP simulation

The version of GTAP used here is that documented in Hertel (1996) with some additional equations and variables described in Appendix A of Adams, Huff, McDougall, Pearson, and Powell (1997). Calibration was based on data from the version 5 database (Dimaranan & McDougall, 2002). The solution software was GEMPACK (Harrison & Pearson, 1996). Table 4 shows the regions distinguished.

4.1.1. Simulation design

The GTAP simulation involved the removal in each APEC country of all ad valorem import tariffs as well as tariff equivalents of bilateral non-tariff barriers on APEC-sourced imports. Import protection between the rest of the world (ROW) and APEC is maintained. Table 5 shows the percentage deviations in the average tariff rate of each region (first row of numbers).

The deviations due to the removal of tariffs were computed under the following assumptions about factor markets and about macrobehaviour in regions:

- capital is mobile, moving across regions to equalize disturbances in rates of return generated by the tariff shocks;
- aggregate employment of labour and of land is fixed in each region;

Table 5
Percentage deviations in the average ad valorem tariff on import by region

	NAM	JPN	AUS	NZL	CHINA	SKOR	TWN	MYS/ SGP	THA/ PHL	IDN	ROW
$t(r)$	−2.9	−12.4	−19.8	−8.7	−33.0	−26.2	−40.4	−29.4	−63.0	−176.5	0
$S_T(r)t(r)$	−0.2	−1.0	−1.4	−1.1	−6.6	−3.4	−3.6	−5.9	−7.6	−1.8	0

Table 6
Values for coefficients and parameters from the GTAP database in the percentage change form of the stylised model[a]

	NAM	JPN	AUS	NZL	CHINA	SKOR	TWN	MYS/ SGP	THA/ PHL	IDN	ROW
$S_C(r)$	0.68	0.60	0.63	0.63	0.51	0.54	0.56	0.47	0.61	0.60	0.63
$S_I(r)$	0.17	0.29	0.22	0.20	0.35	0.37	0.22	0.38	0.37	0.29	0.19
$S_G(r)$	0.16	0.10	0.18	0.14	0.12	0.10	0.14	0.11	0.10	0.08	0.18
$S_X(r)$	0.12	0.10	0.19	0.31	0.36	0.32	0.48	1.33	0.42	0.27	0.26
$S_M(r)$	0.14	0.09	0.21	0.28	0.34	0.34	0.39	1.28	0.51	0.25	0.26
$S_L(r)$[b]	0.64	0.58	0.60	0.54	0.44	0.49	0.63	0.40	0.31	0.41	0.60
$S_K(r)$[c]	0.36	0.42	0.40	0.46	0.56	0.51	0.37	0.60	0.70	0.59	0.40
$S_{FC}(r)$	0.92	0.92	0.93	0.87	0.80	0.87	0.91	0.80	0.88	0.99	0.92
$S_T(r)$	0.08	0.08	0.07	0.13	0.20	0.13	0.09	0.20	0.12	0.01	0.08
$\sigma_M(r)$[d]	2.98	2.60	2.80	2.77	2.69	2.60	2.68	2.71	2.74	2.64	2.73
$\sigma_X(r)$[e]	−5.48	−6.09	−4.95	−4.68	−5.82	−5.68	−5.42	−5.22	−5.33	−5.49	−5.44
$\sigma_{KL}(r)$[f]	1.32	1.32	1.28	1.27	1.10	1.21	1.31	1.23	1.17	1.04	1.25

[a] *Source*: GTAP database, Version 5.
[b] Ratio of the economy-wide cost of skilled and unskilled labour to the total cost of endowed commodities.
[c] Ratio of the economy-wide cost of capital, land and natural resources to the total cost of endowed commodities.
[d] Computed as a weighted average of the import substitution elasticities across commodity in the home region. The weights were calculated from the cif-paid values of imports.
[e] Computed as a weighted average of the import substitution elasticities by commodity across regions of destination. The weights were calculated from the fob values of exports.
[f] Computed as a weighted average of the factor substitution elasticities across industries. There weights were based on total factor payments.

- government budget balances are slack[9];
- in the solution year, investment and capital in each region move together, with the world rate of return adjusting to ensure that the weighted sum of changes in each region's investment equals the change in global savings.

Because of the capital-mobility assumption, we describe our simulation as long run.[10]

Table 6 shows initial values for the coefficients identified in Table 3 derived from the version 5 GTAP database. Table 7 shows results for the 17 variables identified as endogenous (long-run closure) in Table 3. The GTAP projections are shown in the columns labelled "GTAP".

4.1.2. Overview of GTAP projections

As shown in the first row of numbers in Table 7, the real-GDP gains from APEC-trade liberalisation tend to favour regions that are small and open. Examples are Thailand/Philippines (THA/PHL), for which an 18.2% gain in real GDP is projected, and Malaysia/Singapore

[9] This implies that the deterioration in government budget balances caused by the loss of tariff revenue is not *explicitly* offset by reduced government spending or by increases in other taxes. Most published GTAP applications adopt this assumption.
[10] GTAP allows other assumptions than those adopted here with respect to factor markets and macrobehaviour. Each set of assumptions describes a closure of the model. The standard GTAP closure is a short-run closure in which each region's endowments of capital, labour and land are held fixed.

Table 7
Percentage changes in key endogenous variables of the stylised model

	NAM		JPN		AUS		NZL		CHINA		SKOR		TWN		MYS/SGP		THA/PHL		IDN		ROW	
	GTAP	Stylised	GTAP	Stylised	GTAP	Stylised	GTAP	Stylised	GTAP	Stylised	GTAP	Stylised	GTAP	Stylised	GTAP	Stylised	GTAP	Stylised	GTAP	Stylised	GTAP	Stylised
1. $y^{mp}(r)$	−0.5	−0.6	0.1	0.7	2.2	1.8	3.2	5.0	5.9	9.8	4.4	4.8	5.6	5.3	8.1	8.4	18.2	13.6	2.8	1.0	−0.8	−1.3
2. $c(r)$	−0.4	−0.6	0.6	0.9	2.7	2.5	5.4	7.3	4.0	8.8	4.6	5.2	6.4	6.8	7.0	7.6	12.0	11.6	2.0	1.1	−0.7	−1.4
3. $i(r)$	−1.6	−2.1	−0.4	−0.2	5.8	1.9	6.7	5.2	9.6	10.6	8.3	6.1	14.5	8.5	13.3	12.4	28.3	16.6	5.1	1.5	−2.0	−2.8
4. $g(r)$	−0.5	−0.6	−0.2	0.9	1.2	2.5	3.0	7.3	2.5	8.8	1.4	5.2	2.3	6.8	3.6	7.6	6.4	11.6	3.0	1.1	−0.5	−1.4
5. $x(r)$[a]	3.0	3.0	9.7	9.7	13.5	13.5	14.5	14.5	25.6	25.6	14.3	14.3	18.2	18.2	10.9	10.9	32.2	32.2	9.3	9.3	−2.3	−2.3
6. $m(r)$	2.8	1.0	11.1	9.9	13.6	15.3	14.7	22.0	29.3	25.2	16.2	16.1	21.7	25.4	13.0	11.9	32.2	28.2	10.3	11.0	−1.4	−3.6
7. $y^{fc}(r)$	−0.6	−0.8	−0.2	−0.1	2.2	0.8	2.9	2.4	4.5	6.0	3.7	3.1	5.1	3.2	7.1	7.5	17.1	11.6	2.4	0.9	−0.7	−1.1
8. $k(r)$	−1.6	−2.1	−0.4	−0.2	5.8	1.9	6.7	5.2	9.6	10.6	8.3	6.1	14.5	8.5	13.3	12.4	28.3	16.6	5.1	1.5	−2.0	−2.8
9. $p^{mp}_{gdp}(r)$	−0.6	0.3	1.1	2.5	2.5	3.4	7.3	5.0	−2.6	−0.8	2.1	1.1	3.3	3.7	−2.8	−4.7	−8.8	−2.3	0.4	2.1	−1.3	−0.8
10. $\text{tot}(r)$[b]	0.2	0.2	2.2	2.2	3.8	3.8	7.5	7.5	−2.9	−2.9	1.3	1.3	3.1	3.1	−0.6	−0.6	−4.8	−4.8	0.5	0.5	−0.2	−0.2
11. $p^{c}(r)$	−0.7	0.3	0.4	2.3	1.9	2.7	5.0	2.6	−1.2	0.2	0.9	0.6	1.5	2.2	−3.4	−4.0	−5.0	−0.3	1.1	2.0	−1.2	−0.8
12. $p^{g}(r)$	−0.7	0.3	1.8	2.3	3.4	2.7	7.8	2.6	0.2	0.2	5.6	0.6	7.1	2.2	1.6	−4.0	1.0	−0.3	0.2	2.0	−1.5	−0.8
13. $\text{rer}(r)$	0.2	0.3	2.3	2.5	2.8	3.4	7.4	5.0	−2.2	−0.8	2.9	1.1	4.4	3.7	−1.7	−4.7	−8.3	−2.3	0.9	2.1	−0.2	−0.8
14. $p^{fc}_{gdp}(r)$	−0.4	0.5	2.1	3.5	3.9	4.8	8.4	6.1	3.9	5.7	5.4	4.4	7.1	7.5	3.2	1.3	−1.2	5.4	2.1	3.8	−1.3	−0.8
15. $\text{rp}_1(r)$	−0.6	−0.6	−0.1	−0.1	1.2	0.6	2.2	1.9	3.3	5.5	3.4	2.6	4.1	2.4	5.8	6.1	12.2	9.9	1.7	0.8	−0.7	−0.9
16. $\text{rp}_k(r)$	0.8	1.0	0.4	0.1	−3.3	−0.9	−4.2	−2.2	−5.3	−4.2	−2.8	−2.5	−6.2	−4.1	−3.7	−4.0	−7.6	−4.3	−2.5	−0.6	1.0	1.3
17. $\text{rw}(r)$	−0.3	−0.3	1.6	1.1	3.2	2.7	5.6	5.4	8.4	11.0	7.8	6.3	9.7	7.8	12.5	11.4	16.0	15.5	2.7	2.7	−0.8	−0.9

[a] Exogenously set equal to the GTAP projections for exports via endogenous shifts in Eq. (7′).

[b] Exogenously set equal to the GTAP projections for the terms of trade via endogenous shifts in Eq. (11′).

(MYS/SGP), for which an 8.2% gain is projected. Apart from being small and open, these regions also have high pre-liberalisation levels of protection against imports, especially against imports of investment goods. The regions that gain least in terms of real GDP are the ROW, which does not cut protection and the large APEC economies, North America (NAM) and Japan (JPN).

Projections for changes in the terms of trade as a result of the APEC liberalisation are given in row 10 of Table 7 ("GTAP" column). Here, the liberalisation favours JPN, the agricultural exporting regions such as Australia (AUS) and New Zealand (NZL) and Taiwan (TWN). JPN's terms of trade improves, in part, because of strong increases in NAM demand for Japanese products due to tariff liberalisation. The terms-of-trade increases in AUS and NZL flow from the existence, prior to liberalisation, of large barriers imposed on agricultural and food commodities from these countries. The terms-of-trade increase in TWN stems mainly from strong increases in demand in other APEC regions for imports of other machinery and equipment from TWN. Regions that experience terms-of trade losses as a result of APEC liberalisation do so either because they are agricultural importing regions or because the ROW (where real activity falls because of liberalisation) is over represented as a destination for their exports.

Rows 5 and 6 of Table 7 ("GTAP" columns) show the trade-enhancing effects in each APEC region of tariff reductions. All APEC regions are projected to experience increases in trade volumes, with the largest increases occurring in regions with the highest initial levels of protection.

Rows 2–4 of Table 7 ("GTAP" columns) show the impact of liberalisation on the components of real domestic demand. Aggregate real consumption (private plus government) is elevated in all APEC regions other than NAM and JPN. The largest increases are in regions that are projected to experience the largest gains in real GDP.

4.2. More detailed interpretation aided by the stylised model

The overview above is fairly typical of explanations offered in published journal articles of results from a GTAP simulation. Even so, in the context of the APEC liberalisation simulation, the overview leaves many questions unanswered. For example, why did real GDP in NAM fall? What accounts for the changes in factor prices (changes that are so important for income distribution analysis)? Why did NZL gain by more than AUS? What accounts for the large GDP gains in THA/PHL, and for the relatively small GDP gain in Indonesia (IDN)?

Answers to these and to many other questions, are revealed with the aid of the stylised macromodel. There are two ways that the stylised model can be used. One is to use individual equations in isolation to understand specific results from the full model. For example, we might use Eq. (2′) to explain outcomes for real GDP at factor cost based on GTAP values for the right-hand coefficients and GTAP-simulated values for right-hand variables. The second way that the stylised model can be used is to employ it as a model in its own right to reproduce the simulation of the primary model using shocks aggregated to a macroeconomic level. Results from the stylised simulation can then be compared with those from the simulation of the primary model, with special attention directed towards significant variations. We adopt this second approach in the discussion below.

4.2.1. Simulation design for the stylised model

The GTAP simulation of the long-run effects of APEC trade liberalisation is reproduced in the stylised macromodel by shocking $t(r)$ and variables that are naturally exogenous in the stylised macromodel but are naturally endogenous in the GTAP model, namely $y_W(r)$, $y^{TAX}(r)$, $p_W(r)$ and ror(r). The shocks to $t(r)$ are equivalent to the shocks imposed in the GTAP simulation (see Table 5). The shocks to $y_W(r)$ and $p_w(r)$ were calibrated so that the stylised model reproduced exactly the GTAP projections for the volume of exports ($x(r)$ in the stylised model) and the terms of trade (tot(r) in the stylised model) (see Table 7). $Y^{TAX}(r)$ and $p^{TAX}(r)$ were set equal to the value of $m(r)$ and to 0, reflecting the fact that imports are the tax base for the taxes that are being removed. The shocks to ror(r) were uniform and set equal to the GTAP outcome for the global rate of return on capital (rorg), 1.28. This is the increase necessary to ensure that the change in global investment matches the change in global savings arising from APEC liberalisation.

4.2.2. Detailed explanation

The projections from the stylised macromodel are given in Table 7 in the columns labelled "Stylised". Our explanation of the GTAP projections using the stylised mechanism starts with real factor prices and the use of factor inputs. It then proceeds to real GDP, to the price of GDP and to the expenditure-side components of real GDP.

4.2.2.1. Changes in real factor prices. Eq. (17′) shows that there are three main mechanisms through which tariff cuts can affect the real cost of capital (the nominal cost of capital relative to the GDP deflator at factor cost). The first is via a change in the global rate of return on capital—essentially the rate of return *required* on global capital markets. The second is via the direct effects of the tariff cuts on the duty-paid prices of imported inputs to investment. The third is via changes in the terms-of-trade that affect the average c.i.f. price of imported capital goods relative to the GDP deflator. In the GTAP simulation, the rate of return on capital increases in all regions by 1.28%, whereas the outcomes for the terms of trade vary across regions. Ultimately, the GTAP-simulated value for rp_k is negative for all regions except NAM, JPN and ROW. In the exceptional cases, the impact of the increase in the required rate of return on the real cost of capital more than offsets the effects of changes in the terms of trade and in tariff rates.

In the GTAP simulation, the regions that experience the largest falls in the real cost of capital are THA/PHL, TWN and CHINA. The tariff cuts as a share of GDP in these regions are relatively large (see the second row of Table 5) and dominate the influences of other factors on the cost of capital. Table 5 shows that the tariff cuts in MYS/SGP are also large, but the GTAP-projected fall in that region's real capital cost is mild relative to the fall projected for THA/PHL. To understand this result, note that the stylised model's projection for MYS/SGP is relatively close to the GTAP projection, whereas for THA/PHL, TWN and CHINA the stylised macromodel underestimates the fall projected by GTAP. This points to compositional effects unaccounted for in the stylised model. Closer inspection of the GTAP projections shows that the tariff cuts in THA/PHL, TWN and CHINA are more oriented towards investment goods than are the cuts in MYS/SGP. Thus in the most-affected regions the falls in the price of investment relative to the price of

GDP (market prices) are much larger than in MYS/SGP. This is why the tariff cuts in the most-affected regions have a stronger influence on the real cost of capital than they do in MYS/SGP.

Eq. (15′) establishes that there is a strong negative relationship between the real cost of labour and the real cost of capital. The degree of responsiveness is determined by values for the ratio of the share of capital to the share of labour, initial estimates of which can be deduced using data in Table 6 for $S_K(r)S_L(r)$. These show that the responsiveness of the real cost of labour to a 1% change in the real cost of capital will be greatest in the developing regions such as THA/PHL. In these regions, wages are low and so the ratios of capital payments to labour payments are high. In developed regions, the situation is reversed; comparatively high wage rates mean that the ratio of capital payments to labour payments is low.

The negative relationship between real factor prices is confirmed by the GTAP results in Table 7. In regions where the real cost of capital declines the real cost of labour rises. The largest rise occurs in THA/PHL, which is projected to experience the largest fall in the real cost of capital and which has a relatively high capital share.

For some regions the stylised macromodel fails to account adequately for changes in the real cost of land as projected by GTAP. This is due primarily to the omission of agricultural land. In GTAP, there are two main fixed factors of production in the long-run, labour and land. Thus, when the real cost of capital falls, the real cost of labour plus land rises. The distribution of this increase in each region between labour and land depends partly on the respective shares of labour and land in GDP. In agriculturally oriented regions like AUS and NZL, in which land's GDP share is over 2%, land absorbs a significant portion of the benefit that would otherwise have gone to labour. In these cases the stylised macromodel tends to overestimate the increase in the real price of labour.

4.2.2.2. Changes in factor inputs and real GDP at factor cost. Eq. (14′) shows that a fall in the real cost of capital relative to the real cost of labour causes producers to substitute capital for labour.[11] Accordingly, with employment unchanged in the long-run, capital is created in regions where the real cost of capital falls (see rows 8 and 16 of Table 7) and is destroyed in regions where the real cost of capital rises. THA/PHL experiences the largest increase in capital, followed by CHINA, TWN and SKOR. ROW and NAM experience the largest falls in capital.

Having explained changes in capital stocks we have also explained changes in real GDP (see Eq. (2′)).[12] Fig. 1 is a chart of the deviations in real GDP at factor cost as projected by GTAP and as projected by the stylised macromodel. This figure illustrates two things: the relativities across regions in factor-cost GDP responses, and the reliability of the stylised model's explanation of deviations in real factor-cost GDP.

[11] In a multi-sectoral model, the economy-wide ratio of capital to labour is affected not only by changes in the ratio of aggregate factor prices but also by changes in the sectoral composition of GDP. For example, in the long-run the capital to labour ratio can rise because of changes in the composition of the economy towards capital-intensive industries. Conversely, it can fall with changes in composition away from capital-intensive industries.

[12] Recall that in the long-run simulation employment is fixed and there is no change in industry technologies.

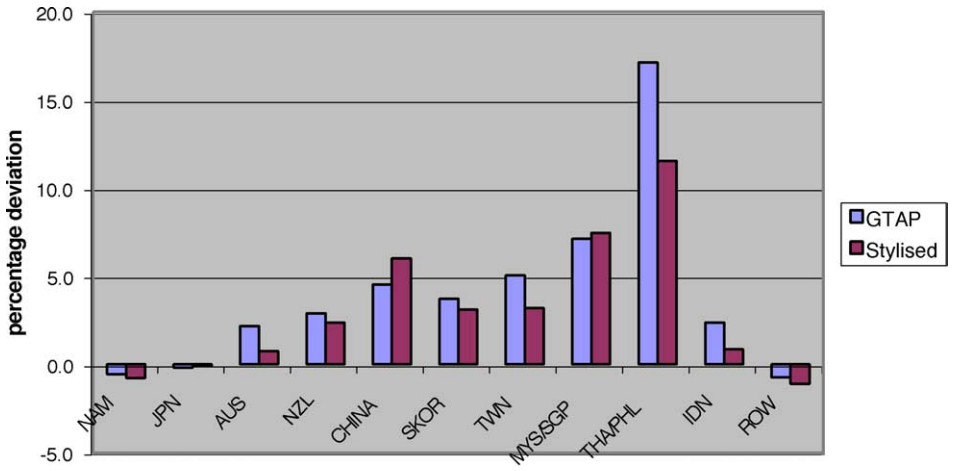

Fig. 1. Long-run deviations in real GDP at factor cost.

Real GDP at factor cost falls in three regions, NAM, JPN and ROW. These falls ultimately reflect projected increases in the real cost of capital in each adversely affected region arising from the global increase in the rate of return on capital. Liberalisation is projected to increase real GDP in all other regions. The regions that expand least are AUS, NZL and IDN. This is consistent with the relatively small tariff cuts in these regions (see Table 5). Note that NZL gains more than AUS despite a smaller tariff cut because the NZL economy is more capital intensive and thus more responsive in a long-run simulation.

Fig. 1 shows that the stylised model underestimates the "true" effects on real factor-cost GDP most significantly for THA/PHL, TWN, AUS and IDN, and overestimates the effects most significantly in CHINA. Underestimation can generally be traced back to an underestimation of the reduction in the real cost of capital. In all of the cases noted above, the error in estimating the impact on the real cost of capital is accounted for by the composition of the tariff shock which is disproportionately weighted towards imported investment goods (see the discussion regarding real factor prices above).

Overestimation of the factor-cost GDP result for CHINA, though, does not stem from an overestimation of the impact on the real price of capital. Indeed, as can be seen in Table 7 the stylised model underestimates the impact on the cost of capital. The key problem here appears to the relationship between the real cost of capital and the real cost of labour. With the stylised model, a 4.2% reduction in the real price of capital translates into a 5.5% increase in the real price of labour. By contrast, in the GTAP simulation a 5.3% increase in the real cost of capital results in only a 3.3% increase in the real price of labour. Again, the omission of land is the main cause of the disagreement. Though the share of land in GDP in CHINA is initially quite small, the increase in land rental in CHINA as projected by GTAP is very large (69%), displacing a significant portion of the benefit that otherwise would have gone to labour. The price of Chinese agricultural land rises strongly because of the significant level of pre-liberalisation tariffs imposed on Chinese agricultural imports by other APEC regions.

4.2.2.3. Changes in real GDP at market prices and in the expenditure-side aggregates of real GDP. Real GDP at market prices is related to real GDP at factor cost by the addition of real indirect taxes net of subsidies (see Eq. (3′)). In the simulation of the stylised macromodel, we assume that real indirect taxes net of subsidies move with the volume of imports. Accordingly, in the stylised simulation the ratio of real GDP at market prices to real GDP at factor cost (row 1 less row 7 in Table 7) increases in all regions where imports rise. This is consistent with the GTAP projections. Note, though, that the stylised model typically overestimates the increase in GDP ratio. This is because the stimulation of imports does not reflect the direct impact of tariff cuts only. Some of the stimulation reflects general expansion in final demand and so the percentage increase in import volume will typically overstate the GTAP-projected percentage increase in real indirect taxes net of subsidies.

We now turn to the expenditure-side aggregates of real GDP. In the stylised macromodel, the change in real private consumption is explained by Eq. (4′). Assuming no change in the average propensity to consume (Ω), and no change in the ratio of the price of GDP at market prices to the price of private consumption the stylised model would predict that real consumption moves in line with real GDP at market prices. Inspection of the GTAP results shows that this is a reasonable approximation (compare rows 1 and 2 in Table 7). Changes in the ratio of the price of GDP to the price of household consumption, though, are important in some regions (compare row 9 with row 11). In the stylised model, changes in this price ratio are linked to changes in the terms of trade (see Eq. (12′)). According to Eq. (12′), in regions where the terms of trade improve, the ratio of the price of GDP to the price of consumption increases and allows room for an increase in real consumption. Overall, the stylised model provides an adequate approximation to the impacts on private consumption of tariff liberalisation, taking into account errors in the estimation of the percentage change in GDP.

The stylised model's account of changes in real public consumption is less convincing than its account of changes in real private consumption. This is so because in the GTAP simulation the price of public consumption does not move with the price of private consumption, as is assumed in Eq. (13′). In this case compositional effects are important. Private consumption tends to be oriented towards capital-intensive goods (housing, for example), with a sizeable share of imports in total expenditure. Public consumption on the other hand is oriented towards labour-intensive goods (such as public administration and community services), with only a small share of imports in total expenditure. It follows that in simulations where wage and import-price effects are significant, the price of public expenditure can move quite differently from the price of private consumption. This is certainly the case in the GTAP projections for SKOR.

Investment in both the stylised macromodel and GTAP is indexed to capital in long-run simulations. Projections for capital are discussed above.

We turn next to trade volumes. Eq. (6′) suggests that in the GTAP simulation changes in import volumes reflect three factors: (a) the changes in relative domestic/import prices due to the direct effects of the tariff cuts, (b) changes in domestic demand and (c) changes in the real exchange rate. In the GTAP simulation, the impact on imports of (a) is unambiguously positive. In most regions, the import-intensive components of demand are investment-related. Thus in most of the APEC regions the effects of (b) reinforce the effects of (a).

The final factor is changes in real exchange rates. In the stylised macromodel, the change in real GDP(Y) in each region is determined, in the main, by changes in relative factor prices, and the change in real domestic absorption ($C + I + G$) in each region reflects the change in real GDP. It follows that the change in net trade volume ($X - M$) is constrained by the requirement for macroeconomic balance ($Y = C + I + G + X - M$). In other words, the volume of net trade has to adjust to reconcile changes in real GDP with changes in real domestic absorption. The residual adjustments occur via changes in real exchange rates.

In the simulation of the stylised macromodel, the change in real domestic absorption in each region generally exceeds that of real GDP because C and G move with GDP, but I moves with capital. This means that the balance of trade for each APEC region will deteriorate in real terms. The stimuli to import volumes from effects (a) and (b) generate some of the deterioration in each economy. The residual adjustment occurs via changes in real exchange rates. Real appreciation is required in most cases (see row 13 of Table 7). However, in some cases (e.g., THA/PHL) where effects (a) and (b) are very large, real devaluation is necessary. The pattern of devaluation and appreciation suggested by the stylised model is consistent with that projected by GTAP.

5. Conclusion

In this paper, we suggest a general strategy for interpretation of macroeconomic projections from a CGE model like GTAP. Central to this strategy is the use of a stylised macromodel. Experience suggests that the stylised framework provides a robust method for understanding CGE projections. The extent of robustness will be inversely proportional to the degree to which compositional changes, not allowed for in the stylised framework, influence the final simulation outcome. In this paper, the robustness is put to the test with an analysis of GTAP projections of the long-run impacts of APEC trade liberalisation.

The stylised model assists in identifying the principal theoretical mechanisms that underlie the projections from the full model. It also aids in highlighting the important elements of the database (see Table 6). In the context of the long-run APEC liberalisation simulation, insights relevant to policy makers from the stylised model include the following.

- changes in relative factor prices play an important role in determining the GDP response in a fixed-factor simulation: in the long-run, with the rate of return on capital determined extraneously, liberalisation that reduces the cost of investment will have a larger positive impact on real GDP than liberalisation which has relatively little impact on investment-cost;
- in the short run, with the real wage rate (wage deflated by the price of consumption) fixed, liberalisation that reduces the cost of consumption will have a larger positive impact on real GDP than liberalisation which has relatively little impact on consumption-cost;
- adjustment of land rentals is an important consideration in understanding the macroresponse to a tariff cut of agricultural-dependent countries (including China);
- the size of the real-GDP response is positively related to the size of the tariff cut as a share of GDP;

- the effects of liberalisation on each region's real exchange rate will reflect the extent to which liberalisation changes real GDP relative to real domestic absorption: increased GDP relative to absorption will typically be accompanied by real devaluation; reduced GDP relative to absorption will typically be accompanied by real appreciation;
- changes in the terms of trade play an important role in determining the size of the GDP response and in determining the composition of that response across the large expenditure-side aggregates: an improvement in the terms of trade, all else unchanged, increases real GDP and allows for increased real consumption; a deterioration in the terms of trade, all else unchanged, reduces real GDP and real consumption.

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