Baseline validation with the GTAP model: an initial effort

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Summary

(1) In an earlier report we described an historical simulation for 2004 to 2014 conducted with a 58-industry, 13-region version of the GTAP model. The historical simulation generated detailed estimates of trends in industry technologies, household preferences and the preferences of importing agents between sources of supply.

(2) We introduced these technology and preference trends into baseline simulations for 2014 to 2017. By comparing baseline results for the values in 2017 of industry outputs in each region with GTAP data for 2017, we assessed the accuracy of our forecasting method.

(3) The baseline forecasts exhibited large and unsatisfactory errors (gaps between baseline forecast values and 2017 data). The introduction of preference and technology trends from the historical simulation did not reduce the errors below those generated in a simulation informed only by movements in real GDP, population and aggregate employment. Our forecasting method barely beat a no-model trending approach.

(4) Although the results in this paper are negative, further GTAP baseline/validation efforts are warranted. Baselines are important. They affect policy results, they are of interest to clients of CGE modellers in the policy arena, and they are an avenue for model improvement.

(5) We suggest several potential directions for future GTAP baseline/validation work, including:
   (a) improving the estimation in the historical simulation of technology and preference trends through incorporation of ideas from new-trade theory;
   (b) improving the projection of technology trends into baseline forecasts by using historical trends for leading countries to inform future trends for following countries; and
   (c) drawing on macro and energy forecasts prepared by specialist national and international organizations.

(6) However, we think that the most likely source of improvement in our results is data revision. Successful baseline/validation projects have been carried out for a single-country U.S. model. There, the data were supplied by a single national statistical agency, the Bureau of Economic Analysis. By contrast, GTAP data is supplied by researchers from around the world. Although the data are centrally processed at GTAP headquarters, achieving compatibility in industry definitions across regions and time is a formidable task.

(7) In this paper we review the GTAP output data for 45 j,r combinations where j refers to industry and r refers to region. The 45 were chosen in light of highly unrealistic results in our validation simulations. For 27 out of the 45, we found evidence of incompatibilities between the GTAP data for 2014 and 2017. Our impression is that the main problems are in the 2017 data.

(8) We suspect that progress on GTAP baseline construction and validation along the lines described in this paper will require an overhaul of GTAP data for 2017. This could be guided by calculations such as those contained in this paper which help to pinpoint problematic areas.

Contents

1. Introduction

The Global Trade Analysis Project provides global databases for 2004, 2007, 2011, 2014 and 2017. For more than 140 countries, these databases include: input-output tables identifying 57 commodities and 58 industries[1] (65 and 66 in 2014 and 2017); the use by the industries of five types of primary factors; trade flows for each commodity between each pair of countries; tax collections associated with all domestic and international flows; and transport costs associated with each international flow. These databases support the GTAP model [Hertel (1997), Corong *et al.* (2017) and Aguiar *et al.* (2019)].

In an earlier report [Dixon and Rimmer (2023)] we described an historical simulation[2] for the period 2004 to 2014 with a 57-commodity, 58 industry, 13-region version of the GTAP model[3]. The historical simulation started from the 2004 database and then in a single-period (10-year) computation produced a picture of 2014. We required this picture to be consistent with a large number of data points in the GTAP database for 2014 and with data on a selection of other variables brought in from non-GTAP sources.

The historical simulation generated detailed estimates of changes in technologies and preferences by calculating the changes required to connect GTAP databases for 2004 and 2014. For all of the 58 industries in 13 regions, the technology estimates distinguished input-saving technical changes for each intermediate input by source (domestic or imported) and for each of the five primary factors. For households, government and capital creators in the 13 regions, the preference estimates distinguished preference changes in favour or against each of the 57 commodities disaggregated by source. The historical simulation also estimated preference changes between sources by importing agents. For imports of each commodity into each region, these preference changes showed shifts in favour or against the 12 foreign supplying countries.

In this paper, we are concerned with GTAP baseline simulations. These are normally used to provide business-as-usual pictures of *future* periods from which the effects of potential policies can be calculated as deviations. Baseline simulations typically take in projections for macro variables (e.g. real GDP, population and employment for each region) and produce projections of industry and trade variables for each region.

Here, we describe baseline simulations for a *past* period. Our simulations start from 2014 and project forward to 2017. We take account only of data up to 2014 with the exception of real GDP, population and employment for each region for which we use the actual movements. In effect, we assume that our baseline for 2014 to 2017 is informed by an excellent macro forecaster. By comparing the projections for 2017 with the GTAP data for 2017, we can assess the performance of our baseline forecasting method for industry and other micro variables. We can also assess the comparability of the GTAP data for 2014 with that for 2017.

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[1] There is one industry for each commodity plus the capital-goods industry, which mixes inputs to investment to create capital goods.

[2] This technique has been used since the 1990s to estimate technology and preference shifts and to analyze structural aspects of economic growth for Australia, the U.S., Vietnam, China and several other countries. References include Dixon and McDonald (1993), Dixon *et al.* (2000), Dixon and Rimmer (2002, 2004), Giesecke (2002), Giesecke and Tran (2009), Dixon and Rimmer (2013), Dixon *et al.* (2013) and Peng (2023).

[3] We aggregated the 2014 database from 65 to 57 commodities and from 66 to 58 industries to make it comparable with the 2004 database.

The technology and preference changes built into baseline projections are usually bland. For example, Britz and Roson (2019) rely on a 4-sector disaggregation (agriculture, mining, manufacturing and services). The main question for this paper is: can we improve the performance of baseline simulations by building in detailed trends in technology and preference variables derived from historical simulations? We address this question by comparing the performance of 2014-17 baselines with and without incorporation of detailed technology and preference trends derived from our historical simulation.

The paper is organized as follows. Section 2 sets out the equations through which we projected the trends in technology and preference variables from our 2004-14 historical simulation into our 2014-17 baseline simulations. Section 3 describes results from the 2014-17 baseline simulations. This leads to an examination of the comparability of the GTAP data for 2017 with that for 2014 and earlier years. Section 4 provides some conclusions and plans for future research.

2. Taking results for technology and preference variables from an historical simulation into a baseline simulation

In the period of an historical simulation, the shares of different inputs in industry costs may vary significantly from the shares that apply in the baseline forecast period. Similarly, there can be large changes in the shares of different commodities in household expenditures and the shares of supplying regions in a country's imports of a commodity. These share changes cause complications in projecting into a baseline simulation technology and preference trends generated in an historical simulation.

For example, consider the case of plant fibres (pfb) in India. Between 2004 and 2014, exports of pfb from India grew from 2.7 per cent of world exports to 17.5 per cent. This was accommodated in our historical simulation by large percentage preferences shifts by importing agents throughout the world towards pfb from India. If these percentage preference shifts were simply projected forward in the 2014-17 baseline simulation starting from India's large 2014 export volume, then the resulting forecast would be an unrealistic domination by India in the world pfb market.

To deal with the share-change problem, we project forward *contributions* rather than simple percentage changes in technology and preference variables. By contributions, we mean percentage effects of technology and preference changes on aggregate variables. In the case of a preference shift towards region r by the importing agent in region s for commodity k, we project forward a modified version of the effect of the preference shift on s's total imports of k. Projecting forward contributions means that large percentage changes in values and quantities off small bases in the historical simulation don't translate into unrealistic absolute changes in the baseline simulation.

As is apparent from Dixon and Rimmer (2023), the 2004-14 historical simulation generated changes in technology and preference variables at different levels of the nested or tiered GTAP demand systems for industry inputs, household consumption of commodities, and imports by supplier. As a preliminary step to estimating historical contributions and projecting them into the baseline, we added equations to the GTAP model to reveal bottom-tier preference and technology changes equivalent to the combination of the changes occurring at different tiers.

This section provides details for industries, households and importing agents on our calculations of technology and preference contributions in the historical simulation and their projection into the baseline simulation. The historical simulation also generates preference changes between commodities by governments, but we didn't project these forward.

2.1. Projecting industry technologies

In Dixon and Rimmer (2023), we derived an estimate from the historical simulation for each industry j in region r of all-input technical change for the period 2004 to 2014. This was the variable we refer to as tech(j,r). A value of *x* for tech(j,r) meant that industry j in region r produced *x* per cent more output per unit of aggregate input in 2014 than in 2004. The percentage change in aggregate input was calculated as a cost-weighted average of the percentage changes in individual inputs (the 5 primary factors and the 57 intermediate inputs disaggregated into domestic and imported).

We projected these all-input technical changes forward for 2014 to 2017 according to

$$tech3(j,r) = 0.3*[(1-\Lambda)*techE10(j,r)+ \Lambda*tech10(j,r)] +adj2(r) \qquad (2.1)$$

In this equation:

tech3(j,r) is the all-input technical change for industry j,r that we adopt for the 3-year period 2014 to 2017.

tech10(j,r) is the all-input technical change for industry j,r from the historical simulation for the 10-year period 2004 to 2014 [referred to above as tech(j,r)].

techE10(j,r) is the all-input technical change that we expected in the historical simulation for industry j,r. As explained in Dixon and Rimmer (2023), techE10(j,r) was derived as a function of: the average across all regions in all-input-saving technical change for industry j; the average across all industries in all-input-saving technical change in region r; and a Balassa-Samuelson effect that takes account of productivity changes in traded industries in region r relative to non-traded industries. It is reasonable to think of the techE10(j,r)s as versions of the tech10(j,r)s that have been revised to smooth out extreme values.

Λ is a parameter that can be set with values from 0 to 1. If Λ = 0, then we allow the smoothed versions of all-input technical changes from 2004 to 2014 to dominate in our prediction of all-input technical changes from 2014 to 2017. If Λ = 1, then we rely on the results from the historical simulation, without smoothing, to inform our all-input-saving technology forecasts.

adj2(r) is a region-specific adjustment variable. Its role in the 2014-17 simulation is to adjust the all-input technical changes for the industries in region r so that they are compatible with the macro assumptions for real GDP and employment.

The 0.3 on the RHS of (2.1) converts 10-year growth into 3-year growth.

Calculating input-saving technical changes for bottom-tier inputs in the historical simulation to facilitate projection of textured technical changes into the 2014-17 simulation

Underlying the estimate of all-input-saving technical change for industry j,r derived from the historical simulation are technical changes disaggregated by input. In the 2014-17 simulation we give texture to the technology assumption for industry j,r by projecting forward the underlying technical changes by input in a way that is consistent with the all-input-saving technical change specified by (2.1). For understanding how this is done, it is necessary to briefly describe the system of input-demand equations used in the GTAP model.

In GTAP, demands for inputs to industry j in region r are specified via a multi-stage cost-minimization problem. This leads to a tiered system of demand equations that show

(1) the inputs of imported and domestic commodity k in industry j,r as functions of:
  the total use of k in j,r,
  the relative prices of imported and domestic k, and
  terms that allow for input-saving or using technical changes by j,r in its use of domestic and imported k.

(2) the total use of each commodity k in industry j,r as a function of:
  the output of j,r, and
  terms that allow for input-saving or using technical changes by j,r in its use of intermediate input k.

(3) the input of each primary factor f in industry j,r as a function of:
  the total use of primary factors in j,r,
  the relative prices of different primary factors, and
  terms that allow for input-saving or using technical changes by j,r in its use of each primary factor.

(4) the total use of primary-factors in industry j,r as a function of:
  the output of j,r, and
  terms that allow for input-saving or using technical changes by j,r in its use of primary factors.

The historical simulation generates technical changes in each of the four tiers of the input demand system. This means that there are several technical change variables that affect the relationship between bottom-tier inputs to j,r and the output of j,r, where by bottom-tier inputs, we mean inputs of domestic k and inputs of imported k [tier (1)] and each of the five primary factors [tier (3)]. For example, the input of imported commodity k per unit of output of j,r is affected by the technical changes in tiers 1 and 2. Similarly, the input of primary factor f per unit of output of j,r is affected by the technical changes in tiers 3 and 4.

In projecting technical changes from an historical simulation into a baseline, we found it convenient to project a single technical change for each bottom-tier input to industry j,r. Before we could do that, it was necessary to calculate the bottom-tier technical changes in the historical simulation. To work these out, we retained in the 2004-14 historical simulation the original GTAP input-demand equations while adding a new set of the form:

$$\mathrm{qfd}(k,j,r) = \mathrm{qo}(j,r) + \{\text{price terms}\} - \mathrm{tcd10}(k,j,r) \quad \text{for all } k \in \mathrm{Com},\ j \in \mathrm{Ind},\ r \in \mathrm{Reg} \qquad (2.2)$$

$$\mathrm{qfm}(k,j,r) = \mathrm{qo}(j,r) + \{\text{price terms}\} - \mathrm{tcm10}(k,j,r) \quad \text{for all } k \in \mathrm{Com},\ j \in \mathrm{Ind},\ r \in \mathrm{Reg} \qquad (2.3)$$

$$\mathrm{qfe}(f,j,r) = \mathrm{qo}(j,r) + \{\text{price terms}\} - \mathrm{tcp10}(f,j,r) \quad \text{for all } f \in \mathrm{PF},\ j \in \mathrm{Ind},\ r \in \mathrm{Reg} \qquad (2.4)$$

where

qfd(k,j,r) and qfm(k,j,r) are percentage changes in demand by industry j,r for domestic and imported intermediate input k;

qfe(f,j,r) is the percentage change in demand by industry j,r for primary factor f;

qo(j,r) is the percentage change in the output of industry j,r;

{price terms} are functions of movements in the prices of bottom-tier inputs, with the functional forms being derived by substituting equations for higher level inputs and prices (e.g. demand and price for k used by industry j,r) into equations for bottom-tier inputs (e.g. demand for imported k by industry j,r)

Com, Ind, Reg and PF are the sets of commodities, industries regions and primary factors; and

tcd10(k,j,r), tcm10(k,j,r) and tcp10(f,j,r) are the required single bottom-tier technical changes for each bottom-tier input.

We used these additional equations in the historical simulation to endogenously determine tcd10, tcm10 and tcp10. With this treatment, tcd10(k,j,r) encapsulates all of the technical changes in the historical simulation that directly affect the input of domestic k per unit of output in industry j,r. The variables tcm10 and tcp10 play similar roles for technical changes affecting the inputs of imported k and primary-factor f per unit of output in industry j,r. As a check on the computation of tcd10, tcm10, and tcp10, we calculated their combined effect for industry j,r and made sure that it was the same as the all-input technical change variable, tech(j,r), analysed in section 3 of Dixon and Rimmer (2023) and referred to in equation (2.1) as tech10(j,r).

Calculating bottom-tier technical change contributions

As we will see shortly, in the 2014-17 simulation we use estimates from the historical simulation of contributions to all-input-saving technical change in industry j,r from each of the technical changes for bottom-tier inputs. For the 10-year period 2004-14, the percentage contribution to j,r's all-input-saving technical change from bottom-tier technical change in the use of domestic k is calculated according to

$$\text{cont\_tcd10}(k,j,r) = \frac{\text{VDFA}(k,j,r)}{\text{VOA}(j,r)} * \text{tcd10}(k,j,r) \quad \text{for all } k \in \text{Com},\ j \in \text{Ind},\ r \in \text{Reg} \qquad (2.5)$$

where

VDFA(k,j,r) is the agent value (purchasers value) of inputs of domestic k to industry j,r, and

VOA(j,r) is the agent value of the output of j,r (sum of agent values of inputs).

The ratio on the RHS of (2. 5) is the share of domestic k in j,r's costs. In the multi-step GEMPACK historical computation, we can think of this cost share as having a value approximately half-way between its 2004 and 2014 values. Similarly we calculated the percentage contributions to total technical change in industry j,r of technical changes associated with inputs of imported k and primary factor f according to

$$\text{cont\_tcm10}(k,j,r) = \frac{\text{VIFA}(k,j,r)}{\text{VOA}(j,r)} * \text{tcm10}(k,j,r) \quad \text{for all } k \in \text{Com},\ j \in \text{Ind},\ r \in \text{Reg} \qquad (2.6)$$

$$\text{cont\_tcp10}(f,j,r) = \frac{\text{EVFA}(f,j,r)}{\text{VOA}(j,r)} * \text{tcp10}(f,j,r) \quad \text{for all } f \in \text{PF},\ j \in \text{Ind},\ r \in \text{Reg} \qquad (2.7)$$

where the ratios on the RHSs of (2.6) and (2.7) are the shares in j,r's costs of imported input k and primary factor f.

Using bottom-tier technical changes from the historical simulation to inform the technical change assumptions in the 2014-17 simulation

In the 2014-17 simulation, we project forward the percentage contributions to total technical change in industry j,r of bottom-tier technical changes according to:

$$\mathrm{cont\_tcd3}(k,j,r) = 0.3 * \mathrm{C\_YD}(k,j,r) * \mathrm{cont\_tcd10}(k,j,r) + \frac{\mathrm{VDFA}(k,j,r)}{\mathrm{VOA}(j,r)} * \mathrm{adj1}(j,r) \quad \text{for all } k \in \mathrm{Com},\ j \in \mathrm{Ind},\ r \in \mathrm{Reg} \tag{2.8}$$

$$\mathrm{cont\_tcm3}(k,j,r) = 0.3 * \mathrm{C\_YI}(k,j,r) * \mathrm{cont\_tcm10}(k,j,r) + \frac{\mathrm{VIFA}(k,j,r)}{\mathrm{VOA}(j,r)} * \mathrm{adj1}(j,r) \quad \text{for all } k \in \mathrm{Com},\ j \in \mathrm{Ind},\ r \in \mathrm{Reg} \tag{2.9}$$

and

$$\mathrm{cont\_tcp3}(f,j,r) = 0.3 * \mathrm{C\_YP}(f,j,r) * \mathrm{cont\_tcp10}(f,j,r) + \frac{\mathrm{EVFA}(f,j,r)}{\mathrm{VOA}(j,r)} * \mathrm{adj1}(j,r) \quad \text{for all } f \in \mathrm{PF},\ j \in \mathrm{Ind},\ r \in \mathrm{Reg} \tag{2.10}$$

In these equations:

cont_tcd3(k,j,r), cont_tcm3(k,j,r) and cont_tcp3(f,j,r) are the bottom-tier technology contributions that we assume in the 2014-17 simulation.

cont_tcd10(k,j,r), cont_tcm10(k,j,r) and cont_tcp10(f,j,r) are the technology contributions defined by (2.5) to (2.7) and calculated in the 2004-14 historical simulation. The coefficient 0.3 converts these 10-year contributions into 3-year contributions.

C_YD(k,j,r), C_YI(k,j,r) and C_YP(f,j,r) are parameters, to be discussed shortly, set at values to ensure that bottom-tier technology contributions from the historical simulation can be accommodated without generating either extreme positive or negative bottom-tier technology changes.

adj1(j,r) is an endogenously determined adjustment variable. Its role in the 2014-17 simulation is to adjust the contributions of the bottom-tier technology changes for industry j,r so that they add up to tech3(j,r) defined in (2.1). That is adj1(j,r) is determined via the equation:

$$\mathrm{tech3}(j,r) = \sum_{k \in \mathrm{Com}} \left[\mathrm{cont\_tcd}(k,j,r) + \mathrm{cont\_tcm}(k,j,r)\right] + \sum_{f \in \mathrm{PF}} \mathrm{cont\_tcp}(f,j,r) \quad \text{for all } j \in \mathrm{Ind},\ r \in \mathrm{Reg} \tag{2.11}$$

The contribution projections generated in (2.8) to (2.11) become operational in the 2014-17 simulation through equations analogous to (2.2) to (2.7):

$$\mathrm{cont\_tcd3}(k,j,r) = \frac{\mathrm{VDFA}(k,j,r)}{\mathrm{VOA}(j,r)} * \mathrm{tcd3}(k,j,r) \quad \text{for all } k \in \mathrm{Com},\ j \in \mathrm{Ind},\ r \in \mathrm{Reg} \tag{2.12}$$

$$\mathrm{cont\_tcm3}(k,j,r) = \frac{\mathrm{VIFA}(k,j,r)}{\mathrm{VOA}(j,r)} * \mathrm{tcm3}(k,j,r) \quad \text{for all } k \in \mathrm{Com},\ j \in \mathrm{Ind},\ r \in \mathrm{Reg} \tag{2.13}$$

$$\mathrm{cont\_tcp3}(f,j,r) = \frac{\mathrm{EVFA}(f,j,r)}{\mathrm{VOA}(j,r)} * \mathrm{tcp3}(f,j,r) \quad \text{for all } f \in \mathrm{PF},\ j \in \mathrm{Ind},\ r \in \mathrm{Reg} \tag{2.14}$$

$$qfd(k,j,r) = qo(j,r) + \{\text{price terms}\} - tcd3(k,j,r) \quad \text{for all } k \in Com,\ j \in Ind,\ r \in Reg \qquad (2.15)$$

$$qfm(k,j,r) = qo(j,r) + \{\text{price terms}\} - tcm3(k,j,r) \quad \text{for all } k \in Com,\ j \in Ind,\ r \in Reg \qquad (2.16)$$

$$qfe(f,j,r) = qo(j,r) + \{\text{price terms}\} - tcp3(f,j,r) \quad \text{for all } f \in PF,\ j \in Ind,\ r \in Reg \qquad (2.17)$$

With values for cont_tcd3(k,j,r), cont_tcm3(k,j,r) and cont_tcp3(f,j,r) coming from (2.8) - (2.11), (2.12) - (2.14) determine tcd3(k,j,r), tcm3(k,j,r) and tcp3(f,j,r). Then the effects of these bottom-tier technology changes feed into the rest of the model via the input-demand system (2.15) - (2.17). Unlike the historical simulation, in the 2014-17 baseline simulation the input-demand system, (2.15) - (2.17), is active: the original GTAP nested system is turned off in the baseline simulation.

Setting values for C_YD, C_YI and C_YP in equations (2.8) to (2.10)

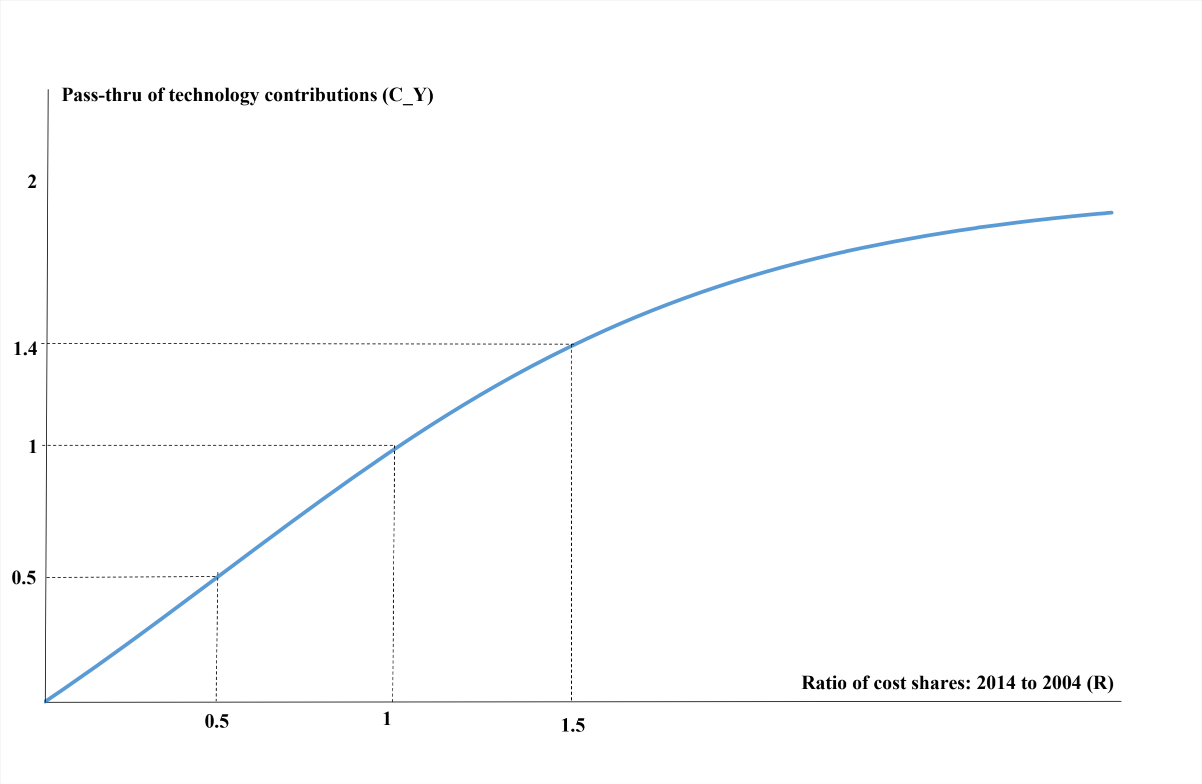
From (2.8) we see that the parameter C_YD(k,j,r) determines the fraction of cont_tcd10(k,j,r) (after the 0.3 multiplication for the 3-year conversion) derived from the historical simulation that is passed through to the baseline simulation for 2014-17. If the share of domestic k in j,r's costs was much lower in 2014 than it was in 2004, then we would expect domestic k's contribution to j,r's total technical change to be lower in 2014-17 than it was (adjusted to 3 years) in 2004-14. Why? If domestic k becomes a low-share of j,r's costs then a given percentage saving of inputs of domestic k can't contribute much to all-input saving technical change in industry j,r. On this basis, we should set C_YD(k,j,r) at less than 1.

At the other extreme, consider the situation in which the share of domestic k in j,r's costs was much higher in 2014 than it was in 2004. Then would expect domestic k's contribution to j,r's total technical change to be higher in 2014-17 than it was (adjusted to 3 years) in 2004-14. On this basis, we should set C_YD(k,j,r) at greater than 1.

With these ideas in mind, we set C_YD(k,j,r) as a logistic function of a ratio of cost shares with the numerator being the share of domestic k in the total cost of inputs to j,r in 2014 and the denominator being the share in 2004. Our chosen logistic function is illustrated in Figure 2.1. The parameters of the logistic function are set so that it has an upper bound at 2, and its value is 0 when the cost ratio is 0, 0.5 when the cost ratio is 0.5 and 1 when the cost ratio is 1. Evaluating C_YD(k,j,r) in this way achieves our objective of modifying pass-thru contributions to take account of changes in cost shares between the historical and baseline forecast periods. It also imposes an upper limit on the forecast contribution of domestic k to total technical change in industry j,r relative to the historical contribution.

We set the parameters C_YI(k,j,r) and C_YP(f,j,r) in (2.9) and (2.10) following the same approach as for C_YD(k,j,r).

Figure 2.1. Evaluation of pass-thru fractions for contributions of bottom-tier technical changes



2.2. Projecting household preferences

Our method for projecting changes in household preferences determined in the 2004-14 historical simulation into the 2014-17 baseline simulation is similar to the method described for industry technologies in the previous sub-section.

First, we added equations to the historical simulation analogous to (2.2) - (2.3) and (2.5) - (2.6) to determine bottom level household preference changes and their contributions to household consumption:

$$\mathrm{qpd(k,r)} = \{\text{aggregate expenditure \& population terms}\} + \{\text{price terms}\} + \mathrm{hprefd10(k,r)} \quad \text{for all } k \in \mathrm{Com},\ r \in \mathrm{Reg} \tag{2.18}$$

$$\mathrm{qpm(k,r)} = \{\text{aggregate expenditure \& population terms}\} + \{\text{price terms}\} + \mathrm{hprefm10(k,r)} \quad \text{for all } k \in \mathrm{Com},\ r \in \mathrm{Reg} \tag{2.19}$$

$$\mathrm{cont\_hprefd10(k,r)} = \frac{\mathrm{VDPA(k,r)}}{\mathrm{VPA(r)}} * \mathrm{hprefd10(k,r)} \quad \text{for all } k \in \mathrm{Com},\ r \in \mathrm{Reg} \tag{2.20}$$

$$\mathrm{cont\_hprefm10(k,r)} = \frac{\mathrm{VIPA(k,r)}}{\mathrm{VPA(r)}} * \mathrm{hprefm10(k,r)} \quad \text{for all } k \in \mathrm{Com},\ r \in \mathrm{Reg} \tag{2.21}$$

where

qpd(k,r) and qpm(k,r) are the percentage changes in demand by households in r for domestic and imported commodity k;

{aggregate expenditure and population terms} are terms appearing in the original GTAP household demand equations;

{price terms} are functions of movements in the prices to households of bottom-tier commodities (domestic and imported varieties of each commodity), with the functional forms being derived by substituting equations for higher tier commodities and prices (not distinguished by dom/imp) into equations for bottom-tier commodities;

hprefd10(k,r) and hprefm10(k,r) are bottom-tier preference changes;

cont_hprefd10(k,r) and cont_hprefm10(k,r) are the contributions to aggregate consumption in region r of bottom-tier preference changes for domestic and imported commodity k;

VDPA(k, r) and VIPA(k,r) are the agent value (purchasers value) of household consumption of domestic and imported k in region r, and

VPA(r) is the agent value of total household consumption in region r.

Next, we added to the baseline simulation three sets of equations. The first set, analogous to (2.8) - (2.9) and (2.11), bring in 2004-14 bottom-tier preference contributions to total consumption to drive the corresponding contributions in the 2014-17 baseline simulation:

$$\begin{aligned} \mathrm{cont\_hprefd3}(k,r) &= 0.3 * \mathrm{C\_HD}(k,r) * \mathrm{cont\_hprefd10}(k,r) \\ &+ \frac{\mathrm{VDPA}(k,r)}{\mathrm{VPA}(r)} * \mathrm{adjh1}(r) \quad \text{for all } k \in \mathrm{Com},\ r \in \mathrm{Reg} \end{aligned} \tag{2.22}$$

$$\begin{aligned} \mathrm{cont\_hprefm3}(k,r) &= 0.3 * \mathrm{C\_HI}(k,r) * \mathrm{cont\_hprefm10}(k,r) \\ &+ \frac{\mathrm{VIPA}(k,r)}{\mathrm{VPA}(r)} * \mathrm{adjh1}(r) \quad \text{for all } k \in \mathrm{Com},\ r \in \mathrm{Reg} \end{aligned} \tag{2.23}$$

$$0 = \sum_{k \in \mathrm{Com}} \left[\mathrm{cont\_hprefd3}(k,r) + \mathrm{cont\_hprefm3}(k,r)\right] \quad \text{for all } r \in \mathrm{Reg} \tag{2.24}$$

In these equations

cont_hprefd3(k,r) and cont_hprefm3(k,r) are the assumed contributions for 2014-17 to aggregate consumption in region r from bottom-tier preference changes for domestic and imported commodity k. The coefficient 0.3 converts these 10-year contributions into 3-year contributions.

C_HD(k, r) and C_HI(k,r) are parameters used to take account of changes between 2004 and 2014 in the shares of domestic and imported commodity k in household consumption in region r. These parameters are set in the same way as the corresponding parameters in (2.8) and (2.9) using a logistic function.

adjh1(r) is an endogenously determined adjustment variable. Its role in the 2014-17 simulation is to adjust the contributions of the bottom-tier household preference changes in region r so that they add up to 0 in accordance with equation (2.23).

The zero constraint in (2.23) ensures that preference changes introduced in the household demand system do not violate the add-up condition: expenditure added over all commodities must equal aggregate expenditure.

The second set of equations added to the baseline are analogous to (2.12) - (2.13). They define for 2014-17 bottom-tier preference contributions to total consumption:

$$\text{cont\_hprefd3}(k,r) = \frac{\text{VDPA}(k,r)}{\text{VPA}(r)} * \text{hprefd3}(k,r) \quad \text{for all } k \in \text{Com},\ r \in \text{Reg} \tag{2.25}$$

$$\text{cont\_hprefm3}(k,r) = \frac{\text{VIPA}(k,r)}{\text{VPA}(r)} * \text{hprefm3}(k,r) \quad \text{for all } k \in \text{Com},\ r \in \text{Reg} \tag{2.26}$$

The third set of equations added to the baseline are analogous to (2.15) - (2.16). They introduce household demand systems in which all preference changes are specified in bottom-tier form:

$$\begin{aligned} \text{qpd}(k,r) = &\{\text{aggregate expenditure \& population terms}\} \\ &+ \{\text{price terms}\} + \text{hprefd3}(k,r) \quad \text{for all } k \in \text{Com},\ r \in \text{Reg} \end{aligned} \tag{2.27}$$

$$\begin{aligned} \text{qpm}(k,r) = &\{\text{aggregate expenditure \& population terms}\} \\ &+ \{\text{price terms}\} + \text{hprefm3}(k,r) \quad \text{for all } k \in \text{Com},\ r \in \text{Reg} \end{aligned} \tag{2.28}$$

These equations are equivalent to the tiered GTAP equations in which preference changes for each commodity are carried by multiple variables in the different tiers.

In summary, we use (2.18) and (2.19) in the historical simulation to express preference changes as single variables for each bottom-tier commodity. Then we use (2.20) and (2.21) in the historical simulation to calculate the 10-year contribution of each of these bottom-tier preference changes in region r to aggregate consumption in region r. The contributions are transferred to the 2014-17 baseline simulation and converted to 3-year form via (2.22) - (2.24). Equations (2.25) - (2.26) in the baseline translate the 3-year contributions into 3-year bottom-tier forecasted preference changes for 2014-17. These forecasted preference changes then influence the 2014-17 results in the rest of the model through the demand systems (2.27) - (2.28).

2.3. Projecting the preferences of importing agents

In the GTAP model, there is an agent in region s who decides from which other regions to source imports of commodity k. The historical simulation generates preference changes for importing agent k,s between sources of supply. We project these preference changes into the baseline simulation following a similar approach to those described in the previous two sub-sections.

We add equations to the historical simulation to calculate the 10-year contribution to total imports of commodity k by region s of the preference change towards/away-from region r as a supplier of k.

These contributions are transferred to the baseline simulation and converted into 3-year forecasts for 2014-17 via equations that preserve the adding up condition. This is the condition that imports of k from r to s added over r must equal s's total imports of k. In effect, preservation of this condition means that preferences are relative. If the preferences of agent k,s move in favour of region r, then there must be an offsetting movement against other regions.

The contribution forecasts for 2014-17 are converted in the baseline simulation into forecasts for preference variables. Finally, the forecasts for the preference variables are taken into the rest of the model via the k,s demand system for imports of k differentiated by source (region of origin).

3. Assessing of performance of the baseline simulation with and without technology and preference trends from the historical simulation

This section describes a series of simulations and other calculations designed to assess the performance for 2014-17 of the baseline projection method described in sections 1 and 2. We make the assessment by computing percentage errors in the projected values of outputs in 2017 by industry and region. The percentage error for industry j in region r is given by

$$E1417_q(j,r) = 200 * \left[\frac{ABS\left\{LevOutputF_q17(j,r) - LevOutputT17(j,r)\right\}}{LevOutputF_q17(j,r) + LevOutputT17(j,r)} \right] \qquad (3.1)$$

In this equation:

ABS refers to absolute value.

$LevOutputF_q17(j,r)$ is the 2017 value in \$US of the output of industry j in region r forecast by method q. These are the methods identified in the first column of Table 3.1. They will be explained shortly.

LevOutputT17(j,r) is the true 2017 value in \$US of the output of industry j in region r given in the GTAP database for 2017.

3.1. Using the model to forecast growth in industry outputs from 2014 to 2017

The first 5 forecasting methods identified in Table 3.1 rely on baseline simulations from 2014 to 2017. As mentioned in section 1, in these simulations we introduce the true movements for each region in real GDP, employment and population. We also introduce the true movement in the world price level. Without this, it would not be reasonable to expect our baseline simulations to do a good job on reproducing output *values*.

Forecasting methods A34, A36 and A35 bring in the historical preference and technology trends projected according to section 2. The three simulations differ in the value used for Λ appearing in equation (2.1). As explained there, if Λ = 0, then smoothed versions of all-input technical changes from 2004 to 2014 are projected forward to 2014 to 2017. If Λ = 1, then technology changes are projected forward without smoothing. If Λ = 0.5, then partial smoothing is applied.

For each forecasting method, we calculate three versions of the average error across all industries j and regions r. The first version is an unweighted average of the 754 errors (= 58 industries by 13 regions):

$$Ave\_E1_q = \frac{\sum_{j,r} E1417_q(j,r)}{754} \qquad (3.2)$$

As can be seen from Table 3.1, the unweighted average errors in forecasts A34, A36 and A35 are 33.9%, 33.8% and 34.0%. The most obvious implication of these results is that the value of Λ doesn't matter much. The more important, and somewhat disappointing implication, is that our forecasts are not credible estimates of the industry output movements implied by the GTAP data. An error of 34.0% is consistent with a situation in which the true movement in

Table 3.1. Average % errors in baseline forecasts for output values by industry and region

Identifier q	Description	Ave_E1 Unweighted	Ave_E2 Weight scheme (3.3)	Ave_E3 Weight scheme (3.6)
A34	All preferences and historical tech (Λ=1)	33.9	28.7	28.1
A36	All pref and partially smoothed tech (Λ=0.5)	33.8	28.8	28.2
A35	All preferences and smoothed tech (Λ=0)	34.0	29.0	28.4
A39	All pref, smoothed tech (Λ=0) & actual cons	33.7	28.7	28.1
A40	No pref and tech trends	31.9	27.4	26.5
NoModel	No model, extrapolated growth trends	34.4	30.0	29.3

the value of the output of industry j,r is an increase of 17 per cent and the forecast movement is a decline of 17 %, or vice versa. A 3-year forecast with this magnitude of error is not likely to be useful.

Given these disappointingly high average errors, we wondered whether errors for unimportant industries might be playing too dominant a role. Consequently, we recalculated the averages using a weighting scheme designed to reduce the influence of unimportant industries. By unimportant we mean a j,r industry in which the share of r's economy devoted to the production of j is low relative to the same share averaged over all regions. With this definition in mind, we calculated weights according to:

$$WGT(j,r) = \frac{\dfrac{VOM14(j,r)}{\sum_k VOM14(k,r)}}{\sum_s \left(\dfrac{VOM14(j,s)}{\sum_k VOM14(k,s)} \right) / 13} \tag{3.3}$$

Weighting scheme (3.3) doesn't dismiss errors for either industries that are typically small fractions of output in all economies or economies which are small parts of the world economy.

Using these weights, we recalculated average errors according to:

$$Ave\_E2_q = \frac{\sum_{j,r} E2\_1417_q(j,r)}{754} \tag{3.4}$$

where

$$E2\_1417_q(j,r) = WGT(j,r) * E1417_q(j,r) \tag{3.5}$$

As anticipated, reducing the influence of unimportant industries gave smaller errors: 28.7, 28.8 and 29.0 per cent. But this is only a moderate improvement. We decided to give the weighting scheme one more try.

While the weights given by (3.3) have an average value of one, we noticed some of them were very high: over 5. We decided to moderate these values by computing another weighing scheme defined by

$$\mathrm{WGT}^{\mathrm{mod}}(\mathrm{j,r}) = \frac{\mathrm{LOGISTIC}\left[\mathrm{WGT}(\mathrm{j,r})\right]}{\sum_{s} \mathrm{LOGISTIC}\left[\mathrm{WGT}(\mathrm{j,s})\right]/13} \tag{3.6}$$

where LOGISTIC[WGT(j,r)] is a logistic function parameterized so that it has an upper bound of 2 and values of 1.8 when WGT(j,r) = 2, 1 when WGT(j,r) = 1, and 0.01 when WGT(j,r) = 0. The numerator in (3.6) is capped at 2. The denominator can be noticeable below 1. However, (3.6) generated only 33 weights out of 754 with a value over 2.5. The largest value was 4.2. With this modified weighting scheme we calculated average errors according to

$$\mathrm{Ave\_E3}_q = \frac{\sum_{j,r} \mathrm{E3\_1417}_q(\mathrm{j,r})}{754} \tag{3.7}$$

where

$$\mathrm{E3\_1417}_q(\mathrm{j,r}) = \mathrm{WGT}^{\mathrm{mod}}(\mathrm{j,r}) * \mathrm{E1417}_q(\mathrm{j,r}) \tag{3.8}$$

Switching to the modified weights made only a slight difference to the average errors.

In forecast A39, we started an investigation of whether average forecast errors would be noticeably reduced if we imposed not only the actual movements in real GDP for each region but also the actual movements in the components of nominal GNE. In A39, the 2014-17 baseline simulation is informed by the actual movements in nominal household consumption for each region as well as technology and preference trends. The results are discouraging, barely any reduction in average errors. Given these results, we did not persist with introducing macro data.

Perhaps the most discouraging of all the results are those for A40. In the A40 baseline simulation, we leave out the historical trends in technologies and preferences. The only shocks that take the 13 economies in our model from 2014 to 2017 are movements in real GDP, population and employment. There are no preference changes and the only technology changes are uniform movements across industries in primary-factor saving to accommodate the exogenous movements in real GDP. The average errors in this simulation are slightly less than those that include the historically derived preference and technology trends.

3.2. Could we do better without the model?

Using the GTAP data for 2004, 2014 and 2017, we calculate *comparable* growth rates in the values of output for the 58 industries and 13 regions in our version of the GTAP model. By comparable we mean adjusted for different lengths of time (10-years and 3-years) and for different rates of world inflation. Thus for industry j in region r, we calculate gcomp0414(j,r) and gcomp1417(j,r) according to:

$$\mathrm{gcomp0414}(\mathrm{j,r}) = 100 * \left[\left(\frac{\mathrm{VOM14}(\mathrm{j,r})/\mathrm{Inflat0414}}{\mathrm{VOM04}(\mathrm{j,r})}\right)^{0.3} - 1\right] \tag{3.9}$$

and

$$\mathrm{gcomp1417}(\mathrm{j,r}) = 100 * \left[\left(\frac{\mathrm{VOM17}(\mathrm{j,r})/\{\mathrm{Inflat1417}\}}{\mathrm{VOM14}(\mathrm{j,r})}\right) - 1\right] \tag{3.10}$$

where

VOMt(j,r), t= 04, 14 and 17 is the value in the GTAP database for year t of the output of industry j in region r; and

Inflat0414 and Inflat1417 are ratios of world price levels, 2014 compared to 2004 and 2017 compared to 2014.

The exponent 0.3 appearing in equation (3.9) translates 10-year growth into 3-year growth and by using the Inflat factors we abstract from changes in value growth caused by changes in world inflation. GTAP value data for GDP combined with OECD real data for GDP in each region, gives inflation factors of 1.3534 and 0.9314: 35.34 per cent inflation between 2004 and 2014 in world prices expressed in U.S. dollars, and 6.86 per cent deflation between 2014 and 2017.

The simplest non-model method for forecasting growth between 2014 and 2017 in the output of industry j,r is to trend forward the 2004 to 2014 growth rate for 3 years, that is to use gcomp0414(j,r). With this method, the 2017 forecast level of output (expressed as an index number with the 2014 value equal to 1) is

$$\text{LevOutputF17}(j,r) = 1 + \text{gconp0414} / 100 \qquad (3.11)$$

while the true value is

$$\text{LevOutputT17}(j,r) = 1 + \text{gconp1417} / 100 \qquad (3.12)$$

The absolute value of the percentage error for industry j,r can be calculated according to (3.1) with q = NoModel to indicate that the forecasting method is based entirely on output trends computed without a model.

These unweighted NoModel errors are given in Table 3.2, together with row and column totals and averages. The grand average over all 754 entries is 34.4 per cent (also shown in the NoModel row of Table 3.1). Out of the 754 entries in Table 3.2, 53 (highlighted) have values of more than 100. Values of more than 100 are consistent with a situation in which 3-year growth in one of our periods is +50% and in the other period is -50%. Extreme changes in growth such as this require investigation.

We start with the question of whether extreme growth changes occur for unimportant entries.

Using the weights defined by (3.3) we calculate weighted errors as

$$\text{E2\_1417}_{\text{NoModel}}(j,r) = \text{WGT}(j,r) * \text{E1417}_{\text{NoModel}}(j,r) \qquad (3.13)$$

Results for these weighted errors are given in Table 3.3. In Table 3.3, 45 entries (highlighted) have values of more than 100, down from 53 in Table 3.2. The average entry in Table 3.3 is 30.0 per cent, down from 34.4 per cent in Table 3.2. These rather modest declines in the number of 100+ entries and the average size of entries indicates that it is not just unimportant entries that are showing extreme growth changes between our two periods.

Notice that in going from Table 3.2 to Table 3.3, the contribution to the total error from agricultural industries in India is sharply increased. For example, in Table 3.2, the paddy rice (pdr) contribution to the total error (25964.3) is 78.0. In Table 3.3, this contribution is 403.2 in a total error of 22592.3. The extreme values for Indian agricultural industries in Table 3.3 arise from the occurrence of large values in weighting scheme (3.3) alluded to earlier.

Table 3.4 shows weighted errors for the NoModel method calculated with the modified weights defined in (3.6):

$$E3\_1417_{NoModel}(j,r) = WGT^{mod}(j,r) * E1417_{NoModel}(j,r) \qquad (3.14)$$

While the adoption of the modified weighting scheme reduces the problem of extreme weighted errors for Indian agriculture, it doesn't affect the impression that errors from the NoModel forecasting method are large and widespread. In Table 3.4, 47 entries (highlighted) have values of more than 100, up from 45 in Table 3.3. The average entry in Table 3.4 is 29.3 per cent, down from 30.0 per cent in Table 3.3.

The average errors in Table 3.1 for the NoModel forecasts are slightly higher than those obtained using the model. However, they are not much higher. Should we conclude that using the model does not contribute much to the accuracy of the forecasts?

Before we can answer this question we need to assess the realism of the data. It mightn't be the forecasting method that is weak. The occurrence of extreme errors in Tables 3.2 - 3.4 for the NoModel method, implying huge turn-arounds in industry growth rates, may indicate data problems.

3.3. Why are the NoModel forecast errors so large? Are the data for 2017 compatible with the data for 2004 and 2014?

In answering these questions, we focus on the highlighted entries in Table 3.3. We chose Table 3.3 in preference to Table 3.2 because we don't want to be distracted by the big entries in Table 3.2 for unimportant industries such as paddy rice (pdr) in Canada, Mexico, Germany, U.K. and Saudi Arabia. All of these big pdr entries disappear when we move to Table 3.3. We chose Table 3.3 in preference to Table 3.4 on the grounds of simplicity. The complicated logistic weighting scheme (3.6) didn't deliver insights beyond those in Table 3.3.

Columns (1), (2) and (3) of Table 3.5 list the 45 highlighted entries from Table 3.3. Columns (4) and (5) show the comparable 3-year growth rates for 2004-14 and 2014-17 computed in (3.9) and (3.10). Columns (6) to (10) give GTAP data on output values (VOM in GTAP notation) for the five database years: 2004, 2007, 2011, 2014 and 2017. Comments on these data are given in column (11).

The rows in Table 3.5 are colour-coded. There are 27 pink rows. For the industry-region item in each of these rows we think there are serious data incompatibilities. In many cases, the data for 2004, 2007, 2011 and 2014 exhibit plausible growth but the data for 2017 appears unrealistic and/or out of line with that for 2014. Sources supporting our comments are cited in the footnotes to Table 3.5.

For the industry-region item in each of the 10 green rows we found data to support the GTAP data. Large growth turn-arounds in output-value growth between 2004-14 and 2014-17 for most of these items can be explained by changes in prices: the price of oil (items 3, 39, 40 and 45); the price of wheat (item 38); the price of other grains (item 42). The turn-arounds in output-growth for electronics from China and Korea (items 17 and 21) are potentially important developments in the world economy. They are identified in the GTAP data and supported by other sources.

While the 8 beige items in Table 3.5 exhibit large growth turn-arounds, our investigations did not reveal either definitive counter evidence or support.

Our investigation of the GTAP data was limited to the 45 industry-region items in Table 3.5 and to only one variable, output values. Potentially, there are many more problems than those we identified. At this stage, we think that further validation work of the type described in this paper should be delayed until the data are audited and thoroughly understood.

4. Concluding remarks

Most CGE applications are concerned with the effects of policies: what difference would it make to macro, industry and distributional variables if we imposed a carbon tax, reduced a tariff, etc. These questions are answered by computing policy-induced deviations from a baseline. The baseline depicts a path of the economy without the policy.

For a long time in CGE modelling, little attention was paid to the baseline. In most CGE applications up to about 20 years ago, the baseline was a no-change situation[4]. Literally, the policy deviation was a deviation from the existing situation, or perhaps the situation of 5-years ago, depending on the vintage of the database. In this case, the computation was telling us how different the economy would have been in some past year if a carbon tax had been imposed from the way it was without the carbon tax.

Gradually, it was recognised that there are three reasons the baseline matters. First, policy deviations often depend on the baseline. For example, if we want to know the effects of a carbon tax, what we build into the baseline about technological developments in green energy makes a difference. Second, the baseline is an important part of the communication between modellers and their clients in the policy-making arena. Policy makers want to hear about where the economy is going, not just how its future path will be affected by a policy. As described by Johansen (1974, ch 10) users of modelling services (as distinct from modellers) understand baselines and want to be engaged in their formulation. Third, baselines offer the possibility of setting up validation tests. It is hard (perhaps impossible) to check the accuracy of a CGE deviation result showing the effect of a carbon tax. Too many other things affect the economy simultaneously, making it difficult to isolate in the data the effect of a particular policy[5]. By contrast, a baseline can be checked *ex post*. Sources of forecasting errors can be identified and strategies for improving the forecasting method and the underlying model can be formulated.

In previous work, we have done validation simulations with a single- country U.S. model focusing on baselines that incorporate trends from an historical simulation.[6] This paper is our first attempt at extending that work to a multi-country model. We have deduced preference and technology trends from a 2004-14 historical simulation with a 58-industry, 13-region version of GTAP. We have introduced these trends into a baseline simulation for 2014 to 2017, and checked the baseline forecasts for the values of industry outputs for 2017 against GTAP data for 2017.

[4] An exception was Johansen who formulated the first CGE model (Johansen, 1960). In an addendum to the second edition of his 1960 book, Johansen (1974, ch 10) gave his model an explicit baseline and discussed its role.
[5] This point was overlooked in the well-known critique by Kehoe (2005) of the performance of CGE models in predicting the effects of NAFTA.
[6] See for example, Dixon and Rimmer (2010 and 2013).

The results in this paper exhibit large and unsatisfactory forecast errors. The introduction of preference and technology trends from the historical simulation did not reduce the errors below those generated in a simulation informed only by movements in real GDP, population and aggregate employment. Our forecasting method barely beat a no-model trending approach.

There are several possible explanations for this negative outcome.

First, there is the fundamental hypothesis of our forecasting method, namely that preference and technology trends persist so that forecasts can be informed by historical trends. This hypothesis was supported in our single-country work for the U.S., but perhaps it needs modification in a multi-country context. For example, we could experiment with lagged formulations for technology forecasts in which historical trends in leading countries inform the baseline trends for other countries.

Second, we may be able to improve our estimation of historical preference and technology trends. In our report on the historical simulation, Dixon and Rimmer (2023), we mentioned one such possibility involving ideas from new-trade theory, particularly the idea that exporting firms have higher productivity than firms which sell only on their domestic market.

Third, perhaps the baseline period was too short. Noise affecting technology and preference variables might be effectively averaged out over a 10-year period, but be seriously distorting for a 3-year period.

Fourth, perhaps we need to help the baseline by the introduction of more comprehensive macro and energy forecasts. In our U.S. validation exercise, we introduced forecasts published by the U.S. Energy Information Administration before the baseline period. These forecasts covered expenditure-side macroeconomic aggregates and the prices of energy products such as oil. As reported in this paper, we started along the track of informing our baseline forecasts with actual movements in macro aggregates, but became discouraged when we saw almost no improvement in the results. Subsequent analysis reported in section 3.3 indicates that the introduction of prices of energy and agricultural products might be helpful in reducing average errors in the baseline forecasts of industry outputs.

Finally, there is the data issue. In a single country model the bulk of the data come from a single national statistical agency, the Bureau of Economic Analysis in the case of the U.S. For GTAP, the data come from many sources and although it is compiled at the GTAP headquarters in Purdue, achieving consistency across regions and time must be extremely difficult. Without consistent data, even the most sophisticated baseline validation exercise will struggle to produce a positive result. In section 3.3, we noted many data problems. These appear to affect the comparability between the GTAP data for 2017 and that for 2014. Our impression is that the data for 2004 and 2014 do not suffer the same comparability problems. This is good news because it means that our estimates of technology and preference trends are not compromised.

We think that baselines and validation in a multi-country context should be a major part of the future work program of CGE modellers. A logical starting point is a review and possible amendment of the 2017 GTAP database.

Table 3.2. Using 2004-14 output growth to forecast 2014-17 output growth: % absolute errors, equation (3.1) with q=NoModel

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	GTAP industries (see appendix)	**USA**	**Canada**	**Mexico**	**China**	**Japan**	**SKorea**	**India**	**France**	**Germany**	**UK**	**RoEU**	**Saudi Arabia**	**RoW**	**Row total**	**Row ave**
1	**pdr**	14.2	181.7	174.4	21.5	46.0	12.6	78.0	67.1	187.6	199.3	29.4	191.0	19.4	**1222.1**	**94.0**
2	**wht**	57.6	32.8	46.3	16.1	70.4	42.0	39.1	44.4	52.0	39.1	29.4	94.9	30.0	**594.0**	**45.7**
3	**gro**	52.4	7.6	3.4	16.0	43.9	81.8	28.1	38.2	24.3	22.2	38.9	31.8	48.8	**437.2**	**33.6**
4	**v_f**	38.2	5.7	22.9	18.8	2.0	3.2	9.5	96.7	62.9	45.6	18.8	67.9	17.7	**410.0**	**31.5**
5	**osd**	8.3	10.5	92.3	6.8	57.5	23.3	55.2	40.2	28.4	89.3	98.1	168.3	12.2	**690.7**	**53.1**
6	**c_b**	23.7	59.6	22.8	100.1	99.3	23.8	90.0	43.5	38.7	0.9	0.8	137.7	12.4	**653.3**	**50.3**
7	**pfb**	78.3	183.9	29.0	55.3	69.0	30.1	29.1	32.6	37.6	101.5	38.3	194.3	28.0	**907.1**	**69.8**
8	**ocr**	70.1	20.4	68.3	92.7	24.2	40.9	103.1	88.8	80.1	53.2	54.6	149.4	59.5	**905.3**	**69.6**
9	**ctl**	27.0	40.5	93.9	11.6	68.4	25.7	96.2	20.8	2.2	34.2	9.6	137.9	15.6	**583.8**	**44.9**
10	**oap**	21.0	15.5	17.6	24.4	62.3	27.8	50.9	4.9	3.8	5.1	10.1	41.2	9.7	**294.4**	**22.6**
11	**rmk**	2.4	12.3	9.8	39.9	19.0	19.2	17.5	5.5	0.0	1.7	6.7	0.6	16.5	**151.0**	**11.6**
12	**wol**	1.2	124.4	61.6	5.3	58.5	16.0	117.8	41.1	68.5	9.0	71.3	147.2	75.2	**797.1**	**61.3**
13	**frs**	30.7	54.6	58.4	3.1	69.9	34.1	15.2	12.4	15.9	50.9	4.2	194.4	13.3	**557.1**	**42.9**
14	**fsh**	35.7	49.3	1.9	16.5	18.7	19.6	16.5	22.2	27.6	16.9	9.6	20.1	12.5	**267.0**	**20.5**
15	**coa**	45.8	48.1	154.3	43.6	10.1	61.9	47.7	93.8	26.8	140.4	49.4	174.5	28.4	**924.8**	**71.1**
16	**oil**	38.7	49.0	103.5	88.5	81.6	68.9	87.7	160.5	90.3	77.1	90.9	77.5	81.3	**1095.4**	**84.3**
17	**gas**	72.1	1.5	27.0	115.9	187.7	127.5	70.0	113.9	64.9	61.1	116.5	12.0	26.5	**996.5**	**76.7**
18	**omn**	22.6	34.2	14.1	67.7	59.2	29.4	51.9	20.7	20.8	1.8	6.2	15.2	18.4	**362.1**	**27.9**
19	**cmt**	15.7	16.6	42.1	83.8	33.7	88.2	37.4	0.8	1.1	38.9	1.3	23.9	23.0	**406.6**	**31.3**
20	**omt**	10.9	3.3	49.7	102.7	36.1	13.4	56.2	2.6	8.8	34.2	3.6	20.3	15.0	**356.9**	**27.5**
21	**vol**	1.6	6.2	13.4	55.0	53.1	53.7	4.4	3.4	13.2	43.7	10.6	26.6	26.2	**311.2**	**23.9**
22	**mil**	18.6	18.4	48.5	76.5	55.1	14.5	21.7	4.7	1.5	6.1	2.8	6.4	42.3	**317.1**	**24.4**
23	**pcr**	97.9	171.4	181.2	110.1	10.9	3.6	4.4	116.8	146.5	193.5	48.3	195.8	31.3	**1311.5**	**100.9**
24	**sgr**	23.8	60.6	18.7	81.2	106.8	48.7	22.5	4.5	7.9	26.9	10.6	40.1	11.9	**464.3**	**35.7**
25	**ofd**	17.1	0.9	59.8	7.6	30.1	9.1	14.8	1.9	1.1	3.7	1.2	22.4	19.3	**189.0**	**14.5**
26	**b_t**	16.8	2.6	12.9	26.9	5.1	24.0	18.3	3.9	2.7	37.8	0.2	25.7	15.4	**192.3**	**14.8**
27	**tex**	3.9	21.8	25.5	50.4	17.9	21.4	5.2	0.0	2.9	53.2	2.7	20.4	13.1	**238.5**	**18.3**
28	**wap**	3.1	2.8	16.1	36.6	0.5	53.4	1.8	2.7	8.6	70.8	13.9	25.6	17.9	**253.7**	**19.5**
29	**lea**	11.6	6.7	56.7	28.6	10.7	17.0	1.8	6.7	9.2	36.6	8.3	24.1	22.9	**240.9**	**18.5**
30	**lum**	17.8	25.3	0.5	28.7	27.2	9.8	6.0	6.2	1.5	1.7	5.6	3.9	14.6	**149.0**	**11.5**

Table 3.2 continues …

… Table 3.2 continued

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	GTAP industries (see appendix)	**USA**	**Canada**	**Mexico**	**China**	**Japan**	**SKorea**	**India**	**France**	**Germany**	**UK**	**RoEU**	**Saudi Arabia**	**RoW**	**Row total**	**Row ave**
31	**ppp**	15.8	33.8	8.5	23.9	12.9	32.7	21.2	31.1	32.7	57.9	28.0	20.3	49.6	**368.5**	**28.3**
32	**p_c**	72.8	52.2	102.4	63.6	85.1	54.2	59.5	94.0	71.4	88.9	67.0	40.2	75.6	**926.9**	**71.3**
33	**crp**	9.8	15.4	4.3	48.3	19.2	18.3	10.3	2.4	4.7	34.3	3.0	20.0	13.6	**203.4**	**15.6**
34	**nmm**	17.5	14.3	26.4	40.1	29.2	3.0	4.2	5.2	0.2	23.0	6.8	10.6	19.7	**200.3**	**15.4**
35	**i_s**	15.0	8.3	4.1	81.9	41.6	93.4	4.0	13.0	9.3	61.4	3.1	2.6	9.3	**347.1**	**26.7**
36	**nfm**	11.1	14.6	18.1	70.6	44.8	52.2	9.5	16.3	3.4	87.4	3.1	3.3	9.9	**344.1**	**26.5**
37	**fmp**	13.2	4.9	25.6	32.3	17.7	0.3	2.5	2.5	0.2	3.0	2.0	11.1	21.5	**136.7**	**10.5**
38	**mvh**	14.0	17.9	10.1	41.7	2.0	6.8	5.4	26.1	0.9	30.9	11.3	5.9	18.3	**191.3**	**14.7**
39	**otn**	4.6	14.8	77.9	50.0	68.7	27.7	17.6	15.3	9.0	3.9	22.6	9.0	17.0	**338.0**	**26.0**
40	**ele**	17.9	13.5	2.7	71.5	19.2	30.6	68.3	41.1	34.4	13.6	28.2	13.1	9.3	**363.2**	**27.9**
41	**ome**	4.2	15.2	14.9	20.1	29.2	37.9	19.4	12.4	10.0	70.2	12.1	57.5	25.0	**327.9**	**25.2**
42	**omf**	73.0	2.2	1.5	2.5	29.2	6.4	5.9	8.5	4.6	8.8	2.6	8.9	6.2	**160.5**	**12.3**
43	**ely**	9.1	6.4	23.1	10.5	20.9	20.2	2.2	21.1	24.8	8.1	31.2	60.0	15.2	**252.7**	**19.4**
44	**gdt**	15.7	11.2	172.5	28.5	32.0	55.5	84.9	105.3	112.8	22.0	57.3	129.7	7.5	**835.1**	**64.2**
45	**wtr**	89.0	155.9	171.1	12.2	120.1	59.7	132.5	79.4	133.9	114.8	112.8	7.6	39.6	**1228.8**	**94.5**
46	**cns**	23.4	15.4	8.7	11.3	38.1	11.1	5.3	2.4	2.5	18.9	7.4	29.0	26.9	**200.5**	**15.4**
47	**trd**	19.8	2.5	12.9	15.4	21.8	9.0	12.5	0.7	2.7	3.5	4.4	24.1	8.2	**137.6**	**10.6**
48	**otp**	24.4	1.0	11.9	17.8	20.1	5.3	12.6	1.8	5.8	10.5	6.2	34.5	19.1	**171.0**	**13.2**
49	**wtp**	8.0	31.6	47.0	12.9	3.4	23.3	15.6	43.9	27.2	5.5	7.6	6.2	33.1	**265.2**	**20.4**
50	**atp**	12.8	8.7	47.6	3.3	12.2	3.4	30.5	19.7	2.0	4.5	2.9	8.4	19.4	**175.6**	**13.5**
51	**cmn**	62.3	16.6	0.1	10.8	105.0	59.9	70.9	99.1	97.8	98.6	96.2	50.8	30.7	**798.8**	**61.4**
52	**ofi**	12.3	1.5	31.2	39.1	13.3	19.7	15.4	5.9	5.1	19.9	0.4	26.8	29.6	**220.2**	**16.9**
53	**isr**	15.4	7.4	6.0	29.2	10.3	3.7	18.7	3.5	0.8	23.1	8.9	24.8	0.1	**152.0**	**11.7**
54	**obs**	10.3	17.0	44.6	4.2	5.3	54.0	11.1	30.9	22.6	5.0	17.6	22.3	15.7	**260.7**	**20.1**
55	**ros**	17.0	25.1	107.1	1.9	40.6	29.8	111.1	2.4	10.2	2.4	9.1	26.4	1.8	**384.9**	**29.6**
56	**osg**	9.7	16.8	27.1	9.8	14.6	9.9	9.6	5.2	4.3	7.2	6.1	10.4	22.9	**153.8**	**11.8**
57	**dwe**	18.5	4.2	189.5	4.3	5.8	52.9	16.0	0.9	3.2	0.2	4.1	38.2	9.8	**347.7**	**26.7**
58	**CGDS**	25.0	18.9	5.5	22.0	33.7	9.5	3.2	2.9	0.7	2.4	12.3	29.3	25.8	**191.4**	**14.7**
59	**Col totals**	**1520.7**	**1815.5**	**2728.8**	**2211.5**	**2330.7**	**1835.3**	**1978.0**	**1794.9**	**1674.4**	**2326.7**	**1366.5**	**3022.4**	**1358.8**	**25964.3**	
60	**Col ave**	**26.2**	**31.3**	**47.0**	**38.1**	**40.2**	**31.6**	**34.1**	**30.9**	**28.9**	**40.1**	**23.6**	**52.1**	**23.4**		**34.4**

Table 3.3. Using 2004-14 output growth to forecast 2014-17 output growth: % simple weighted absolute errors, (3.5) with q=NoModel

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	GTAP industries (see appendix)	**USA**	**Canada**	**Mexico**	**China**	**Japan**	**SKorea**	**India**	**France**	**Germany**	**UK**	**RoEU**	**Saudi Arabia**	**RoW**	**Row total**	**Row ave**
1	**pdr**	0.8	26.6	3.7	43.4	54.8	19.7	403.2	0.8	0.1	0.5	1.4	0.1	53.7	**608.7**	**46.8**
2	**wht**	14.9	44.6	11.9	12.7	2.4	0.6	202.3	49.0	28.0	16.5	18.6	101.2	40.3	**543.1**	**41.8**
3	**gro**	83.2	7.4	5.9	22.0	0.7	1.2	54.0	34.8	9.4	4.1	38.7	4.4	132.7	**398.6**	**30.7**
4	**v_f**	9.5	1.8	24.6	46.6	1.1	2.3	36.8	29.5	6.6	5.6	12.8	25.6	38.4	**241.1**	**18.5**
5	**osd**	7.0	25.4	6.3	5.1	1.0	3.1	263.7	23.3	5.8	21.2	44.7	0.1	31.0	**437.8**	**33.7**
6	**c_b**	4.7	8.5	48.4	50.2	7.2	0.2	546.7	25.6	9.5	0.1	0.2	0.1	32.7	**734.1**	**56.5**
7	**pfb**	34.3	97.5	30.6	57.5	3.9	1.1	201.9	7.3	1.9	5.9	6.4	0.1	67.4	**515.8**	**39.7**
8	**ocr**	29.5	4.3	67.8	13.6	11.9	15.7	547.0	88.2	60.4	13.9	66.3	0.9	108.2	**1027.8**	**79.1**
9	**ctl**	24.8	36.2	79.8	14.1	18.7	12.7	230.5	24.8	0.9	31.7	8.1	30.7	37.1	**550.0**	**42.3**
10	**oap**	11.8	10.6	24.3	69.7	24.7	17.8	87.4	3.3	2.5	1.8	11.2	18.6	14.9	**298.5**	**23.0**
11	**rmk**	1.1	8.3	6.0	9.5	4.5	3.1	105.7	4.7	0.0	0.7	5.7	0.4	18.2	**167.8**	**12.9**
12	**wol**	0.0	14.1	2.1	6.0	8.5	3.2	830.1	4.4	24.5	2.7	49.9	4.7	212.7	**1162.9**	**89.5**
13	**frs**	12.9	118.8	37.9	3.4	14.5	8.8	65.7	8.2	6.8	10.6	4.0	0.1	21.2	**313.0**	**24.1**
14	**fsh**	4.7	28.4	1.1	49.7	17.0	24.7	42.8	8.6	2.2	5.7	5.1	3.1	30.7	**223.6**	**17.2**
15	**coa**	53.0	51.4	83.0	149.0	0.1	1.8	164.1	0.2	17.6	26.3	22.0	0.0	58.2	**626.8**	**48.2**
16	**oil**	8.2	41.7	131.1	11.3	0.1	0.2	15.2	3.1	0.8	18.1	3.5	675.2	109.4	**1018.1**	**78.3**
17	**gas**	17.5	4.2	15.8	2.8	0.0	0.0	24.0	0.1	1.9	11.3	38.1	64.4	79.9	**260.0**	**20.0**
18	**omn**	7.9	67.6	28.0	153.2	11.4	7.6	28.0	6.2	6.8	0.7	5.1	16.0	46.5	**384.9**	**29.6**
19	**cmt**	22.9	25.6	50.8	33.4	14.1	71.0	19.2	1.2	0.7	28.8	1.1	8.3	62.6	**339.6**	**26.1**
20	**omt**	10.7	3.4	63.9	196.8	12.6	11.6	4.2	3.3	9.6	25.6	6.1	7.1	19.9	**374.8**	**28.8**
21	**vol**	0.6	5.9	12.1	114.9	12.9	22.2	14.7	1.3	6.6	7.1	12.4	2.5	62.3	**275.6**	**21.2**
22	**mil**	14.6	17.7	90.9	31.7	23.3	6.3	31.0	7.9	1.6	3.2	3.9	1.8	72.4	**306.4**	**23.6**
23	**pcr**	4.9	37.1	14.1	275.3	12.0	3.2	26.2	3.0	1.3	2.1	3.7	0.1	64.9	**447.9**	**34.5**
24	**sgr**	11.6	61.6	48.7	48.5	29.0	14.8	68.6	3.9	3.5	6.4	5.7	5.7	29.1	**337.0**	**25.9**
25	**ofd**	13.4	0.7	123.6	8.5	28.2	7.5	12.5	2.1	0.9	2.9	1.4	11.7	25.5	**238.9**	**18.4**
26	**b_t**	11.9	1.3	20.9	42.2	6.4	19.2	13.9	4.4	2.3	41.5	0.2	11.4	17.9	**193.5**	**14.9**
27	**tex**	3.1	4.0	12.4	172.1	6.5	18.7	15.9	0.0	1.8	26.2	2.3	4.2	16.5	**283.8**	**21.8**
28	**wap**	2.3	0.5	18.8	93.3	0.2	78.9	2.8	1.5	5.8	30.3	15.6	9.7	30.8	**290.7**	**22.4**
29	**lea**	2.8	0.5	94.8	79.1	2.3	14.0	3.1	5.4	5.3	12.6	15.8	5.9	37.1	**278.7**	**21.4**
30	**lum**	42.3	45.1	0.3	49.7	12.8	4.2	3.7	3.8	1.4	0.9	7.1	1.7	17.2	**190.3**	**14.6**

Table 3.3 continues …

… *Table 3.3 continued*

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	GTAP industries (see appendix)	**USA**	**Canada**	**Mexico**	**China**	**Japan**	**SKorea**	**India**	**France**	**Germany**	**UK**	**RoEU**	**Saudi Arabia**	**RoW**	**Row total**	**Row ave**
31	**ppp**	21.7	38.9	5.5	25.8	13.3	30.8	11.8	34.2	48.5	66.2	38.8	5.2	42.6	**383.3**	**29.5**
32	**p_c**	55.1	46.8	89.9	49.1	83.5	83.3	97.8	34.2	30.0	32.0	48.7	104.4	80.7	**835.5**	**64.3**
33	**crp**	7.7	9.7	3.5	74.7	18.4	28.6	9.3	2.0	5.6	27.1	3.2	21.0	11.6	**222.3**	**17.1**
34	**nmm**	9.0	6.7	26.4	106.1	18.8	3.2	4.7	3.2	0.2	12.4	5.8	19.5	18.8	**234.8**	**18.1**
35	**i_s**	5.3	3.0	2.8	187.3	61.9	275.6	4.6	4.9	6.2	23.6	2.0	2.6	5.9	**585.8**	**45.1**
36	**nfm**	6.6	19.9	17.1	171.4	37.6	73.3	6.9	5.9	2.9	101.8	2.2	1.1	12.3	**459.0**	**35.3**
37	**fmp**	12.0	3.5	13.9	42.7	15.0	0.4	3.1	2.3	0.2	2.2	2.5	7.0	16.6	**121.5**	**9.3**
38	**mvh**	10.3	15.1	19.8	40.5	3.3	10.6	2.8	13.7	1.6	19.7	8.2	3.6	8.1	**157.4**	**12.1**
39	**otn**	5.5	14.9	48.6	46.5	47.9	34.2	19.0	31.9	14.0	4.3	11.6	3.0	11.0	**292.4**	**22.5**
40	**ele**	15.1	2.9	3.5	132.2	31.0	112.9	16.8	13.3	26.4	5.4	16.1	3.3	8.7	**387.6**	**29.8**
41	**ome**	4.0	6.6	13.6	39.9	31.9	47.9	18.5	9.9	18.2	52.1	14.3	16.8	14.0	**287.7**	**22.1**
42	**omf**	32.7	1.1	1.7	2.3	20.1	8.4	12.3	8.2	6.3	8.5	3.5	3.4	5.4	**114.1**	**8.8**
43	**ely**	6.4	5.2	17.4	7.5	27.6	15.7	4.6	15.3	21.6	4.7	30.7	92.1	17.2	**265.9**	**20.5**
44	**gdt**	28.6	11.5	355.2	3.7	5.2	3.2	190.8	9.2	34.7	27.7	40.8	142.2	15.4	**868.1**	**66.8**
45	**wtr**	156.2	17.3	15.5	4.8	124.9	53.0	76.9	86.0	87.7	96.5	86.9	24.3	63.7	**893.8**	**68.8**
46	**cns**	19.8	17.0	7.3	12.2	27.0	8.9	7.2	2.2	1.6	19.1	6.9	52.1	27.0	**208.1**	**16.0**
47	**trd**	22.9	2.7	13.6	8.5	25.8	8.1	12.7	0.9	2.6	4.5	5.4	6.6	8.8	**123.2**	**9.5**
48	**otp**	15.3	0.7	17.1	13.7	21.1	3.8	21.7	2.0	6.0	10.6	8.3	11.0	22.6	**153.7**	**11.8**
49	**wtp**	4.2	18.5	12.9	9.1	5.0	34.2	11.7	44.7	38.1	8.9	10.8	1.3	51.9	**251.2**	**19.3**
50	**atp**	20.5	9.9	19.9	1.4	7.4	3.6	7.4	27.1	2.9	7.0	3.6	3.0	30.2	**144.1**	**11.1**
51	**cmn**	71.9	22.1	0.1	6.5	108.1	62.4	36.3	122.4	108.5	116.4	100.5	28.0	34.2	**817.2**	**62.9**
52	**ofi**	22.0	2.0	16.8	36.7	11.4	17.2	11.2	6.7	4.9	30.3	0.4	10.4	27.6	**197.7**	**15.2**
53	**isr**	30.2	8.9	3.6	9.7	10.6	4.5	11.1	4.9	0.9	40.1	8.0	2.2	0.1	**134.8**	**10.4**
54	**obs**	9.3	20.3	31.1	1.9	6.4	35.4	4.1	55.6	36.8	8.5	26.5	4.6	10.7	**251.2**	**19.3**
55	**ros**	36.2	17.1	215.2	1.2	41.0	24.0	8.3	2.5	11.4	3.1	9.6	7.9	1.6	**379.1**	**29.2**
56	**osg**	14.3	25.2	20.3	5.2	17.7	7.5	4.7	6.3	4.6	9.3	6.3	8.7	20.1	**150.1**	**11.5**
57	**dwe**	28.3	5.3	292.0	2.1	9.0	37.4	11.0	1.1	2.3	0.4	3.5	7.5	7.1	**407.0**	**31.3**
58	**CGDS**	22.5	20.9	5.5	27.1	29.3	8.4	4.1	3.0	0.6	1.9	10.2	36.1	26.4	**195.9**	**15.1**
59	**Col totals**	**1160.4**	**1174.5**	**2449.3**	**2935.3**	**1203.0**	**1432.0**	**4696.2**	**913.5**	**751.9**	**1109.3**	**932.2**	**1644.9**	**2189.8**	**22592.3**	
60	**Col ave**	**20.0**	**20.2**	**42.2**	**50.6**	**20.7**	**24.7**	**81.0**	**15.8**	**13.0**	**19.1**	**16.1**	**28.4**	**37.8**		**30.0**

Table 3.4 Using 2004-14 output growth to forecast 2014-17 output growth: % logistic weighted absolute errors, (3.8) with q=NoModel

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	GTAP industries (see appendix)	**USA**	**Canada**	**Mexico**	**China**	**Japan**	**SKorea**	**India**	**France**	**Germany**	**UK**	**RoEU**	**Saudi Arabia**	**RoW**	**Row total**	**Row ave**
1	**pdr**	1.0	28.2	5.8	57.3	82.7	29.1	230.3	1.6	2.9	3.3	1.7	2.9	56.0	**502.8**	**38.7**
2	**wht**	15.1	62.4	12.0	16.4	3.0	1.1	106.9	68.0	32.7	18.1	22.6	139.9	56.4	**554.8**	**42.7**
3	**gro**	90.9	8.0	6.2	24.7	0.9	1.7	54.6	37.5	8.2	3.2	42.5	3.5	104.7	**386.6**	**29.7**
4	**v_f**	9.4	1.9	33.2	48.3	1.3	2.8	25.4	29.9	6.4	5.3	15.5	26.9	44.0	**250.3**	**19.3**
5	**osd**	10.0	30.0	7.1	7.2	1.8	3.3	164.5	30.2	6.2	23.2	54.4	2.6	35.2	**375.9**	**28.9**
6	**c_b**	5.9	10.6	72.6	72.6	9.4	0.6	311.0	38.7	12.1	0.2	0.3	2.4	41.6	**577.9**	**44.5**
7	**pfb**	49.6	147.7	55.1	103.4	5.4	1.7	103.8	9.5	2.7	8.2	8.2	3.6	95.6	**594.7**	**45.7**
8	**ocr**	33.6	4.5	96.1	13.8	14.1	17.6	292.4	125.0	80.1	14.7	96.1	2.9	145.1	**935.8**	**72.0**
9	**ctl**	27.2	39.3	85.7	16.0	15.5	11.7	204.1	28.1	0.8	34.6	8.7	24.9	33.1	**529.8**	**40.8**
10	**oap**	11.4	10.9	27.9	54.1	22.2	17.9	95.5	3.4	2.5	1.5	12.8	17.1	16.8	**294.2**	**22.6**
11	**rmk**	1.4	11.8	8.2	10.8	5.1	3.5	54.7	7.1	0.0	0.9	8.5	0.6	28.9	**141.5**	**10.9**
12	**wol**	0.0	19.7	3.7	11.8	11.8	4.4	454.8	6.1	36.8	4.0	88.2	8.2	284.7	**934.2**	**71.9**
13	**frs**	13.7	133.5	44.7	4.5	13.8	8.6	39.9	9.8	7.3	10.1	5.2	2.6	27.7	**321.5**	**24.7**
14	**fsh**	4.3	31.1	1.2	41.1	21.0	32.0	40.5	8.5	2.1	5.5	5.4	2.8	30.3	**225.8**	**17.4**
15	**coa**	72.7	69.9	95.1	116.5	0.2	2.3	127.6	1.4	21.3	25.6	24.1	2.3	69.5	**628.6**	**48.4**
16	**oil**	12.7	85.4	284.6	17.3	1.9	1.8	23.2	7.3	2.9	28.2	6.4	328.5	236.9	**1037.2**	**79.8**
17	**gas**	22.7	5.0	24.4	5.0	3.3	2.3	32.7	2.1	3.1	14.3	51.5	42.4	92.5	**301.5**	**23.2**
18	**omn**	7.1	71.7	29.6	148.9	9.6	6.6	27.9	5.4	6.1	0.7	5.7	18.9	41.5	**380.0**	**29.2**
19	**cmt**	25.5	28.3	57.3	29.2	12.5	74.5	17.8	1.3	0.6	29.5	1.2	7.1	49.5	**334.4**	**25.7**
20	**omt**	10.9	3.5	67.1	186.3	10.0	11.6	3.2	3.5	10.0	24.5	6.1	5.6	20.9	**363.3**	**27.9**
21	**vol**	0.6	7.3	14.7	124.9	11.7	22.0	10.9	1.3	6.8	6.3	15.8	2.3	61.8	**286.5**	**22.0**
22	**mil**	14.5	18.4	88.9	26.7	19.7	5.4	33.0	8.1	1.7	2.8	4.2	1.5	73.6	**298.4**	**23.0**
23	**pcr**	6.3	43.3	16.8	339.5	19.4	5.0	14.1	4.8	3.6	5.1	4.4	3.2	91.5	**557.1**	**42.9**
24	**sgr**	12.3	79.1	46.5	54.4	27.7	14.4	57.0	4.9	3.6	6.0	6.3	5.3	29.2	**346.6**	**26.7**
25	**ofd**	13.1	0.7	113.4	9.0	28.9	7.4	12.5	2.2	0.9	2.9	1.5	10.3	27.1	**229.9**	**17.7**
26	**b_t**	11.2	1.1	21.1	42.9	6.7	18.6	13.2	4.6	2.2	42.9	0.2	9.5	18.7	**193.0**	**14.8**
27	**tex**	3.8	3.8	13.5	131.0	6.6	23.8	13.6	0.0	2.1	28.5	2.9	4.0	22.1	**255.8**	**19.7**
28	**wap**	2.3	0.4	21.0	77.2	0.2	87.1	3.1	1.4	5.7	26.8	17.4	8.4	32.6	**283.5**	**21.8**
29	**lea**	2.3	0.4	104.7	63.3	1.9	15.1	3.4	5.8	5.1	11.0	16.6	4.9	41.4	**276.0**	**21.2**
30	**lum**	37.1	47.0	0.3	52.5	11.5	3.7	3.5	3.7	1.5	0.8	7.9	1.5	19.2	**190.4**	**14.6**

Table 3.4 continues …

… Table 3.4 continued

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	GTAP industries (see appendix)	**USA**	**Canada**	**Mexico**	**China**	**Japan**	**SKorea**	**India**	**France**	**Germany**	**UK**	**RoEU**	**Saudi Arabia**	**RoW**	**Row total**	**Row ave**
31	**ppp**	22.4	40.0	4.9	26.4	13.5	30.7	10.3	34.9	49.3	68.1	39.9	3.9	41.5	**385.6**	**29.7**
32	**p_c**	56.3	50.0	95.7	50.5	91.0	91.2	105.2	29.2	26.3	27.3	49.3	85.2	89.1	**846.3**	**65.1**
33	**crp**	7.4	8.7	3.4	76.1	18.5	29.1	9.3	2.0	5.8	26.1	3.3	21.5	11.4	**222.7**	**17.1**
34	**nmm**	8.4	6.1	29.3	86.3	18.6	3.6	5.3	3.1	0.2	11.7	6.2	20.3	20.6	**219.6**	**16.9**
35	**i_s**	4.8	2.8	3.0	181.4	73.3	216.0	5.5	4.6	6.6	21.8	2.1	3.1	6.2	**531.2**	**40.9**
36	**nfm**	6.1	21.6	18.0	144.1	38.6	79.6	6.8	4.9	3.0	111.0	2.2	0.9	13.5	**450.5**	**34.7**
37	**fmp**	12.0	3.3	12.2	44.6	14.7	0.4	3.2	2.3	0.2	2.1	2.6	6.4	15.9	**120.2**	**9.2**
38	**mvh**	10.2	15.6	19.3	43.1	3.5	11.3	2.5	12.4	1.6	18.8	8.1	3.4	7.0	**156.8**	**12.1**
39	**otn**	5.9	15.5	44.9	47.8	45.8	36.5	20.1	29.2	14.6	4.6	10.2	2.4	10.3	**287.8**	**22.1**
40	**ele**	17.7	2.6	4.3	150.9	37.3	74.2	15.1	12.4	30.2	5.2	16.9	3.0	10.4	**380.1**	**29.2**
41	**ome**	4.2	5.6	13.9	37.8	33.9	51.3	19.2	9.8	18.0	50.8	15.3	13.2	12.6	**285.5**	**22.0**
42	**omf**	27.7	1.0	1.8	2.4	19.1	9.0	11.2	8.5	6.7	8.8	3.7	2.8	5.4	**108.2**	**8.3**
43	**ely**	6.2	5.2	17.0	7.2	29.6	15.5	4.2	14.9	22.0	4.3	32.1	96.8	18.3	**273.4**	**21.0**
44	**gdt**	29.6	12.6	344.2	2.9	4.1	2.8	174.5	7.4	28.9	31.1	41.1	158.0	15.0	**852.1**	**65.5**
45	**wtr**	171.7	14.3	13.0	4.4	144.0	59.2	76.5	99.7	90.3	106.3	93.5	17.3	72.2	**962.4**	**74.0**
46	**cns**	19.5	17.6	7.1	12.6	25.4	8.6	7.5	2.2	1.4	19.5	6.9	50.6	27.6	**206.8**	**15.9**
47	**trd**	23.3	2.8	13.7	7.3	26.4	7.9	12.8	0.9	2.6	4.6	5.5	4.9	8.9	**121.7**	**9.4**
48	**otp**	13.8	0.7	17.7	13.1	21.7	3.6	21.4	2.0	6.1	10.8	8.7	8.5	23.5	**151.7**	**11.7**
49	**wtp**	3.6	16.5	9.9	8.6	5.2	35.5	11.2	46.1	39.8	9.0	11.2	1.0	53.1	**250.6**	**19.3**
50	**atp**	20.8	10.4	16.3	1.2	6.7	3.7	5.5	28.3	3.0	7.1	3.8	2.4	30.9	**140.2**	**10.8**
51	**cmn**	73.6	22.7	0.1	5.7	109.1	63.0	30.7	125.8	110.6	119.5	101.6	24.1	34.9	**821.4**	**63.2**
52	**ofi**	21.5	2.1	14.7	37.2	11.4	17.1	10.6	7.0	5.0	31.2	0.4	8.4	28.0	**194.6**	**15.0**
53	**isr**	28.4	9.4	3.3	7.7	11.0	4.7	10.1	5.1	1.0	40.0	8.1	1.7	0.1	**130.6**	**10.0**
54	**obs**	9.4	21.6	29.6	1.7	6.8	33.2	3.4	55.0	37.8	8.6	27.8	3.5	10.2	**248.6**	**19.1**
55	**ros**	33.2	16.5	204.2	1.1	43.4	24.2	6.6	2.6	12.2	3.3	10.3	6.3	1.7	**365.6**	**28.1**
56	**osg**	14.7	25.8	19.2	4.5	18.4	7.1	4.0	6.5	4.7	9.7	6.4	8.4	19.8	**149.2**	**11.5**
57	**dwe**	29.2	5.5	300.2	1.8	9.2	35.2	10.2	1.2	2.2	0.4	3.4	5.6	6.8	**411.0**	**31.6**
58	**CGDS**	22.1	21.3	5.5	27.9	28.5	8.2	4.2	3.0	0.6	1.8	9.8	37.1	26.6	**196.7**	**15.1**
59	**Col totals**	**1232.6**	**1382.6**	**2725.2**	**2942.9**	**1288.5**	**1400.0**	**3182.4**	**1022.6**	**809.3**	**1152.5**	**1072.8**	**1297.7**	**2549.9**	**22059.1**	
60	**Col ave**	**21.3**	**23.8**	**47.0**	**50.7**	**22.2**	**24.1**	**54.9**	**17.6**	**14.0**	**19.9**	**18.5**	**22.4**	**44.0**		**29.3**

Table 3.5. Analysis of selected entries from the GTAP data matrices for output by industry and region

	GTAP inds (see appendix)	Region	E2_1417q q=NoModel,	gcomp 0414	gcomp 1417	GTAP output values, $USb (VOM) 2004	2007	2011_	2014_	2017	Comment
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
1	wtr	USA	156	1	164	113.1	132.4	143.3	160.8	395.8	Unrealistic growth in 2014-17, see col 5 and cols 9&10. This applies for wtr in nearly all countries, not just those in this table. Was there a redefinition of wtr?
2	frs	Canada	119	-3	-44	12.0	13.6	14.1	14.8	7.7	Canadian I-O data shows value of Forestry output in $C went up 12.22% in 2014-17. $C/$US went up by 20% in 2014-17, suggesting a 6.5% decline in $US value, not 48 percent as implied by cols 9&10
3	oil	Mexico	131	19	-62	39.2	49.7	54.6	95.5	33.7	$US oil price dropped by 45% between 2014 and 2017 (see footnote ad). Consequently, the sharp declines in output value in Mexico and other countries is OK.
4	ofd	Mexico	124	8	-42	46.2	61.8	70.5	80.6	43.7	See row 6. We looked for an explanation in the GTAP trade data for the collapse in output of ofd as we go from col 9 to 10, but couldn't find one.
5	gdt	Mexico	355	-7	-93	5.8	7.4	6.3	6.1	0.4	In 2014, the Mexican gdt industry produced its output using mainly primary factors and inputs of gdt. There was also a large production tax. Inputs of gas (imported) were small. Sales of gdt were mainly to ely. In 2017, the industry is quite different. It is a tiny industry that facilitates the flow of imported gas, mainly to ely. It looks as though there was a change in the definition of the industry. Most of what the industry was doing in 2014 disappears leaving only the facilitation of flows of imported gas. There are also suspicious declines in outputs of gdt in France, Germany and others not in this table.
6	ros	Mexico	215	7	-68	62.7	83.9	93.0	105.6	31.8	Between 2014 and 2017, the Peso price level increased by about 11% and the Peso devalued relative to the U.S. $ by about 38%. This suggests $US prices decreased in Mexico by about 20%. Real GDP in Mexico rose by 8.5%. Putting this all together, it seems highly unlikely that the value of ros could fall as much as implied in cols 9&10.
7	dwe	Mexico	292	7	-97	73.1	97.5	108.3	124.0	3.3	Looks like a mistake, data implies that dwelling rentals almost disappeared in 2017

Table 3.5 continues …

… Table 3.5 continued

GTAP inds (see appendix)	Region	E2_1417q q=NoModel,	gcomp 0414	gcomp 1417	GTAP output values, $USb (VOM) 2004	2007	2011_	2014_	2017	Comment
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
8	coa	China	149	45	-7	43.5	80.4	149.2	202.7	175.7	From 2014 to 2017 the quantity of hard coal production in China declined by 4.28% (footnote k). Over this period the $US price of coal grew by 13.92% (footnote l), suggesting an increase in U.S. $ value of output of 9 %. Cols 9&10 imply a decline of 13.2%.
9	omn	China	153	60	-21	51.8	121.0	294.9	334.1	245.7	The sharp decline in $US value of output of omn between 2014 and 2017 is surprising at first glance. However it is supported by source cited in footnote x which shows a 42% reduction in the $US value of Chinese mining output excluding oil, gas and coal.
10	omt	China	197	84	-41	19.4	48.3	117.9	200.2	110.2	In China, pork is the major component of omt. Between 2014 and 2017, pork prices in CNY rose by 5 per cent. Pork production fell by 6.33% implying a CNY value decline of about 1.65% . China devalued by about 10 per cent. So in $US, output value falls by about 12 per cent. Hence we think that the reduction in col 10 relative to col 9 is unrealistic.
11	vol	China	115	110	19	8.6	43.9	111.2	137.4	152.5	No obvious problem here. Included in the table because of the huge change in growth from 110 to 19 (cols 4&5). But the 110 reflects a very low starting point in 2004 (col 6). In this situation, we should make use of observations for 2007 and 2011 (cols 7&8).
12	pcr	China	275	51	-56	30.0	13.6	32.3	158.8	64.5	The GTAP database shows a sharp increase in private consumption of domestic pdr between 2014 and 2017, offset by a sharp reduction in consumption of pcr. These changes seem implausible.
13	tex	China	172	44	-14	178.2	339.3	542.2	810.1	648.6	Cols 9&10 imply a sharp reduction in the $US value of output of Chinese textiles between 2014 and 2017. World prices of tex were fairly flat (footnote q). Within the GTAP database the explanation for the decline in tex output is the decline in apparel exports and private consumption of apparel in China. Both these apparel effects need to be confirmed. The decline in consumption seems especially suspicious.
14	nmm	China	106	70	13	107.5	281.9	746.1	854.4	901.2	Same comment as in row 11.

Table 3.5 continues …

… Table 3.5 continued

	GTAP inds (see appendix)	Region	E2_1417q q=NoModel,	gcomp 0414	gcomp 1417	GTAP output values, $USb (VOM) 2004	2007	2011_	2014_	2017	Comment
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
15	i_s	China	187	59	-33	210.1	497.4	963.6	1330.3	824.5	An internet search suggests that Chinese steel production rose moderately from 2014 to 2017 and the price translated into $US rose by about 20% (footnotes c,d,and e). This is inconsistent with the sharp decline in the value of i_s output implied by columns 9&10.
16	nfm	China	171	83	-13	75.2	246.2	489.2	760.7	619.8	Sources cited in footnotes r&t show non-ferrous metal production and aluminium production in China increasing by more than 20% between 2014 and 2017. Source s implies that the $US price of aluminium was close to flat. Thus, the sharp decline in Chinese output value between 2014 and 2017 looks unrealistic.
17	ele	China	132	41	-33	330.9	527.8	1018.5	1422.9	887.0	Similar to SKorea (see row 21). It seems that ele production was moving away from China and SKorea back towards the U.S. and possibly emerging economies such as India.
18	wtr	Japan	125	-10	263	29.1	26.8	37.2	28.2	95.2	See comment in row 1.
19	cmn	Japan	108	-10	190	178.9	165.3	226.8	172.9	467.4	See comment in row 33.
20	i_s	SKorea	276	26	-54	68.8	116.7	179.5	202.4	86.5	An internet search suggests that SKorean steel production and $US prices were relatively flat between 2014 to 2017 (footnotes g&f). This is inconsistent with the sharp decline in the value of i_s output implied by columns 9&10.
21	ele	SKorea	113	23	-10	123.0	145.5	278.7	329.2	276.4	According to GTAP data, output of SKorea ele grew by 168 per cent between 2004 and 2014 with 92% growth between 2007 and 2011. Between 2011 and 2014 output growth was a modest 18 per cent with a decline of 16% from 2014 to 2017. This seems plausible. UNCTAD (footnote w) shows growth in the value for world imports of ele that are consistent with the GTAP numbers for 2004, 2014 and 2017, and imply a sharp slowdown in ele trade between 2014 and 2017.

Table 3.5 continues …

… Table 3.5 continued

	GTAP inds (see appendix)	Region	E2_1417q q=NoModel,	gcomp 0414	gcomp 1417	GTAP output values, $USb (VOM) 2004	2007	2011_	2014_	2017	Comment
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
22	pdr	India	403	29	194	9.5	17.0	25.6	30.1	82.6	The pocketbook of Indian agriculture shows moderate growth or small declines in the INR values of output of most agricultural products (see footnote a). INR devalued against the US$ by about 10 % between 2014 and 2017 (footnote b). The huge percentage increases and decreases in $US values of outputs of some Indian agricultural products implied by the GTAP data for 2014 to 2017 seem unrealistic. For pdr in particular, source ab indicates that the quantity rise between 2014 and 2017 was only moderate and source ac indicates that the $US price at the world level fell by about 5%. These quantity and price data do not support the spectacular value rise implied by cols 9&10.
23	wht	India	202	32	-11	9.9	18.8	28.7	34.1	28.3	The GTAP movement between 2014 and 2017 is supported by source ab for wheat.
24	osd	India	264	29	-27	9.9	18.5	28.4	31.2	21.2	See comment in row 22. Source ab shows strong quantity increase in India between 2014 and 2017 in almost oil seed products. Hence the value implied by cols 9&10 seems unlikely.
25	c_b	India	547	27	-52	4.9	8.8	13.5	14.8	6.7	See comment in row 22.
26	pfb	India	202	28	71	5.6	10.7	16.7	16.9	27.0	Cotton production in India fell by 2% between 2014 and 2017 (see footnote ab) and the $US world price rose by 4% (footnote ai). Hence steep value implied by cols 9&10 seems unrealistic.
27	ocr	India	547	18	-62	23.2	32.3	48.5	53.7	18.8	See comment in row 22.
28	ctl	India	230	25	-56	6.3	10.4	15.8	17.7	7.2	See comment in row 22.
29	rmk	India	106	23	47	26.0	41.8	62.3	70.3	96.0	Plausible growth for 2014-17 but see comment in row 22.
30	wol	India	830	25	-68	2.2	3.6	5.7	6.1	1.8	See comment in row 22. Also see row 44.
31	coa	India	164	59	-2	5.8	8.1	10.4	37.2	33.8	Between 2014 and 2017 coal output in India increased by about 10% but the $US price fell by about 40% (includes devaluation). See footnotes o, p & b. The value decline implied by cols 9&10 might be too small.
32	gdt	India	191	31	-47	3.5	5.0	8.6	11.6	5.7	See comment in row 5

Table 3.5 continues …

… Table 3.5 continued

	GTAP inds (see appendix)	Region	E2_1417q q=NoModel,	gcomp 0414	gcomp 1417	GTAP output values, $USb (VOM) 2004	2007	2011_	2014_	2017	Comment
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
33	cmn	France	122	0	195	85.8	108.0	117.9	114.8	315.7	The GTAP data for value of output shows huge growth between 2014 and 2017, following moderate growth between 2007 and 2014. A similar pattern applies to Germany. Growth in communication output for the U.S., Japan, India, U.K. RoEU and Saudi Arabia seems unrealistically large for 2014 to 2017. Was there a broadening of the definition of cmn?
34	cmn	Germany	108	-1	188	114.2	136.9	146.2	149.5	401.5	See comment in row 33.
35	nfm	UK	102	39	-46	17.0	30.2	33.2	68.2	34.5	We assume aluminium is the principal product. Source u shows almost no change in the value of output in pounds. Between 2014 and 2017 the pound devalued against the $US by 24% (footnote v). The 50% reduction in the $US value of nfm output implied by cols 9&10 seems too large.
36	cmn	UK	116	-1	191	89.4	115.7	102.1	116.9	317.2	See comment in row 33.
37	cmn	RoEU	100	1	188	237.0	322.1	342.6	332.0	891.3	See comment in row 33.
38	wht	SaudiAr	101	19	-58	0.9	1.0	1.7	2.1	0.8	World price of wheat in $US fell by 25% between 2014 and 2017 and world output grew slightly (footnotes y&z). Consequently, reductions in output values at the regional level are plausible, but the percentage reduction for Saudi Arabia is extreme. However an extreme reduction is supported by footnote aa.
39	oil	SaudiAr	675	30	-43	112.0	224.7	360.1	361.8	193.2	See comment in row 3
40	p_c	SaudiAr	104	21	-19	37.3	62.5	93.7	96.4	72.6	Probably OK in light of movement in the price of oil, see row 3.
41	gdt	SaudiAr	142	134	-50	0.1	0.4	0.7	1.8	0.9	For Saudi Arabia, the GTAP data indicate that gas is the dominant input to gdt. The sharp decline implied by cols 9&10 is partly explained by a 32% reduction in the $US price of gas. Nevertheless, the reduction seems extreme.
42	gro	RoW	133	30	-21	47.5	79.7	137.9	154.0	113.3	We assume that the principal product is corn and the principal producing countries in RoW are Brazil, Argentina, Ukraine and South Africa. Total production in these countries barely changed between 2014 and 2017 (see footnote ab) and the $US price fell by 20%. Consequently the value change between cols 9&10 is plausible.

Table 3.5 continues …

… *Table 3.5 continued*

	GTAP inds (see appendix)	Region	E2_1417q q=NoModel,	gcomp 0414	gcomp 1417	GTAP output values, $USb (VOM) 2004	2007	2011_	2014_	2017	Comment
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
43	ocr	RoW	108	20	-35	62.2	97.2	161.4	154.8	93.7	Difficult to make a judgement about the realism of the sharp value decline between 2014 and 2017. Ocr contains many products and R0W contains many countries. We looked at the prices of coffee and tea. World coffee prices in $US went down by 25 % (footnote ag) and world tea prices went up by about 30% (footnote ah).
44	wol	RoW	213	13	-49	10.7	15.3	27.3	22.0	10.5	Internet search suggests that U.S. $ prices of wool increased strongly between 2014 and 2017 and global output was flat (footnotes m&n). Consequently, the sharp reduction in the value of output for Row implied by columns 9&10 is suspicious. GTAP data added over all countries implies a reduction in global output value of 38%, inconsistent with the information we found on global prices and quantities.
45	oil	RoW	109	26	-47	575.2	1090.0	1620.6	1691.1	839.1	See comment in row 3

Footnotes to Table 3.5

[a] https://agricoop.nic.in/sites/default/files/pocketbook_0.pdf

[c] https://www.statista.com/statistics/448869/steel-production-volume-in-china/#:~:text=In%202021%2C%20China%20produced%20nearly,0.9%20percent%20compared%20to%202020 .

[d] https://tradingeconomics.com/commodity/steel

[e] https://www.macrotrends.net/2575/us-dollar-yuan-exchange-rate-historical-chart

[f] https://www.oecd.org/sti/ind/86th%20Steel%20Committee%20meeting%20%20Presentation%20by%20KISA,%20Korean%20Steel%20Market.pdf

[g] https://www.oecd.org/sti/ind/steel-market-developments.htm

[h] https://data.worldbank.org/indicator/FP.CPI.TOTL.ZG?locations=MX

[i] https://www.statista.com/statistics/697844/china-pork-production/

[j] https://www.pig333.com/markets_and_prices/china_106/

[k] https://www.statista.com/statistics/267574/production-of-hard-coal-in-china-since-1993/

[l] https://tradingeconomics.com/commodity/coal

[m] https://fred.stlouisfed.org/graph/?id=PWOOLCUSDA

[n] https://2030.wool.com/globalassets/2030/documents/GD3821-WCG-Wool-2030-Discussion-Paper-1-5.pdf

[o] https://www.ceicdata.com/en/indicator/india/coal-production

[p] https://www.google.com/search?q=price+of+coal+india&rlz=1C1GCEB_enAU992AU998&oq=price+of+indian+coal&aqs=chrome.2.69i57j0i22i30l9.13474j0j15&sourceid=chrome&ie=UTF-8
[q] https://fred.stlouisfed.org/series/WPU034201
[r] https://www.statista.com/statistics/449036/china-non-ferrous-metal-production-volume/
[s] https://tradingeconomics.com/commodity/aluminum
[t] https://www.ceicdata.com/en/china/non-ferrous-metal-production
[u] https://www.ibisworld.com/united-kingdom/market-size/aluminium-production/
[v] https://www.xe.com/currencycharts/?from=GBP&to=USD&view=10Y
[w] https://unctad.org/news/trade-electronic-components-drives-growth-technology-goods
[x] https://www.statista.com/forecasts/1053773/mining-and-quarrying-revenue-in-china
[y] https://www.macrotrends.net/2534/wheat-prices-historical-chart-data
[z] Wheat Data-All Years.xls downloaded from USDA.
[aa] https://www.indexmundi.com/agriculture/?country=sa&commodity=wheat&graph=production
[ab] https://www.indexmundi.com/agriculture/?country=in&commodity=copra-oilseed&graph=production
[ac] https://www.indexmundi.com/commodities/?commodity=rice&months=120
[ad] https://www.statista.com/statistics/262860/uk-brent-crude-oil-price-changes-since-1976/
[ae] https://www.macrotrends.net/2478/natural-gas-prices-historical-chart
[af] https://www.statista.com/statistics/675820/average-prices-maize-worldwide/
[ag] https://www.macrotrends.net/2535/coffee-prices-historical-chart-data
[ah] https://www.indexmundi.com/commodities/?commodity=tea&months=120
[ai] https://www.macrotrends.net/2533/cotton-prices-historical-chart-data

References

Aguiar, A., E. Corong, and D. van der Mensbrugghe (2019). "The GTAP Recursive Dynamic (GTAP-RD) Model: Version 1.0". Center for Global Trade Analysis, Purdue University, available at https://www.gtap.agecon.purdue.edu/resources/download/9871.pdf .

Britz, Wolfgang and Roberto Roson (2019), "G-RDEM: A GTAP-Based Recursive Dynamic CGE Model for Long-Term Baseline Generation and Analysis", *Journal of Global Economic Analysis*, Vol. 4, No. 1, pp. 50-96.

Corong, E., T. Hertel, R. McDougall, M. Tsigas and D. van der Mensbrugghe (2017), "The standard GTAP model, Version 7", *Journal of Global Economic Analysis*, vol. 2(1), pp. 1-119.

Dixon, P.B. and D. McDonald (1993), An Explanation of Structural Changes in the Australian Economy: 1986-87 to 1990-91, Background Paper no. 29, June, EPAC (Economic Planning and Advisory Commission), Canberra.

Dixon, P.B., J. Menon and M.T. Rimmer (2000), "Changes in technology and preferences: a general equilibrium explanation of rapid growth in trade", *Australian Economic Papers*, Vol. 39(1), March, pp.33- 55.

Dixon, P.B. and M.T. Rimmer (2002), *Dynamic General Equilibrium Modelling for Forecasting and Policy: a Practical Guide and Documentation of MONASH,* Contributions to Economic Analysis 256, North-Holland Publishing Company, pp. xiv+338.

Dixon, P.B. and M.T. Rimmer (2004), "The US economy from 1992 to 1998: results from a detailed CGE model", *Economic Record*, Vol. 80 (Special Issue), September, pp.S13-S23.

Dixon, P.B. and M.T. Rimmer (2010), "Validating a detailed, dynamic CGE model of the U.S.", *Economic Record,* 86 (Special issue), September, pp. 22-34.

Dixon, P.B. and M.T. Rimmer (2013), "Validation in CGE modeling", Chapter 19, pp. 1271-1330 in P.B. Dixon and D.W. Jorgenson (editors) *Handbook of Computable General Equilibrium Modeling*, Elsevier.

Dixon, P.B., R.B. Koopman and M.T. Rimmer (2013), "The MONASH style of CGE modeling: a framework for practical policy analysis", Chapter 2, pp. 23-102 in P.B. Dixon and D.W. Jorgenson (editors) *Handbook of Computable General Equilibrium Modeling*, Elsevier.

Dixon P.B. and M.T. Rimmer (2023), "What do GTAP databases tell us about technologies for industries and regions?", paper to be presented at the GTAP conference, June 2023 available at https://www.gtap.agecon.purdue.edu/resources/download/11738.pdf .

Giesecke, J.A. (2002), "Explaining regional economic performance: an historical application of a dynamic multi-regional CGE model", *Papers in Regional Science*, Vol. 81(2), April, pp. 247-278.

Giesecke, J.A. and N. H. Tran (2009), "Sources of growth and structural change in the Vietnamese economy, 1996-2003: A CGE analysis", *Asian Economic Journal*, Vol. 23(2), June, pp. 195-224.

Hertel, T. W., editor, (1997), *Global trade analysis: modeling and applications,* Cambridge University Press, Cambridge, UK, pp. xvii + 403.

Johansen, L. (1960), *A Multisectoral Study of Economic Growth*, Contributions to Economic Analysis 21, North-Holland Publishing Company, pp. x+177.

Johansen, L. (1974), *A Multisectoral Study of Economic Growth*, *second enlarged edition*, Contributions to Economic Analysis 21', North-Holland Publishing Company, pp. x+274.

Kehoe, T.J. (2005), "An Evaluation of the Performance of Applied General Equilibrium Models of the Impact of NAFTA." In Timothy J. Kehoe, T.N. Srinivasan, and John Whalley, editors, Frontiers in Applied General Equilibrium Modeling: Essays in Honor of Herbert Scarf, 341–77. Cambridge, UK: Cambridge University Press.

Peng, X. (2023), *CHINAGEM - a Dynamic General Equilibrium Model of China: Theory, Data and Applications*", Springer, forthcoming July.

Appendix. *GTAP industries*

		Description
1	pdr	Paddy Rice: rice, husked and unhusked
2	wht	Wheat: wheat and meslin
3	gro	Other Grains: maize (corn), barley, rye, oats, other cereals
4	v_f	Veg & Fruit: vegetables, fruitvegetables, fruit and nuts, potatoes, cassava, truffles,
5	osd	Oil Seeds: oil seeds and oleaginous fruit; soy beans, copra
6	c_b	Cane & Beet: sugar cane and sugar beet
7	pfb	Plant Fibres: cotton, flax, hemp, sisal and other raw vegetable materials used in textiles
8	ocr	Other Crops: live plants; cut flowers and flower buds; flower seeds and fruit seeds; vegetable seeds, beverage and spice crops, unmanufactured tobacco, cereal straw and husks, unprepared, whether or not chopped, ground, pressed or in the form of pellets; swedes, mangolds, fodder roots, hay, lucerne (alfalfa), clover, sainfoin, forage kale, lupines, vetches and similar forage products, whether or not in the form of pellets, plants and parts of plants used primarily in perfumery, in pharmacy, or for insecticidal, fungicidal or similar purposes, sugar beet seed and seeds of forage plants, other raw vegetable materials
9	ctl	Cattle: cattle, sheep, goats, horses, asses, mules, and hinnies; and semen thereof
10	oap	Other Animal Products: swine, poultry and other live animals; eggs, in shell (fresh or cooked), natural honey, snails (fresh or preserved) except sea snails; frogs' legs, edible products of animal origin n.e.c., hides, skins and furskins, raw , insect waxes and spermaceti, whether or not refined or coloured
11	rmk	Raw milk
12	wol	Wool: wool, silk, and other raw animal materials used in textile
13	frs	Forestry: forestry, logging and related service activities
14	fsh	Fishing: hunting, trapping and game propagation including related service activities, fishing, fish farms; service activities incidental to fishing
15	coa	Coal: mining and agglomeration of hard coal, lignite and peat
16	oil	Oil: extraction of crude petroleum and natural gas (part), service activities incidental to oil and gas extraction excluding surveying (part)
17	gas	Gas: extraction of crude petroleum and natural gas (part), service activities incidental to oil and gas extraction excluding surveying (part)
18	omn	Other Mining: mining of metal ores, uranium, gems. other mining and quarrying
19	cmt	Cattle Meat: fresh or chilled meat and edible offal of cattle, sheep, goats, horses, asses, mules, and hinnies. raw fats or grease from any animal or bird.
20	omt	Other Meat: pig meat and offal. preserves and preparations of meat, meat offal or blood, flours, meals and pellets of meat or inedible meat offal; greaves
21	vol	Vegetable Oils: crude and refined oils of soya-bean, maize (corn),olive, sesame, ground-nut, olive, sunflower-seed, safflower, cotton-seed, rape, colza and canola, mustard, coconut palm, palm kernel, castor, tung jojoba, babassu and linseed, perhaps partly or wholly hydrogenated,inter-esterified, re-esterified or elaidinised. Also margarine and similar preparations, animal or vegetable waxes, fats and oils and their fractions, cotton linters, oil-cake and other solid residues resulting from the extraction of vegetable fats or oils; flours and meals of oil seeds or oleaginous fruits, except those of mustard; degras and other residues resulting from the treatment of fatty substances or animal or vegetable waxes.
22	mil	Milk: dairy products
23	pcr	Processed Rice: rice, semi- or wholly milled
24	sgr	Sugar
25	ofd	Other Food: prepared and preserved fish or vegetables, fruit juices and vegetable juices, prepared and preserved fruit and nuts, all cereal flours, groats, meal and pellets of wheat, cereal groats, meal and pellets n.e.c., other cereal grain products (including corn flakes), other vegetable flours and meals, mixes and doughs for the preparation of bakers' wares, starches and starch products; sugars and sugar syrups n.e.c., preparations used in animal feeding, bakery products, cocoa, chocolate and sugar confectionery, macaroni, noodles, couscous and similar farinaceous products, food products n.e.c.
26	b_t	Beverages and Tobacco products
27	tex	Textiles: textiles and man-made fibres
28	wap	Wearing Apparel: Clothing, dressing and dyeing of fur
29	lea	Leather: tanning and dressing of leather; luggage, handbags, saddlery, harness and footwear
30	lum	Lumber: wood and products of wood and cork, except furniture; articles of straw and plaiting materials

Table continues …

… Table continued

		Description
31	ppp	Paper & Paper Products: includes publishing, printing and reproduction of recorded media
32	p_c	Petroleum & Coke: coke oven products, refined petroleum products, processing of nuclear fuel
33	crp	Chemical Rubber Products: basic chemicals, other chemical products, rubber and plastics products
34	nmm	Non-Metallic Minerals: cement, plaster, lime, gravel, concrete
35	i_s	Iron & Steel: basic production and casting
36	nfm	Non-Ferrous Metals: production and casting of copper, aluminium, zinc, lead, gold, and silver
37	fmp	Fabricated Metal Products: Sheet metal products, but not machinery and equipment
38	mvh	Motor Motor vehicles and parts: cars, lorries, trailers and semi-trailers
39	otn	Other Transport Equipment: Manufacture of other transport equipment
40	ele	Electronic Equipment: office, accounting and computing machinery, radio, television and communication equipment and apparatus
41	ome	Other Machinery & Equipment: electrical machinery and apparatus n.e.c., medical, precision and optical instruments, watches and clocks
42	omf	Other Manufacturing: includes recycling
43	ely	Electricity: production, collection and distribution
44	gdt	Gas Distribution: distribution of gaseous fuels through mains; steam and hot water supply
45	wtr	Water: collection, purification and distribution
46	cns	Construction: building houses factories offices and roads
47	trd	Trade: all retail sales; wholesale trade and commission trade; hotels and restaurants; repairs of motor vehicles and personal and household goods; retail sale of automotive fuel
48	otp	Other Transport: road, rail ; pipelines, auxiliary transport activities; travel agencies
49	wtp	Water transport
50	atp	Air transport
51	cmn	Communications: post and telecommunications
52	ofi	Other Financial Intermediation: includes auxiliary activities but not insurance and pension funding (see next)
53	isr	Insurance: includes pension funding, except compulsory social security
54	obs	Other Business Services: real estate, renting and business activities
55	ros	Recreation & Other Services: recreational, cultural and sporting activities, other service activities; private households with employed persons (servants)
56	osg	Other Services (Government): public administration and defense; compulsory social security, education, health and social work, sewage and refuse disposal, sanitation and similar activities, activities of membership organizations n.e.c., extra-territorial organizations and bodies
57	dwe	Dwellings: ownership of dwellings (imputed rents of houses occupied by owners)
58	CGDS	Capital goods: this is an artificial industry that collects the inputs to capital creation

* *Source: downloaded from https://www.gtap.agecon.purdue.edu/databases/contribute/detailedsector57.asp*