

Updating USAGE: Baseline and Illustrative Application

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Abstract

USAGE is a dynamic, CGE model of the U.S. economy created at CoPS in collaboration with the U.S. International Trade Commission (USITC). The model has been used by and on behalf of: the USITC; the U.S. Departments of Commerce, Agriculture, Energy, Transportation and Homeland Security; private sector organizations such as the Cato Institute and the Mitre Corporation; and the Canadian Embassy in Washington DC. To keep the model relevant for policy analysis, it must be updated periodically. This paper describes a major update of USAGE undertaken for the USITC. In accordance with the CoPS contract with the USITC, the update task was to:

1. build a NAICS-based database at the 400-industry level for USAGE using the 2007 BEA benchmark input-output tables;
2. update this database to 2014;
3. create a baseline projection starting from the base year of 2014 and proceeding at 5 year intervals to 2024; and
4. conduct an illustrative USAGE policy simulation around the baseline.

At the completion of this work in August 2016, the ITC requested a fifth task:

5. update from 2007 to 2015 rather than 2014 and create a baseline from 2015 to 2020.

This paper describes how we undertook the five tasks.

Keywords: USAGE CGE model; data updating; baseline forecasting;

JEL codes: C67, C68, C81, C82, D57, D58

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1. Introduction

This paper describes the building of a new database for the USAGE model based on the NAICS-based 400-order Benchmark BEA input-output tables for 2007. It then describes the update process to 2014 and a baseline forecast with illustrative policy application out to 2024. Subsequently, as described in the paper, the database was updated to 2015. In the update to 2015, detailed trade data for 2007 to 2015 were introduced. A new baseline for 2015 to 2020 was created and a policy simulation conducted around this new baseline was compared with a similar policy simulation conducted around the original baseline starting from 2014.

2. Creating the NAICS-based USAGE database for 2007

The main work under this heading was modification and extension of the 2007 benchmark input-output table (about 400 industries) published by the Bureau of Economic Analysis (BEA). This work is described in detail in the appendices. In broad terms we were concerned with the treatments of: imports; margins; taxes; investment; government expenditures; capital stocks; the balance of payments and foreign assets and liabilities; the division of value added; and the introduction of special industries.

Imports

The BEA benchmark input-output tables represent imports by commodity as a single column of numbers in the USE matrix. With some exceptions, these import flows are shown in the benchmark tables by negative numbers. This negative approach is motivated by the BEA's requirement that totals across rows in the input-output USE matrix represent sales of domestically produced commodities. The interpretation and treatment of the exceptional cases (positive entries in the import column) are explained in Appendix 1.

For USAGE we need a disaggregation of the import column into a matrix showing imports by commodity and user (industries, households, capital creators, and government). An imports matrix was supplied by the BEA to the USITC and then to us. As explained in Appendix 1, considerable effort was needed to deal with cases in which the import entry for a commodity/user cell exceeded the corresponding entry in the BEA's published benchmark table in which the entries are combined domestic and import values. This effort involved communication with the BEA and cell-by-cell decisions.

Margins

The use of margin services (e.g. road transport, wholesale trade, retail trade) is represented in the benchmark input-output tables by single rows. These rows show the combined value of margin and direct uses. For example, the entry in the household column of the road transport row shows the use of road transport to deliver all commodities to households (margin use) plus expenditures by households on taxis, buses, etc (direct use).

For USAGE we need to separate out direct use and then to disaggregate the remaining margin use into the parts associated with each commodity flow. Thus, for example, the original road-transport/household entry is separated into direct use of road transport by households and margin use to deliver to households each commodity, e.g. cheese, vegetables, apparel etc. As explained in Appendix 1, this involved reconfiguration of data supplied to us by the USITC together with cell-by-cell treatment of cases in which the apparent use of margins was implausible in view of the apparent direct flows that the margins were facilitating (e.g. positive margins on zero flows).

Taxes

Commodity flows in the BEA input-output tables are shown at producer values. This means that sales and excise taxes are buried in the flows. For USAGE, we need to identify taxes on each flow. For example, we need to be able to calculate the rate of tax applying to household use of tobacco products. Appendix 1 describes the process by which we derived tax matrices and separated tax flows from producer values. In this process, we ensured that tax totals by commodity in the USAGE database are compatible with published BEA information.

Investment

Investment by commodity is shown in the BEA input-output tables in four columns: sales of commodities to non-residential investment in structures, equipment and intellectual property, and residential fixed investment. For USAGE we require a matrix showing flows of commodities to investment in each industry. As explained in Appendices 1 and 2, we: aggregated the four columns into one to obtain investment by commodity; created investment column totals by industry by considering capital stock by industry; and filled in the matrix via a RAS procedure applied to an earlier USAGE investment matrix.

Government expenditures

The BEA input-output tables contain 12 columns of data for government spending by commodity: Federal government defence and non-defence consumption expenditure; State & local government consumption expenditure; Federal government defence and non-defence investment expenditure on structures, equipment and intellectual property; and State & local government investment expenditure on structures, equipment and intellectual property. As explained in Appendix 1, we reconfigure these data into intermediate input and investment columns for three USAGE industries: Federal government defence; Federal government non-defence; and State and local government.

Capital stocks

USAGE requires data for the value and quantity of capital stock by industry. Industry-specific capital is an input to production functions in the USAGE model and accumulation of capital through investment is an important part of the model's dynamic specification. As explained in Appendix 2, capital data in the U.S. is available mainly on an ownership basis. For USAGE we require measures of capital on an activity basis (what it is used for rather than who owns it). While it is possible to obtain investment data on an activity basis, we found no new data (beyond what we had used in earlier versions of USAGE) identifying capital by using industry (activity basis). Appendix 2 explains how we used aggregate data for capital combined with output measures by industry and capital data created for 70-sector versions of USAGE to estimate capital by using industry at the 400-sector level.

The balance of payments and foreign assets and liabilities

USAGE contains detailed modelling of the U.S. current account. In addition to measures of exports and imports derived from input-output data, the USAGE balance of payments specification requires data on: income flows from U.S. foreign assets; income payments on U.S. foreign liabilities; and transfer payments into and out of the U.S. As explained in Appendix 2, we assembled the required current account data from BEA sources.

USAGE tracks U.S. foreign assets and liabilities through their link with the current account. The model also computes revaluations of foreign assets and liabilities reflecting movements in exchange rates and price levels. As described in Appendix 2, calibrating this part of the model required us to assemble data on the value of U.S. assets at the start of 2007 divided

into credits (denominated in U.S. or foreign currency) and U.S. owned foreign equities, together with corresponding data on U.S. liabilities.

The division of value added

Apart from taxes, value added by industry in the U.S. input-output tables is divided into Compensation to employees and Other value added. For USAGE, these data need to be reconfigured to introduce self-employment and returns to agricultural land. As in most CGE models, data on Other value-added by industry is the starting point for representing rentals on capital stocks. However, as explained in Appendix 2, considerable adjustment is required to ensure that the resulting estimates of capital rentals imply realistic rates of return.

Special industries

Tourism is not explicitly represented in the BEA input-output tables. As explained in Appendix 2 we used BEA's tourism satellite accounts to form three tourism industries in the 2007 USAGE database. The data for these industries show inputs to: Export tourism (tourism services sold to foreign visitors); Foreign vacation, an artificial industry that creates international vacations for U.S. residents by mixing U.S. and foreign provided airline services with non-comparable imports; and Vacation that mixes hotel, travel, shopping, etc in the U.S. to create domestic vacations for U.S. residents. Other special industries in the USAGE model that we recreated for the 2007 database are: Export education (sales of goods and services to foreign students in the U.S.); and Other non-resident (sales to foreign diplomats, World Bank officials, etc). We also split the BEA industries Air Transport and Water transport into four USAGE industries: Air transport domestic; Air transport international; Water transport domestic; and Water transport international. These industry splits facilitate modelling of the effects of trade and other policies that impact differently on the different segments of Air and Water transport.

3. Updating to 2014

Having created a complete 400-sector USAGE database for 2007, we performed an historical simulation to create a database for 2014. In an historical simulation, we start the model from a known database (in this case 2007) and introduce data for an historical period (in this case 2007 to 2014) as shocks to variables that we treat as exogenous. For example, we observe the movement in aggregate consumption from 2007 to 2014. To introduce this observation to the 2014 database we exogenize aggregate consumption and shock it with the 2007-2014 movement. Exogenization of a naturally endogenous variable such as aggregate consumption requires corresponding endogenization of a naturally exogenous variable, the average propensity to consume in this example.

The database produced by an historical simulation is consistent with all of the observations used to generate the shocks. Our 2007-2014 historical simulation produces a 2014 database that is consistent with BEA data for 2014 on:

- macro expenditure variables (current dollar values of private consumption, public consumption, private investment, public investment, exports, imports, inventory accumulation and GDP);

- aggregate labor-market and demographic variables (employment, average wage rate, labor supply, population and aged population);

- aggregate non-residential and residential capital stocks;

balance of payments (imports, exports, U.S. income derived from foreign credits and equity holdings, U.S. payments to service foreign debts and foreign holdings of U.S. equity, and transfer payments into and out of the U.S.);

U.S. foreign assets and liabilities disaggregated into credits and debts denominated in domestic and foreign currencies together with U.S. holdings of foreign equity and foreign holdings of U.S. equity;

rates of interest and rates of return on foreign assets and liabilities; and

outputs in nominal and real terms at the 77-order industry level.

While historical simulation does not produce a complete “observed” database, it does produce a database that is consistent with what is observed. The unobserved variables are filled in by the simulation in a defensible manner. For example, when we introduce data on the output movement for a 77-level industry, the historical simulation allocates that movement across the constituent 400-order industries in a way that equalizes the implied taste or technology shift in demand for the commodities produced by these constituent industries. As discussed in the conclusion, the quality of a database derived by historical update can be improved by successive introduction of observations for further variables.

4. Creating the baseline from 2014 to 2024

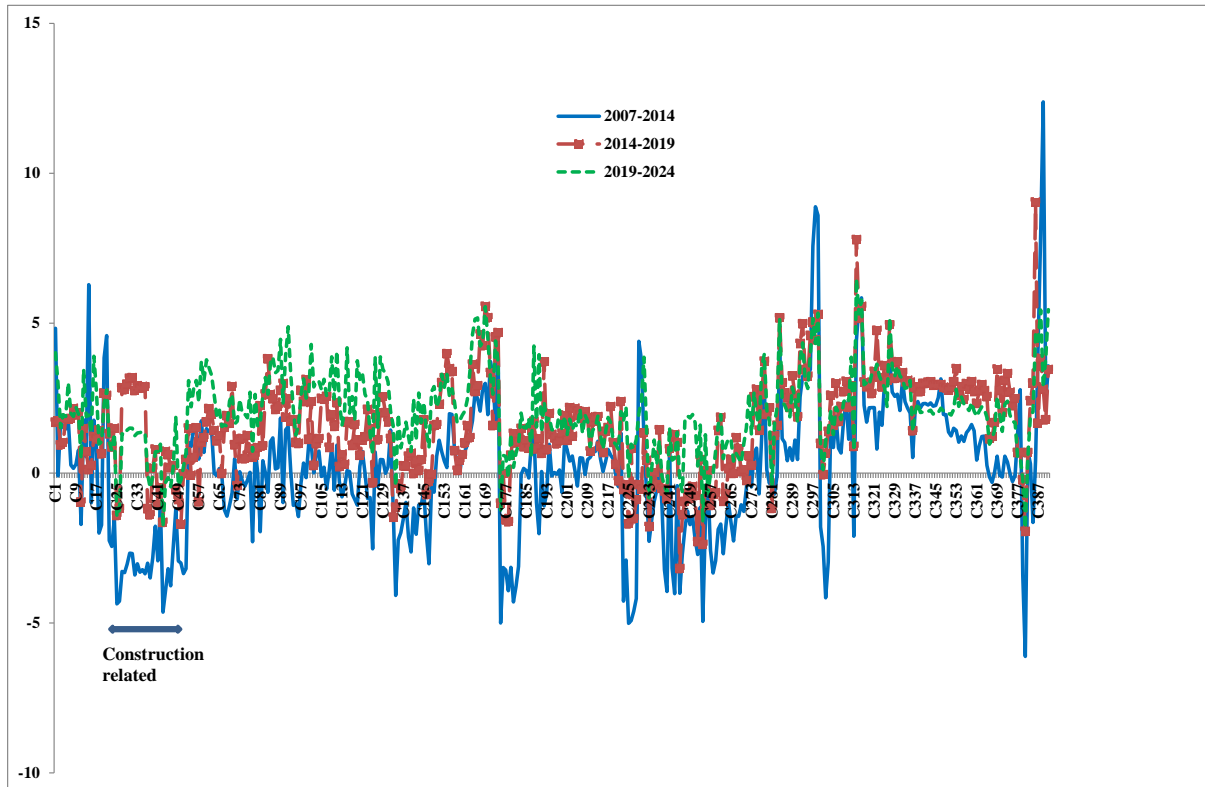
Starting from the 2014 database we produced a baseline out to 2024. As required for the Project, the baseline was created in two 5-year steps: a simulation for the period 2014 to 2019 followed by one for 2019 to 2024.

The philosophy underlying baseline simulations is similar to that underlying historical simulations. Whereas in historical simulations we exogenize and shock variables for which we know the historical movements, in baseline simulations we exogenize and shock variables for which we have credible forecasts. For this Project we introduced forecasts for all macro expenditure and labor-market variables from the reference case in the Energy Information Administration’s (EIA) 2016 publication titled Annual Energy Outlook. Thus our baseline forecasts for 2019 and 2024 are consistent at a macro level with the EIA’s forecasts.

A by-product of the historical simulation for 2007 to 2014 is trend estimates of input-saving/using changes in technologies and consumer preferences. To see how these arise, assume that historical information shows an increase in the output of commodity c between 2007 and 2014 of 20 per cent. Next assume that on the basis of changes in expenditure aggregates and prices, the equations in USAGE imply an increase in demand of only 15 per cent. In these circumstances, the historical simulation reconciles the 20 and 15 per cents by showing a commodity-c-using change in technology/preferences that absorbs 5 per cent of the total production of commodity c. In our baseline forecasts we extrapolated forward technical/preference changes by commodity emerging from the historical simulation. To avoid extreme output movements by commodity in our baseline forecasts, we capped some of the historically revealed technology/preference movements.

Chart 1 shows that our baseline forecasts for movements in industry outputs between 2014 and 2019 and between 2019 and 2024 are quite similar. On the other hand, there are considerable differences between the baseline forecast movements and the movements for the period 2007 to 2014. These differences mainly reflect changes in the macro-economic outlook. For example, whereas aggregate real investment declined by 5 per cent between 2007 and 2014, it is projected in the EIA reference case to grow by 25 per cent between 2014 and 2019 and by 16 per cent between 2019 and 2024.

Chart1. Annual percentage growth rates for commodity outputs: USAGE historical simulation for 2007-14 and baseline forecasts for 2014-19 and 2019-24



5. An illustrative policy application

In policy mode, USAGE shows the effects of proposed policies or other shocks to the economy as deviations from a baseline. To demonstrate this and to test the workings of the model with its newly created database and baseline, we conducted an illustrative policy simulation. For this exercise we simulated the effects of a 10 per cent reduction in the requirements for wholesale services per unit of exports of each commodity. While this shock is arbitrary and not intended to refer to any particular policy, it produces a simulation that illustrates the ability of the USAGE model to project the effects of efficiency improvements in the conduct of trade.

We assume that the shock (reduction in wholesale requirements) takes place in 2014. Tables 1 and 2 show effects in 2019 and 2024 on macro variables and commodity outputs. These effects are percentage deviations from baseline values. Because the effects in 2019 and 2024 are very similar, we will focus on just one of these years, 2019.

The cost of wholesale margins on U.S. exports in our database for 2014 is 1.1 per cent of GDP. Saving 10 per cent of this cost is equivalent to a technological improvement that makes a direct contribution to GDP in 2019 of 0.11 per cent (row 9, col 1, Table 1).

Under the assumptions that we have adopted for this simulation, an improvement in technology leads in the medium term to an increase in aggregate capital stock (0.130 per cent, row 8, Table 1). In qualitative terms the relationship between technological improvement and capital stock can be understood via the equation

$$\frac{Q}{P_g} = A * F_k \left(\frac{K}{L} \right) \quad (1)$$

Table 1. Macro effects of a 10% cut in 2014 in Wholesale margins applying to U.S. exports

		Deviations from baseline in:	
		2019	2024
<i>Percentage changes</i>			
1	Real GDP (Y)	0.160	0.165
2	Real private consumption (C)	0.109	0.118
3	Real investment (I)	0.130	0.146
4	Real public consumption (G)	0.112	0.121
5	Real exports (X)	1.098	1.094
6	Real imports (M)	0.636	0.676
7	Aggregate employment (L)	0.000	0.000
8	Aggregate capital (K)	0.130	0.144
9	Technology contrib. to GDP	0.111	0.113
10	Real wage (W/P _c)	0.160	0.165
11	Real exchange rate	0.413	0.432
12	Price deflator for C (P _c)	0.000	0.000
13	Price deflator for I (P _i)	-0.013	-0.016
14	Price deflator for G (P _g)	0.059	0.058
15	Terms of trade	-0.330	-0.314
16	Price deflator for GDP (P _y)	-0.029	-0.028
<i>Percentage point changes</i>			
17	Trade balance, % of GDP	0.016	0.014
18	Net f'gn liabilities, % of GDP	0.006	0.006

where

Q is the rental on a unit of capital;

P_g is the price of a unit of GDP;

A is technology;

K is aggregate capital;

L is aggregate employment; and

F_k is the derivative of F with respect to K in the constant-returns-to-scale production function $A \cdot F(K, L)$. F_k is a declining function of K/L.

In the medium-term policy closure adopted in the simulation, we assume that the shock under consideration (improvement in technology in 2014) has no effect on rates of return in 2019: capital adjusts to restore rates of return to their baseline levels. Under this assumption, there can be little change in Q/P_g. A technological improvement is represented in equation (1) by an increase in A. With Q/P_g fixed, an increase in A causes a reduction in F_k. Thus, there must be an increase in K/L. Another assumption built into our medium-term policy closure is that L is fixed: wage rates adjust to keep employment on its baseline path. With L fixed and

K/L increasing, K must rise. Corresponding to the increase in K there is an increase in investment (row 3).

An increase in K (row 8) with an improvement in technology (row 9) and no change in employment (row 7) must generate an increase in GDP. This is shown in row 1.

A major benefit of technological improvement is that it allows U.S. workers to receive higher real wage rates (row 10) without harming employment. It also allows U.S. households and the public sector to have higher levels of consumption (rows 2 and 4).

The percentage increases in consumption (0.109 and 0.112 per cent) are less than that in GDP (0.160 per cent). Increases in consumption are limited by a decline in the terms of trade (0.330, row 15). Terms-of-trade declines reduce the ability of the economy to translate units of GDP into units of consumption.

Why is there a decline in the terms of trade? The technological improvement centered on margin costs of exporting causes an increase in export volumes (1.098 per cent, row 5). This is made possible by a reduction in the foreign-currency price of U.S. exports. At the same time there is almost no change in the foreign-currency prices of imports, and consequently there is a reduction in the terms of trade. The reduction in the terms of trade explains the reduction in the price deflator for GDP relative to the price deflators for private and public consumption and investment (row 16 compared with rows 12, 14 & 13): a decline in the terms of trade reduces the value of a unit of GDP (production) relative to the value of a unit of absorption (C+I+G).

As can be seen from row 11, despite the reduction in the terms of trade, the export-centered technological improvement causes real appreciation (an increase in the nominal exchange rate adjusted for changes in the U.S. price level relative to that of its trading partners). A useful framework for understanding real appreciation is the GDP identity in real terms:

$$Y = C + I + G + X - M \quad (2)$$

As already explained, terms-of-trade decline means that the percentage stimulation of C+I+G is less than that in Y. Consequently, although X increases, it is not clear *a priori* whether M will increase or fall. In our simulation it happens that the stimulation of X is sufficiently large that to maintain equation (2) M must increase (0.636 per cent, row 6). The mechanism by which M increases is real appreciation.

Despite stimulation of exports and a small improvement in the 2019 trade balance (row 17), there is an increase in net foreign liabilities as a share of GDP (row 18). This arises because the increase in capital stock induced by the technological improvement is financed over the period 2014 to 2019 mainly by foreign saving.

Table 2 shows the five commodities for which the reduction in export-margin costs causes the largest percentage increases in output. It also shows the five commodities with the largest percentage decreases in output.

For the commodities at the top of Table 2, wholesale margins account for a high share of export costs (between 25 and 39 per cent compared with an average over all commodities of about 8 per cent). Another characteristic of these commodities is a high export share in their sales (between 47 and 81 per cent compared with an average over all commodities of about 7 per cent). To gain significantly from a cut in export-margin costs an industry must be producing commodities that are both heavily exported and intensive in export margins.

Table 2. Effects on commodity outputs in 2019 & 2024 of a 10% cut in 2014 in Wholesale margins applying to U.S. exports (% deviations from baseline) and data for 2014

Commodity	2019	2024	Export share in 2014	Wholesale share in exports in 2014
92 Optical instruments	3.40	3.53	0.81	0.28
115 Computer terminals	2.88	3.13	0.66	0.33
190 Toys	2.87	3.11	0.70	0.27
93 Photo equipment	2.80	3.12	0.47	0.39
188 Jewelry	2.56	2.69	0.70	0.25
...'''...'''				
...'''...'''				
...'''...'''				
231 Pulp mills	-0.73	-0.80	0.65	0
274 Wholesale trade	-0.74	-0.88	0.00	0
388 Export tourism	-0.82	-0.85	1	0
392 Water international	-0.94	-1.06	1	0
389 Export education	-1.22	-1.27	1	0
<i>Average over all commodities</i>			<i>0.07</i>	<i>0.08</i>

Wholesale trade appears among the five losing commodities in Table 2 because our assumed shock is a direct reduction in demand for wholesale services. The other four commodities at the bottom of the table have high export shares. What distinguishes them from the top commodities is lack of reliance on wholesale margins. With no wholesale margins in their export costs, a cut in required wholesale margins gives them no cost reduction. At the same time these bottom commodities are negatively impacted by real appreciation caused by the reduction in export margin costs accruing to producers of other commodities.

6. Adjusting the update to 2015 and the baseline to 2015-20

In December 2016, the USITC asked us: (1) to apply the methods described above to update the USAGE database from 2014 to 2015 and to create a baseline for 2015 to 2020; and (2) to improve the update to 2015 by incorporating data supplied by the ITC on exports and imports by commodity and then create a baseline to 2020 starting from the improved database for 2015.

We completed the work under (1) by revising all of the shocks that took us from 2007 to 2014 so that they became shocks from 2007 to 2015. As explained in section 3, these shocks cover:

macro expenditure variables (current dollar values of private consumption, public consumption, private investment, public investment, exports, imports, inventory accumulation and GDP);

aggregate labor-market and demographic variables (employment, average wage rate, labor supply, population and aged population);

- aggregate non-residential and residential capital stocks;
- balance of payments (imports, exports, U.S. income derived from foreign credits and equity holdings, U.S. payments to service foreign debts and foreign holdings of U.S. equity, and transfer payments into and out of the U.S.);
- U.S. foreign assets and liabilities disaggregated into credits and debts denominated in domestic and foreign currencies together with U.S. holdings of foreign equity and foreign holdings of U.S. equity;
- rates of interest and rates of return on foreign assets and liabilities; and
- outputs in nominal and real terms at the 77-order industry level.

We also revised the shocks that created the baseline from 2014 to 2019 so that they became shocks for 2015 to 2020.

With shocks for 2007-15 and 2015-20 in place, we repeated the update and baseline simulations to generate a 392-order database for 2015 consistent with all of the 2015 data listed above, and a baseline from 2015 to 2020 incorporating the newly obtained shocks for this period.

6.1. Incorporating detailed trade data

To enable us to perform the work under (2), Marinos Tsigas and Austin Drenski (T&D) of the ITC supplied us with data for goods imports valued at cif prices and goods exports valued at fob prices. These data show 95 categories each of which is an aggregation from the 256 *goods* categories in the 392-commodity USAGE model. We used the T&D data for 2007 and 2015 (they also supplied data for 2014).

The USAGE 2007 database shows imports and exports at the 392 level consistent with the BEA Benchmark input-output tables. We compared the 95-order T&D data for 2007 with the USAGE data. This comparison was useful for working out the mapping from the USAGE data for 256 goods to the T&D data for 95 goods. The correspondence between the USAGE and T&D data for 2007 was adequate – for most T&D categories the gap between the T&D data and aggregated USAGE data was less than 20 per cent.

To incorporate the T&D data into the USAGE 2015 update, we added to the 2007-15 simulation shocks representing the percentage differences between the USAGE 2007 values for exports and imports in the 95 T&D categories, and their values in the T&D data for 2015. In this way we ensured that export and import values in the new 2015 USAGE database are consistent with the 2015 values in the T&D database.

In the update simulation, we were not primarily concerned with the realism of the 2007-15 shocks for imports and exports. Rather, our aim was to embed the T&D values for 2015 in the USAGE database for 2015. Consequently, it was not necessary to correct discrepancies between the USAGE and T&D values for 2007.

Export and import values by commodity are naturally endogenous variables. In the 2007-15 update they had to be exogenized and shocked in the 95 T&D categories. This required us to define exports and imports in these categories. Then, to achieve the export targets, we endogenized 95 export-demand shift variables. These shift variables imposed uniform export-demand shifts for USAGE commodities in the same T&D category. To achieve the import targets we endogenized 95 import/domestic twist variables. These twist variables imposed uniform changes in the import/domestic preferences for USAGE commodities in the same T&D category.

As mentioned in section 3, in the original update simulation we introduced data on output growth between 2007 and 2014 (now 2015) by commodity at the 77 level. These data were absorbed by endogenizing input-using technical and taste changes that were uniform for USAGE commodities within each 77-order category. Now we found it helpful to allow non-uniform input-using changes within 77-order categories to help absorb the T&D import data. For example, if USAGE commodities a and b are in the same 77-order category and the T&D data show strong import growth for a but not b , then we allowed a -input-using technical change to be more rapid than b -input-using technical change.

6.2. Illustrative policy simulation

In section 5, we reported a policy simulation showing the effects in 2019 of a 10 per cent cut in wholesale margins applying to U.S. exports. In that simulation, the baseline data for 2019 was the update from 2014. We have repeated this simulation but it now refers to effects in 2020, with the baseline for 2020 being the update from 2015. Tables 3 and 4 and Chart 2 provide a comparison of results from our new policy simulation with those from our earlier policy simulation reported in section 5.

Table 3 shows that the macro results are only slightly affected by the switch from 2014-19 to 2015-20. For most macro variables, the percentage deviation in the new simulation is a little smaller in absolute size than the corresponding deviation in the old simulation. For example the GDP deviation in the new simulation is 0.153 per cent compared with 0.160 per cent in the old simulation. This reflects a slight decrease in the ratio of Wholesale margins on exports to GDP in our 2015 database relative to the 2014 database: 0.96 per cent relative to 1.08 per cent. As can be seen from the final row in Table 4, the decrease in the export-wholesale-margin/GDP ratio reflects a slightly lower average export share in the output of U.S. commodities and a slightly lower wholesale share in the value of exports.

Table 4 and Chart 4 show that the new results for commodity outputs are broadly similar to the results reported in section 5. The 5 commodities with the largest positive output deviations in the section 5 simulation are all in the top 16 in the new simulation. These 5 commodities are shaded in the top part of Table 4. The 5 commodities with the largest negative output deviations in the simulation reported in section 5 are the same 5 as in the new simulation. These are the shaded commodities in the bottom part of Table 4. Regressing results for all of the USAGE commodities from the new simulation with those from the section 5 simulation produces an R^2 of 0.871 (Chart 2).

However the first two columns of Table 4 show noticeable differences for some commodities. For example, Broadcast equipment had an output deviation of 1.69 per cent in the simulation reported in section 5. In the new simulation this deviation is 4.17 per cent. The difference is caused by the revision in the USAGE database in the share of exports in the output of Broadcast equipment: up from 39 per cent in the 2014 database to 88 per cent in the 2015 database.

The case of Broadcast equipment shows that the introduction of detailed trade data in an update can have large effects on export shares for some commodities. In the USAGE data for 2007 (based on the BEA Benchmark input-output tables), the export share for Broadcast equipment is 36 per cent. In our initial update, this share increased to 39 per cent in 2014. In the absence of detailed trade data the 2014 shares for almost all commodities were close to the 2007 shares. This is illustrated in Chart 3. By contrast, Chart 4 shows considerable variation between the 2007 shares and the 2015 shares.

Table 3. Macro effects of a 10% cut in 2014 in Wholesale margins applying to U.S. exports: results from the updated 2015-20 simulation and the earlier 2014-19 simulation

		Deviations from baseline in:	
		2014-2019	2015-2020
		Section 5 sim	Updated sim
<i>Percentage changes</i>			
1	Real GDP (Y)	0.160	0.153
2	Real private consumption (C)	0.109	0.103
3	Real investment (I)	0.130	0.138
4	Real public consumption (G)	0.112	0.103
5	Real exports (X)	1.098	1.073
6	Real imports (M)	0.636	0.630
7	Aggregate employment (L)	0.000	0.000
8	Aggregate capital (K)	0.130	0.132
9	Technology contrib. to GDP	0.111	0.103
10	Real wage (W/P _c)	0.160	0.144
11	Real exchange rate	0.413	0.378
12	Price deflator for C (P _c)	0.000	0.000
13	Price deflator for I (P _i)	-0.013	-0.026
14	Price deflator for G (P _g)	0.059	0.049
15	Terms of trade	-0.330	-0.314
16	Price deflator for GDP (P _y)	-0.029	-0.032
<i>Percentage point changes</i>			
17	Trade balance, % of GDP	0.016	0.015
18	Net f'gn liabilities, % of GDP	0.006	0.006

For Broadcast equipment, the increase in the export share in 2015 relative to 2007 reflects the T&D data which show a sharp increase in the value of imports (73 per cent) in the category relevant for Broadcast equipment. With imports already occupying about 60 per cent of the domestic market in 2007, the 73 per cent increase in imports suggests a large reduction in the output of Broadcast equipment. At the same time, the T&D data show a moderate reduction in the value of exports in the relevant category. The moderate reduction in exports combined with a large reduction in output produces the increase in the export share that we estimate for 2007-15.

Supply of results

Via Hightail we have supplied ITC with a Rundynam simulation zip containing: (a) the 2007-15 update simulation which generates the 2015 USAGE database incorporating the T&D trade data; (b) the 2015-20 baseline; and (c) the policy simulation.

Table 4. Effects on USAGE outputs for selected^(a) commodities of a 10% cut in Wholesale margins applying to U.S. exports (% deviations from baseline): results from the 2015-20 and 2014-19 simulations

Commodity	2019	2020	Export share ^(b)		Wholesale share in exports ^(c)	
			2014	2015	2014	2015
117 Broadcast equip	1.69	4.17	0.39	0.88	0.34	0.40
92 Optical instruments	3.40	3.07	0.81	0.67	0.28	0.28
230 Leather manufact	2.51	3.03	0.32	0.39	0.40	0.39
116 Telephone	0.86	2.95	0.18	0.53	0.34	0.39
149 Misc electronic equip	2.05	2.85	0.46	0.63	0.28	0.27
190 Toys	2.87	2.69	0.70	0.61	0.27	0.28
146 Comp electrical wire	2.04	2.64	0.30	0.41	0.28	0.27
133 Lightbulbs	2.00	2.63	0.37	0.49	0.28	0.28
141 Motor generators	2.38	2.46	0.44	0.45	0.28	0.28
188 Jewelry	2.56	2.44	0.70	0.61	0.25	0.25
130 Radiation instruments	2.23	2.41	0.46	0.48	0.32	0.31
143 Relays	2.28	2.34	0.45	0.45	0.28	0.28
93 Photo equip	2.80	2.13	0.47	0.33	0.39	0.38
77 Valves	1.78	2.09	0.29	0.34	0.33	0.32
72 Hardware	1.81	2.04	0.23	0.25	0.41	0.41
115 Computer terminals	2.88	1.94	0.66	0.42	0.33	0.33
...""...""						
...""...""						
...""...""						
231 Pulp mills	-0.73	-0.65	0.65	0.61	0.00	0.00
274 Wholesale trade	-0.74	-0.75	0.00	0.00	0.00	0.00
388 Export tourism	-0.82	-0.78	1.00	1.00	0.00	0.00
392 Water internationsl	-0.94	-0.93	1.00	1.00	0.00	0.00
389 Export education	-1.22	-1.16	1.00	1.00	0.00	0.00
Average over all commodities			0.073	0.069	0.084	0.081

(a) We selected the 16 commodities with the largest output deviations in the new simulation and the 5 commodities with the smallest (most negative) deviations.

(b) Basic value of exports divided by gross output (MAKE).

(c) Wholesale margins to facilitate exports divided by basic value of exports.

Chart 2. Effects on 392 USAGE commodity outputs of a 10% cut in Wholesale margins applying to U.S. exports (% deviations from baseline): results from the 2015-20 and 2014-19 simulations

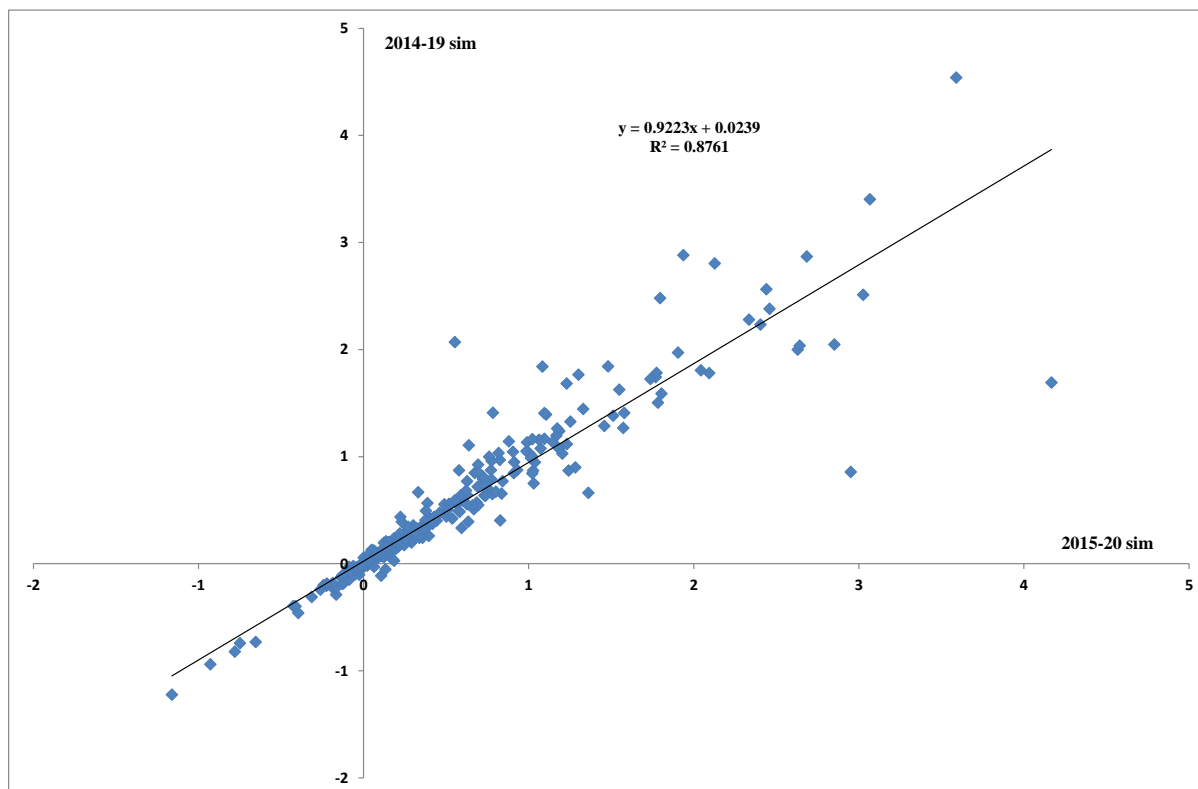


Chart 3. Export shares in commodity outputs: USAGE 2007 (Benchmark BEA) compared with the update for 2014

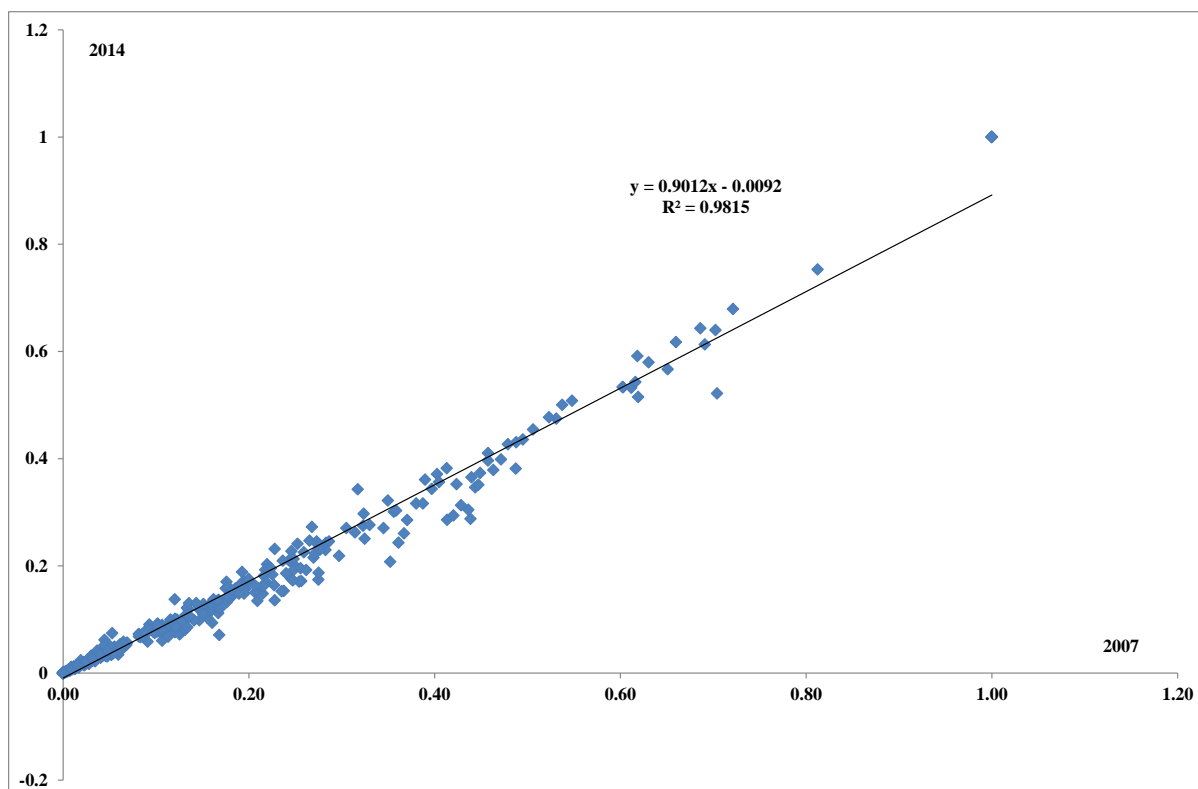
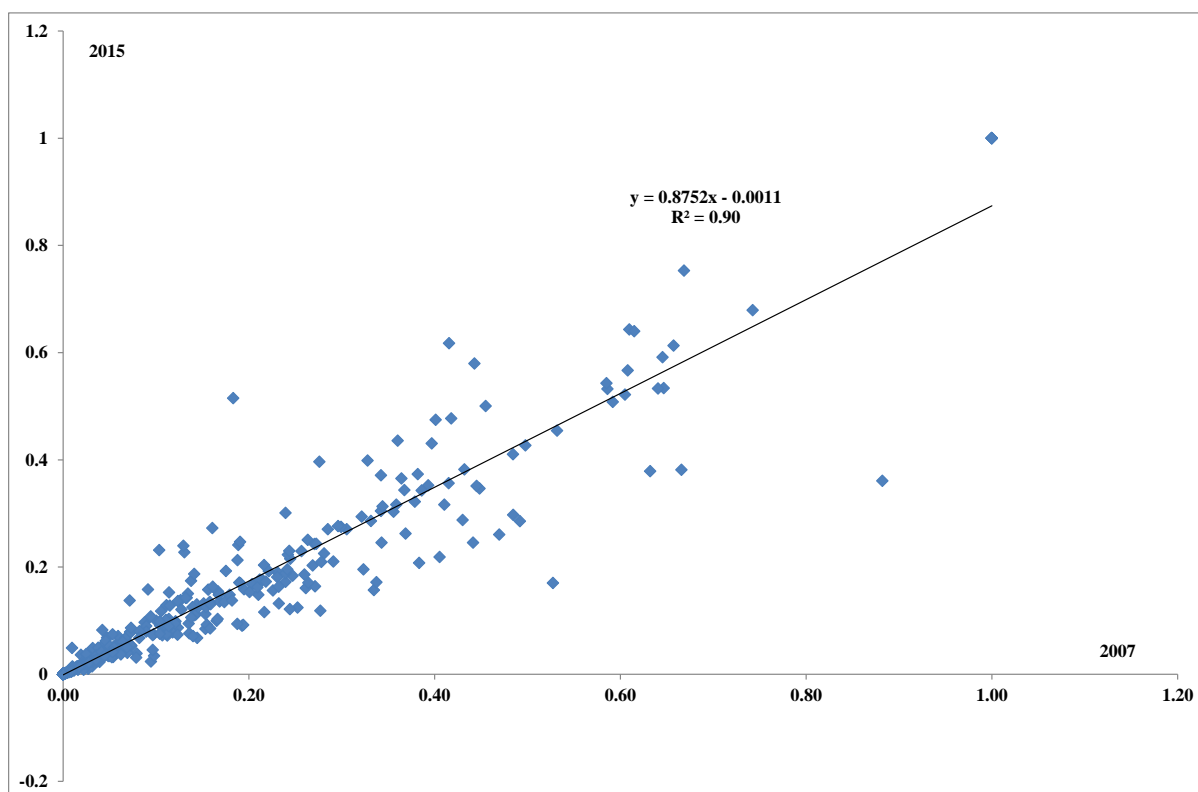


Chart 4. Export shares in commodity outputs: USAGE 2007 (Benchmark BEA) compared with update for 2015 incorporating ITC trade data



7. Concluding remarks

The original version of the USAGE model was built on the 1992 SIC-based Benchmark 500-order input-output tables published by the BEA. The major task described in this paper is the derivation of a new base year database from the BEA's 2007 NAICS-based Benchmark 400-order input-output tables. Many adjustments were made to the 1992 SIC-based tables to derive a database suitable for the original USAGE model. These adjustments required a large amount of expensive work effort. While much was learnt from that effort, a considerable effort was still required for the conversion of the 2007 NAICS-based tables.

CGE modelling is a major application of input-output tables. In our view the tables could be published in a form that is friendlier to CGE modelling without requiring extra expenditure by the BEA or lessening of the value of tables for non-CGE uses. In particular, CGE modelling would be enhanced if the tables were presented in basic values (rather than producer values) and if supplementary data consistent with the basic-value tables were made readily available on imports, taxes and margins on a commodity and user basis.

Another task described in this paper is the creation of baselines. Baselines are of interest in themselves. However, for a policy agency such as the USITC, the main purpose of baselines is to provide realistic paths for economic variables from which the effects of policies can be calculated as deviations. This is illustrated in this paper by simulations of the effects of reductions in the margin costs (e.g. warehousing) of exporting.

Appendix 1: Creating an Updated 2007 Benchmark Input-Output Database for the USAGE Model

Summary

This paper documents work to update the benchmark database for the USAGE Computable General Equilibrium model from 1992 to 2007. The Steps which form headings throughout the paper refer to those detailed in Dixon, P. and M. Rimmer (June 2002), "MONASH-USA: Creating a 1992 Benchmark Input-Output database" and Dixon, P. and M. Rimmer (November 2002), "USAGE-ITC: Creating a 1992 Benchmark Input-Output database, further developments" which documented creation of the database for the 1992 USAGE model. Work on this updated database builds upon the project work started by Marinos Tsigas and his team at the US-ITC.

This appendix covers:

0. Correcting errors in imported ITC data
 1. Elimination of negative entries
 2. Government activities
 3. Imports
 4. Indirect taxes
 5. Domestic/import disaggregation of margins
 6. Investment by investing industry
 7. Accounting for capital creation in the public sector
 8. Eliminating some unwanted negatives: Scrap and Used and 2nd hand goods

Data for this project were downloaded from the US Bureau of Economic Analysis:

18/03/2016	Imports	ImportMatrices_After_Redefinitions_DET_2007.xlsx
18/03/2016	Make	IOMake_Before_Redefinitions_2007_Detail.xlsx
18/03/2016	Use	IOUse_Before_Redefinitions_PRO_2007_Detail.xlsx
23/03/2016	Margins	Margins_Before_Redefinitions_2007_Detail.xlsx

MAKE and USE tables are available from http://www.bea.gov/industry/io_annual.htm. MARGINS and IMPORTS are available from the [Underlying detail: Additional data from the Industry Economic Accounts](http://www.bea.gov/industry/more.htm) link which opens to <http://www.bea.gov/industry/more.htm>.

The Investment matrix used in Step 6 was supplied by the US ITC. Data used to scale tax revenues in "Step 4" were sourced from [Table 3.5U. Taxes on Production and Imports \(Q\)](#) downloaded on 18/02/2016 from SECTION 3 - GOVERNMENT CURRENT RECEIPTS AND EXPENDITURES.

Step 0: Correcting errors in imported ITC data

1) See MFId1.tab – lines 228-275

There are $388-77=311$ commodities for which $\text{sum}(j, \text{USEind}, \text{USE}(i,j)) - \text{sum}(j, \text{MAKEind}, \text{MAKEorig}(j,i))$ is non-zero, likely due to the fact that the source USE and MAKEorig matrices are in US\$million. This difference is accommodated by subtracting it from $\text{USE}(i, \text{"ChPvtInvtry"})$.

There are $388-38=350$ industries for which $\text{sum}(i, \text{USEcom}, \text{USE}(i,j)) - \text{sum}(i, \text{MAKEcom}, \text{MAKEorig}(j,i))$ is non-zero, likely due to the fact that the source USE and MAKEorig matrices are in US\$million. This difference is accommodated by subtracting it from $\text{USE}(\text{"GrossOpSurp"}, j)$.

2) See MFId1.tab – lines 283-321

The row in the USE matrix for ROWAdjust sums to 1071 while at the same time $\text{MAKE}(\text{ROWAdjust}, \text{FedGovNonDef}) = 1071$. We start by making

$$\text{MAKE}(\text{ROWAdjust}, \text{FedGovNonDEF}) = 0$$

and compensate by making

$$\text{USE}(\text{ROWAdjust}, \text{FedGovNonDEF}) = -1071.$$

This negative will be taken care of later on when we introduce Export tourism and Export education. Note that an offsetting entry at lines 1059-1060 will also need to be reversed.

3) See MFId1.tab – line 859-864

After constructing margin matrices $M\#(.)$ from the raw data in Mar2007.HAR, there were a large number of commodities for which $PV\#(.)=0$ when the corresponding value for $M\#(.)>0$, including 72 investment commodities. To avoid problems later, the margins $M2(.)$ are set equal to zero here.

This is clearly undesirable, and is due to the fact that there were errors in creating the margin datafile Mar2007.HAR from the BEA margin datafile Margins_Before_Redefinitions_2007.Detail.xlsx. It seems that whatever method was used to translate this MSeExcel file into the Mar2007.HAR file assigned many values for margin usage to the wrong industry. This had to be corrected, and we constructed a corrected Margins matrix AggMargins under header MARS in the Header Array File BEA_Matrices_Before_Redef_2007.HAR. In fact, there were some other apparent errors in other matrices (for example, the first element of the USE matrix $\text{USE}(\text{"OilSeedFarm"}, \text{"OilSeedFarm"})=2286$ did not match the corresponding value in the BEA MSeExcel file "IOUse_Before_Redefinitions_PRO_Detail.xlsx" where $\text{USE}(\text{"OilSeedFarm"}, \text{"OilSeedFarm"})=2358$). Since there may have been some updates to these datafiles since this data project was begun, we recreated the necessary USE, MAKE and Imports matrices, and collected all of the required data matrices in the single Header Array File BEA_Matrices_Before_Redef_2007.HAR.

Once the data in the margin matrix was translated to HAR format correctly, there remained the following instances where positive margin use is associated with non-positive entries in the USE matrix:

- 9 instances in Investments, all associated with commodity 387Used2HndGds
- 5 instances in Government industry 408SLGGInvEqp, all associated with commodity 387Used2HndGds
- 57 instances in industry usage of intermediate inputs, of which:
 - 6 instances in industry 283TruckTrans, associated with commodity 387Used2HndGd
 - 6 instances in industry 314GenlRentl, associated with commodity 387Used2HndGd
 - 5 instances in industry 357PerfArts, associated with commodity 387Used2HndGd

- 6 instances in industry 381FedGovDef, associated with commodity 387Used2HndGd
- 24 instances in industry 382FedGovNonDef, 7 each in usage of intermediate inputs 1OilSeedFarm, 2GrainFarm, 6OthCropFarm and 204MilkButter, each associated with negative intermediate input usage.
- 4 instances in industry 311Housing where row 41341 of BEA file “Margins_Before_Redefinitions_2007_Detail.xlsx reports that this industry’s use of “retail trade margins” associated with usage of “Small electrical appliance manufacturing” is 1 when the corresponding producers’ value of this intermediate input is 0
- 3 instances in industry 314GenrlRentl where row 41810 of BEA file “Margins_Before_Redefinitions_2007_Detail.xlsx reports that this industry’s use of “retail trade margins” associated with usage of “Other petroleum and coal products manufacturing” is 1 when the corresponding producers’ value of this intermediate input is 0
- 3 instances in industry 315MachEquRntl where row 41984 of BEA file “Margins_Before_Redefinitions_2007_Detail.xlsx reports that this industry’s use of “retail trade margins” associated with usage of “Other petroleum and coal products manufacturing” is 1 when the corresponding producers’ value of this intermediate input is 0

We interpret the 10 instances in the last 3 bullet points as a result of rounding error, likely where usage of these intermediate inputs was less than \$0.5million while usage of the associated margin was more than \$0.5million but less than \$1.5million. We deal with these cases by rounding the associated margins down to zero (see MFId1.tab - lines 346-354). The values for the remaining cases are listed in the following table:

		Margins			
		USE	1 TransCosts	2 Wholesale	3 Retail
COM	IND				
387Used2HndGds	283TruckTrans	-221	3.00	224.00	0.00
387Used2HndGds	314GenrlRentl	-25	4.00	3.00	0.00
387Used2HndGds	357PerfArts	-67	21.00	15.00	0.00
387Used2HndGds	381FedGovDef	-8	1.00	1.00	0.00
387Used2HndGds	392NRPFixInvEqp	-86172	5946	6219	3652
387Used2HndGds	408SLGGInvEqp	-3311	3.00	13.00	0.00
1OilSeedFarm	382FedGovNonDef	-497	26	15	0
2GrainFarm	382FedGovNonDef	-640	25	21	0
6OthCropFarm	382FedGovNonDef	-433	157	116	0
204MilkButter	382FedGovNonDef	-343	5	24	0

The four cases at the bottom of the table deal with negative inputs in industry 382FedGovNonDef .

As detailed in “Step 1” below, we interpret these as cases where the US Federal Government runs down its stockpile of these commodities. The remaining instances involve negative use of commodity 387Used2HndGds . As noted in “Step 4” below, these are resolved following Dixon and Rimmer (2002:4-7) by moving these negative entries to PV61(i) inventories.

The non-zero margins associated with the negative transactions in commodity 387Used2HndGds are rebalanced to household consumption, reasoning that the majority of these transactions ultimately involved sales of used and second-hand goods to private households. Those associated with the negative transactions in industry 382FedGovNonDef are rebalanced to federal government demand.

4) See MFId1.tab – lines 891-898

After deducting margins from PV matrices using:

$$(All,m,MARG7)(All,j,IND388) \text{ PV11}(m,j) = \text{PV11}(m,j) - \text{sum}[i,COM387, M11(i,j,m)];$$

there are a number of PV matrices with negative elements. Margins for these are simply set equal to zero. Again, this is clearly undesirable.

Even after constructing a corrected Margin matrix as detailed in item 3) above, it was still the case that deducting margins from the PV matrices generated PV matrices with negative elements. After correspondence with Ricky Stewart at the U.S. Department of Commerce, BEA, we found that this was due to the fact that all Retail margins from the margins matrix had been deducted from the USE matrix only from the commodity “278RetailTr”, even though the use of commodities “275AutoDealers”, “276FoodBev” and “277GenMerch” in the USE matrix also included use of retail trade margins. The set MARGret = (275AutoDealers, 276FoodBev, 277GenMerch, 278RetailTr) was introduced, increasing the number of margin industries from 7 to 10.

Once these corrections were made there remain the following instances of PV matrices with negative elements after deducting margins from the PV matrices:

- PV11: 171 negatives - the vast majority of negatives are \$-1.0 or smaller – the largest negative is \$-2.55
- PV21: 1 negative - usage of commodity 274WholesaleTrade falls from \$135299 to \$-7
- PV51: 6 negatives, the largest of which is \$-0.878
- PV61: 1 additional negative – usage of commodity 274WholesaleTrade falls from \$2631 to \$-13

These negatives are all deemed to be sufficiently small that we eliminate them by adding back the negatives into the margin matrices before deducting margins from the PV matrices (see lines 935-960). This leaves only 17 negatives in PV11, the largest of which is -0.003906. These last remaining 17 negatives are simply set equal to zero (see line 964).

Step 1: Elimination of negative entries in MAKE and PV11 and alterations to entries in –PVM (p.15)

See MFId1.tab - Section “Step 2.1 - Corrections”

$$\text{PVM1}(i) = \text{sum}(j, \text{IMPT}, \text{USE}(i,j)) \text{ (4 positive values)}$$

Commodity	Value	Notes
(1) 274WholesaleTr	28773	these are duties, according to MONASH
(2) 281WaterTrans	12681	
(3) 16GoldOthMetl	1439	should add -4047
(4) 286Couriers	3545	

(1) first scale all elements of vector of import duties (US\$m) DUTY387 by
 $PVM1("274WholeSaleTr")/trfRev = \$28773/\$26716$; (see MFId1.tab – line 547)

Then move total import duties out of PVM1("274wholeSaleTr") by subtracting them from
TAX01("274WholeSaleTr"), Make1("275WholeSaleTr", "274WholeSaleTr") and
PVM1("274WholeSaleTr").

(2) eliminate positive PVM1("281WaterTrans") by adding PVM1("281WaterTrans") to
PV41("281WaterTrans") and setting PVM1("281WaterTrans")=0

The ITC reports that Imports of "Passenger water transportation services" was \$673 million in 2007
(see Table 2 in Griffith, Eric S. and Steven L. Zemanek (June 2009), "U.S. Travel and Tourism Satellite
Accounts for 2005-2008", Survey of Current Business). While it would be consistent with the
treatment in Dixon and Rimmer (June 2002:15-16) to subtract \$13,354 million (=12681+673) from
the entry for "281WaterTrans" in the "397Imports" column, to reflect imports of \$673 million, and
add \$13,354 million to exports of "281WaterTrans", this would yield an error since the BEA's
Imports by Commodity and Industry reports zero imports of "281WaterTrans"

(3) eliminate positive PVM1("16GoldOthMetl") by adding PVM1("16GoldOthMetl")=1439+2567 to
PV41("16GoldOthMetl") and setting PVM1("16GoldOthMetl")=-2567

(4) eliminate positive PVM1("286Couriers") by adding PVM1("286Couriers")=3545 to
PV41("286Couriers") and setting PVM1("286Couriers")=0

Finally each element of IMPMAT is scaled using $IMPMAT(i,j) \cdot [-PVM1(i)/\sum(j, USEind, IMPMAT(i,j))]$
so that each element of PVM1(i) balances against the corresponding column sum of IMPMAT(i,j).
Note that $[-PVM1(i) - \sum(j, USEind, IMPMAT(i,j))]$ returns 263 zeroes, with minimum of -0.047 and
maximum of 0.125, so multipliers on IMPMAT(i,j) are all equal to or close to zero. See "Step 3:
Imports" below.

See MFId1.tab - Section "Step 2.2 - fixing other negative numbers"

Commodity 307 InsCarriers (lines 634-638)

eliminate negative use of commodity "307InsCarriers" in industry "302NewsInfoServ" by adding
\$134 to MAKE1("302NewsInfoServ", "307InsCarriers") and setting
PV11("307InsCarriers", "302NewsInfoServ") = 0

The single negative entry for MAKE1("385OthFedGEnt","307InsCarriers") is accommodated by adding 74 to PV11("307InsCarriers","385OthFedGEnt") and setting MAKE1("385OthFedGEnt","307InsCarriers")=0.

Industry 382 FedGovNonDef (lines 640-655)

eliminate negative use of the 4 commodities "1OilSeedFarm", "2GrainFarm", "6OthCropFarm", and "204MilkButter" used in industry "382FedGovNonDef" by adding to MAKE1("382FedGovNonDef",xxx) and setting PV11(xxx,"382FedGovNonDef")=0 and likewise with ("387Used2HndGds","381FedGovDef")

Rather than adopt this treatment for resolving the negative entries in USE for industry 382FedGovNonDef, we interpret these entries as cases where the US Federal Government runs down its stockpile of the corresponding commodity. As such, we resolve these negative entries by rebalancing them to the inventory vector, consistent with the treatment of commodities 386Scrap and 387Used2HndGds in Dixon and Rimmer (2002), as detailed in “Step 4” below. For each negative entry in industry 382FedGovNonDef, the entry in the corresponding PV(.) matrix was set equal to zero, and the absolute value of the entry was subtracted from the corresponding commodity in the inventory vector PV61(i). To ensure that the column sum for industry 382FedGovNonDef remained balanced, the absolute value of the sum of these found negative values was subtracted from OVA(.) in industry 382FedGovNonDef.

Finally, any non-zero margins and imports associated with these commodities were rebalanced from 382FedGovNonDef to the own industry (ie: from ("1OilSeedFarm","382FedGovNonDef") to ("1OilSeedFarm","1OilSeedFarm")).

Commodity 386 Scrap (lines 657-664)

The negative investment entry in PV21(i) for “386Scrap” is accommodated by adding 12234 to OVA("381FedGovDef") and MAKE1("381FedGovDef","386Scrap") and setting PV21("scrap")=0.

The negative personal consumption entry in PV31(i) for “386Scrap” is accommodated by adding 4670 to OVA("381FedGovDef") and MAKE1("381FedGovDef","386Scrap") and setting PV31("scrap")=0.

Rather than adopt this treatment for resolving the negative entries in USE for commodity 386 Scrap, we adopt the treatment used in Dixon and Rimmer (2002:4-7) and move these negative entries to PV61(i) inventories. See “Step 8: Eliminating some unwanted negatives: dealing with Scrap (C480) and Used and 2nd hand (C481)” below.

Commodity 387 Used2HndGds (lines 666-706)

eliminate negative use of commodity "Used2HndGds" in 7 abcde industries by subtracting from OVA(abcde) and PV31("387Used2HndGds") and setting PV11("387Used2HndGds",abcde)=0

eliminate negative use of commodity "Used2HndGds" in industry "381FedGovDef" by adding 8 to MAKE1("381FedGovDef", "387Used2HndGds") and setting PV11("387Used2HndGds", "381FedGovDef")=0

eliminate negative investment in PV21(i) for "387Used2HndGds" by adding (2923+79269+3980) to OVA("381FedGovDef") and MAKE1("381FedGovDef", "387Used2HndGds") and setting PV21("387Used2HndGds")=0.

eliminate negative government demand in PV51(i) for "387Used2HndGds" by subtracting (4+33+3311) to PV31("381FedGovDef") and setting PV51("387Used2HndGds")=0.

Rather than adopt these different treatments for resolving the negative entries in USE for commodity 387 Used2HndGds, we adopt the treatment used in Dixon and Rimmer (2002:4-7) and move these negative entries to PV61(i) inventories. See "Step 8: Eliminating some unwanted negatives: dealing with Scrap (C480) and Used and 2nd hand (C481)" below.

PV61(i) = USE(i, "395ChPvtInvtry")

Negative values in PV61(i) represent a running down of inventories and do not need to be resolved.

Step 2: Government activities (p.18)

PV51 remains a (COM387xGOVT) – it is only aggregated to a (COM387x1) from PV53(i,g,s) to BAS54(i,s) at line 1815 – see item 4) at "Step 0" above.

From Dixon and Rimmer (2002:18): "the row sum for commodity n across PV1, ..., PV6, -PVM, together with the sum of the n-entries in MAR1 to MAR6 if n is a margin commodity, equals the value of commodity n produced by domestic *non-government* activities. The restriction to non-government activities is achieved by the negative entries in PV5 and MAR5 in Figure 4.1." But there are no negative entries in PV5 or MAR5 from the 2007 version of the USE or MAR matrices.

Step 3: Imports (p.21)

There are a few irregularities in the BEA's ImportMatrices_After_Redefinitions_DET_2007.xlsx.

There are a number of commodities for which the sum over industries in the Imports matrix is not equal to the value of commodity imports in the USE matrix. The following table lists all commodities where the ratio of these two totals is either greater than 1.01 or smaller than 0.990 (see header "rati" in file chk13.har):

13 AggForSup p	0.978	207 IceCream	0.976	288 Newspape rPb	1.028	303 MonetDepCr ed	1.067	334 BusnsSupS vc	1.284
17 CopNickMi ne	1.017	236 Stationry	1.013	289 PerdclPub	1.034	316 LegalSvces	1.011	336 DetectivSv ce	1.313
45 ConcPipeB ric	1.014	242 AsphaltP ave	1.019	292 SoftwrPub	1.013	320 Accounting	1.011	339 WasteMg mt	1.167
47 LimeGyps um	1.013	244 OthPetro Coal	1.153	297 WiredTelc o	1.054	322 DesignSvce	1.126	356 PerfArts	1.041
50 GrdMinEa rth	1.011	246 IndGas	1.082	299 SatOthTelc o	1.563	327 MscProfSvce s	1.010	358 Promoters	1.120
62 NonFerrFo und	1.289	265 PlstPipe	1.012	300 DataHostS erv	1.121	328 PhotoSvce	1.176	382 PostalSvc	1.027
71 MetalCntn r	1.020	285 ScenSup pTran	1.250	302 NetPubSea rch	1.032	333 EmplSvce	1.026	387 Used2Hnd Gds	1.042

In a 5 May 2016 email message from Ricky Stewart at the U.S. Department of Commerce, BEA, he writes: "... the reason the ratios do not exactly equal 1 is due to rounding at our publication level."

See MFId1.tab – lines 613-614

The Imports matrix is adjusted here so that for each commodity, the sum over industries in the Imports matrix balances against the Imports column in the USE matrix:

$$\text{IMPMAT}(i,j) = \text{IMPMAT}(i,j) * [-\text{PVM1}(i) / \text{sum}(j, \text{USEind}, \text{IMPMAT}(i,j))];$$

See MFId1.tab – lines 1001-1011

Confirms that each element (commodity) of $\text{PVM1}(i)$, itself constructed from column "393Imports" of the USE matrix in Use2007.har, is equal to the sum across industries $\text{IMPMAT}(i,j)$ read from header "IMP" in "BEA_Matrices_Before_Redef_2007.har". $\text{IMPMAT}(i,j)$ is then used to construct import matrices $\text{PM\#1}(\cdot)$ for $\# = 1, 2, 3, 5, 6$.

See MFId1.tab – lines 1171-1209

Create $\text{PV\#3}(\cdot, "dom") = \text{PV\#1}(\cdot) - \text{PM\#1}(\cdot)$ and $\text{PV\#3}(\cdot, "imp") = \text{PM\#1}(\cdot)$ for $\# = 1, 2, 3, 5, 6$

For intermediate inputs and government demand, there are some negative entries which result when $PM11(i,j)$ is subtracted from $PV11(i,j)$. This is dealt with by setting $PV13(i,j,"dom") = PV11(i,j)$ and then setting $PV13(i,j,"imp") = 0$. This is unsatisfactory.

Instead, the code which implements this correction is commented out and replaced with code over lines 1367-1383 which splits PV by source using:

```
PV#3(., "dom") = PV#1(.) - PM#1(.), and
PV#3(., "imp") = PM#1(.)          for #=1,2,3,5,6
```

This results in 615 negative entries in $PV13(i,j,"dom")$. There are 503 values between \$0 and \$-0.1million with a total value of \$-0.967. These are treated as rounding errors and resolved by adding the negative value back into $PM11(i,j)$ (see line 1160). Afterwards there remain 112 cases where $PV13(i,j)$ is negative (see headers "CCC2" or "p13a" in chk14). Of these, there are 94 instances where subtracting imports of 279AirTrans results in negative $PV13(i,"279AirTrans")$, and the 18 cases in this table:

IND	COM	USE	IMP	result
320 OthCptrSvce	114 CmptrStorage	382	544	-161.946
320 OthCptrSvce	115 CompTermin	160	202	-42.027
368 OthFoodDrink	220 Wineries	338	544	-206
368 OthFoodDrink	221 Distilleries	192	364	-171.925
189 Jewelry	58 NonferrMetl	2081	2345	-264.136
20 OilGasDrill	100 MtlWorkMach	257	287	-31.62063
371 MachinerRp	102 GearManuf	330	495	-165
372 HhGoodsRpr	104 OthEngEquip	65	72	-7.01361
28 ManufStruc	109 Scales	859	932	-73.8966
370 ElEquiRepair	120 OtElectric	273	311	-38.02
355 SocialSvce	190 Toys	12	13	-1
170 RlrdCars	228 OthTextMills	265	265	-0.14673
302 NewsInfoServ	307 InsCarriers	-134	1	-0.99119
230 ApparelMf	230 LeatherMf	80	81	-1.009628
372 HhGoodsRpr	230 LeatherMf	26	45	-19.005348
272 Tires	387 Used2HndGds	3	3	-0.124528
276 AutoDealers	387 Used2HndGds	5	5	-0.207547
361 MuseumZoo	387 Used2HndGds	10	10	-0.415094

See MFId1.tab – line 1221

We regard these as re-exports, given the description of re-exports on p.7-6 of the BEA's "Concepts and Methods of the U.S. I-O Accounts". To rebalance re-exports, we move a share of imports of, for example, commodity 114CmptrStorage by industry 320OthCptrSvce to imports of commodity 114CmptStorage by industry 114CmptrStorage, such that after rebalancing, use of domestic and imports of 114CmptrStorage by industry 320OthCptrSvce are the same. Industry 114CmptrStorage then transforms these imports into domestic output of 114CmptrStorage which is sold to industry 320OthCptrSvce. MAKE(114CmptrStorage, 114CmptrStorage) is increased so that all balance conditions in the database are maintained. After rebalancing, domestic use and imports of 114CmptrStorage by 320OthCptrSvce will be $382/2 = 191$, so $544 - 191 = 353$ is rebalanced from 320OthCptrSvce to 114CmptrStorage. This method is used to rebalance all cases in the table above (except for the three cases with 387Used2HndGds – see below), as well as the 94 instances where subtracting imports of 279AirTrans results in negative domestic use of 279AirTrans.

See MFId1.tab – line 1351

- there are also 9 instances where imports of 279AirTrans are negative in the BEA file "ImportMatrices_After_Redefinitions_DET_2007.xlsx":

278 GenMerch	-3	283 TruckTrans	-31	288 Warehousing	-1
279 RetailTr	-10	286 ScenSuppTran	-14	316 AssetLessors	-1
282 WaterTrans	-2	287 Couriers	-12	381 FedGovDef	-105

for a total of 121 negative entries in PV13(i,j)

Along with the three cases where subtracting imports of 387Used2HndGds results in negative domestic use, these are treated as rounding errors and simply set to zero.

- there are also 3 negative entries in PV33(i), where too many margins for the negative entries moved to inventories are dumped into households, causing PV33 of margins 275WholesaleTr, 275AutoDealers and 278RetailTr to go negative

- there are 5 negative entries in PV53(i): the 4 cases where negative entries in 382FedGovNonDef were moved to 402NonDfCE (1OilSeedFarm = -24.959150, 2GrainFarm = -3.997070, 6OthCropFarm = -8.015109 and 204MilkCheeseButter = -1.008982) and 119AudVidEquip = -0.201660

All use of PV11("nonComplImprt",j), PV21("nonComplImprt") and PV31("nonComplImprt") is assigned to PV13("nonComplImprt",j,"imp"), PV23("nonComplImprt","imp") and PV33("nonComplImprt","imp"), with corresponding value of PV#3("nonComplImprt","dom")=0.

Finally there is an adjustment to the MAKE1(i,j) matrix and the OVA vector at lines 1430-1436.

formula

(all,i,com_ind) MAKE1(i,i) = MAKE1(i,i) - D_S_M3a(i);

```
MAKE1("FedGovDef","Used2HndGds")=MAKE1("FedGovDef","Used2HndGds") -
D_S_M3a("Used2HndGds");
MAKE1("FedGovDef","NonComplmprt")=MAKE1("FedGovDef","NonComplmprt") -
D_S_M3a("NonComplmprt");
```

formula (all,i,com_ind) OVA(i) = OVA(i) - D_S_M3a(i);

```
OVA("FedGovDef") = OVA("FedGovDef") - D_S_M3a("Used2HndGds") - D_S_M3a("NonComplmprt");
```

This is fine since D_S_M3a(i) contains 372 zeros, has a maximum of 0.004 and a minimum of -0.031.

Step 4: Indirect taxes (p.22)

The (1xIND388) row vector of taxes is constructed from the USE matrix using
TAX01(j) = USE("390TxProdImLSUB",j). Import duties are deducted from this TAX matrix at line 553:

```
TAX01("wholeSaleTr") = TAX01("wholeSaleTr")- PVM1("wholeSaleTr") ;
```

This reduces total taxes from \$979,982million to \$951,209million.

The row-sum gives total tax revenue of \$979,982million, including:

Retail Taxes: USE("390TxProdImLSUB","279RetailTr") = \$89,195million

Wholesale Taxes: USE("390TxProdImLSUB","275WholesaleTr") =\$175,323million

Also find:

Customs Duties: USE("274WholesaleTr","393Imports") = \$28,773million

Sales taxes are read into TAX(i,j) = TAXES(I,J) from file "taxes.har", accounting for \$505,400million.

See MFId1.tab – line 173

After reading in the raw tax data from file TAX.har, there are 8 negative entries:

taxes("307InsCarriers","287Couriers") = -6.174253

taxes("384OthSLGEnt","135LightFxtr") = -2.000110

taxes("384OthSLGEnt","264OthChemical") = -8.957015

taxes("384OthSLGEnt","266PlstPipe") = -2.347955

taxes("384OthSLGEnt","267LamPlstPlate") = -9.435303

taxes("384OthSLGEnt","299WirelesTelco") = -1.087017

taxes("384OthSLGEnt","343Physician")	= -2.826243
taxes("384OthSLGEnt","380FedGovDef")	= -1.173978

These are all set equal to zero at line 202:

formula (all,c,USEcom)(all,r,USEind:taxes(c,r)<0) taxes(c,r) = 0;

It seems there are problems with the data in TAX.har, so to construct the required tax matrices, we use tax rates from previous model by aggregating from the SIC industries/commodities in the previous model to the NAICS industries/commodities in the current dataset, and then scaling the data so that total tax revenues match those reported in the BEA Table 3.5U: Taxes on Production and Imports available from Section 3: Government Current Receipts and Expenditures at: <http://www.bea.gov/iTable/iTable.cfm?ReqID=12&step=1#reqid=12&step=1&isuri=1&1204=1998&1203=2020&1206=q&1205=2014&1210=x&1211=0>.

Code to construct tax information is in the subsequent file "MFId1_tax.tab" – line references in this section refer to this file.

In constructing the aggregation from 514 SIC industries to 399 NAICS industries and from 504 SIC commodities to 391 NAICS commodities, a number of assumptions had to be made, including:

- All of SIC industry/commodity "Meatanimals" was mapped to NAICS industry/commodity "CattRancFarm", and all of SIC industry/commodity "livestckmisc" was mapped to NAICS industry/commodity "OtherAnimal". Alternatively, a portion of SIC industry/commodity "Meatanimals" could have been mapped to NAICS industry/commodity "OtherAnimal" as well as "CattRancFarm"
- All of the SIC industries/commodities "Foodgrains" and "Feedgrains" are mapped to NAICS industry/commodity "GrainFarm" – none is mapped to NAICS industry/commodity "OthCropFarm" which is composed of SIC industries/commodities "Cotton", "Grasseeds", "Tobacco", "Sugarcrops" and "Cropsmisc"
- All of the SIC industry/commodity "Fruits" is mapped to the NAICS industry/commodity "FruitNutFarm", and the NAICS industry/commodity "VegMelonFarm" is mapped entirely from the SIC industry/commodity "Vegetables". This implies that the part of SIC industry/commodity "Fruits" accounted for by "Melon" production/consumption is mapped to NAICS industry/commodity "FruitNutFarm" instead of "VegMelonFarm". We expect "Melon" production/consumption is much smaller than "Vegetable" production/consumption
- The SIC aluminum industries/commodities "PrimAluminum", "AluminumRoll" and "AluminCast" are mapped to the NAICS industries/commodities "AlRefManuf", "RollForming" and "PurchAlProd", respectively, with the SIC industry "PrimAluminum" being disaggregated into NAICS industries "AlRefManuf" and "AlSmelt"
- The SIC industry/commodity "LubricatOils" is classified under the NAICS industry/commodity "PetrolRefine" – it could have been classified under "OthPetroCoal"

These concordance issues are also relevant when parameters in the USAGE model are updated.

We forecast the previous model out to 2010, aggregate from SIC to the required NAICS industry and commodity aggregation, calculate tax rates using the expression $TAX\#4G(\cdot) / [TAX\#G(i) + BAS\#(i)]$

for #=1,...,6, and then impose these tax rates on the current dataset to calculate the required TAX matrices.

We can confirm that the tax rates from the previous version forecasted out to 2010 are identical to those in the 2007 version before scaling: Comment out the TAXSCALE formulae over lines 286-289 and lines 303-307 and then compare headers "SHR1" – "SHR5" in file "chk15.har" with the corresponding headers "TSH1" – "THS5" in the file "Tax_Shares.har".

These tax rates are then scaled so that total tax revenue on commodities Breweries, Wineries, Distilleries, Tobacco, PetrolRefine and AirTrans exactly matches that reported in BEA Table 3.5U: Taxes on Production and Imports for 2007. The required scaling factors are:

220Breweries, Wineries, Distilleries	0.852457
223Tobacco	1.193380
241PetrolRefine	0.571815
279AirTrans	5.222989

The equation which determines the scale factor for AllOtherGoods over lines 303-307 is rearranged from the more intuitive commented equation over lines 298-301 which is interpreted as follows:

Total taxes in TAX_ALL will be equal to the sum of three terms:

- the 4 known (post-scaling) taxes on Alcohol, Tobacco, Petrol and Air Transport,
- the sum of all taxes over all other commodities COMRest multiplied by the scalar TAXSCALE,
- what is left in TAX0, which is the sum over industries of TAX04(j) less the domestic taxes in the newly-constructed TAX matrices

The equation used to determine the appropriate scale factor for AllOtherGoods is solved so that total tax revenue after scaling is \$951,209 (the sum over industries of USE("390TxProdImLSUB",j) less customs duties). This process results in a scale factor on AllOtherGoods which is negative (= -0.216844). As a result, this method for updating tax information is also inappropriate.

Instead, we proceed by following these three steps:

Step 1: in file "taxes on production and imports.xlsx", cell Q37 reports property taxes in 2007 of \$403828. We begin by creating a subset of the TAX0 vector by leaving the \$170153 in element (311Housing), and spreading the balance \$403828-170153 over all remaining industries.

If we use shares generated with 392GrossOpSurp to spread this balance of all remaining industries, then property taxes for many industries end up larger than initial output taxes in TAX0, with the result that many remaining sales taxes in TAX0 would end up being negative. Instead, we use shares generated by TAX0.

This leaves output taxes for wholesale and retail margins which are deemed to be too high, because tax shares of wholesale and retail margins are so high, so we remove a share (25%) from wholesale and retail output/property taxes and distribute them over all remaining commodities (not including housing).

Step 2: After deducting the property taxes from the initial TAX0 we are left with TAX0R. From this, leave out the taxes on Wholesale and Retail margins - these will be dealt with in Step 3. We transpose TAX0R from industry to commodity and leave out Wholesale and Retail margins. Taxes for the two industries "AlSmelt" and "SLGPassTrans" are added to the nearest commodity. These taxes are then spread over all users at a common rate for each commodity.

But in re-balancing the dataset, note that imports are at landed-duty- paid prices (ie: basic prices), so the import component of the PV matrices will not contain taxes. As a result, all taxes (on both domestic and imported goods) are deducted from the domestic component of the PV matrices only.

Note that in Step 2 above, all sales taxes were dumped into domestic tax. Now that taxes have been removed from the domestic BAS matrices, these taxes need to be split between domestic and foreign, using BAS shares.

Step 3: Finally, convert output taxes on Wholesale and Retail margins into sales taxes.

Step 5: Domestic/import disaggregation of margin matrices (p.33)

See MFId1.tab – lines 362-363

To begin, create MARG1(USEcom,USEind,MARG7) by distributing MARG0(c,r,"TransCosts") between MARGtrans (AirTrans, RailTrans, WaterTrans, TruckTrans, Pipeline) using:

$$\text{MARG1}(c,r,m) = \text{MARG0}(c,r,\text{"TransCosts"}) * [\text{USE}(m,r) / \text{TranspCost}(r)]$$

This was insufficient because a similar process needed to be followed with retail margins which did not include a number of retail margin sectors (see items 3) and 4) in "Step 0" above). Code was added in lines 365-366 to distribute MARG0(c,r,"Retail") between MARGret (AutoDealers, FoodBev, GenMerch, RetailTr).

See MFId6.tab, starting from line 83

Ultimately this was inadequate because it resulted in proportions of components of transport margins (Air, Rail, Water, Truck, Pipeline) which were unrealistic. Instead, we use the same method by which tax rates were imported from the previous database forecasted out to 2010, and read in transport margin shares from this previous database. The incorrect transport margins generated by the code at lines 362-363 in MFId1.tab are added back to the PV matrices, and the updated and corrected transport margins are then subtracted.

This method results in a few cases where domestic use of margin commodities in the BAS matrices are negative after margins are subtracted from the PV matrices. To resolve this problem, we set the maximum amount of margins which can be subtracted from the margin commodities in the PV matrices at 95% of the initial value of use of margin commodities in the PV matrices.

See MFId1.tab – lines 1476-1534

Domestic/import disaggregation of margin matrices follows equation (4.22) in Dixon and Rimmer (2002:33) by using:

$$M\#3(.,m,"dom") = M\#1(.,m)*PV\#3(.,"dom")/(PV\#1(.)+tiny);$$

$$M\#3(.,m,"imp") = M\#1(.,m) - M\#3(.,m,"dom") ;$$

with the exception of:

- Export margin matrix not disaggregated by source: $M43(i,m) = M41(i,m)$
- All government margins assigned to “dom”: $M53(i,g,m,"dom") = m51(i,g,m);$
 $M53(i,g,m,"imp") = 0$
- All inventory margins assigned to “dom”: $M63(i,m,"dom") = m61(i,m); M63(i,m,"imp") = 0$

The code over lines 1503-1530 contains many conditions which were likely included because of errors in earlier data, especially problems with the Margins matrix (ie: situations where errors led to positive margin flows being associated with zero PV flows). These conditions are now inappropriate and were replaced with the code over lines 1481-1500.

Step 6: Investment by investing industry (p.33)

See MFId1.tab – from line 1680: “Step 4 Disaggregate Investment by Industry”

Latest BEA data on Investment by Using Industry seems to be for 1997:

http://www.bea.gov/industry/capflow_data.htm. These data are updated to 2007 using BEA 2-digit Investment in Private Fixed Assets by Industry and by Commodity, resulting in INDxCOM Investment matrix.

See MFId1.tab – lines 1709-1714

The investment matrix has only a single industry “312RealEstate” and commodity “311RealEstate”, while the USE matrix has this industry/commodity divided into “310Housing” and “311OthRealEst”. Note that in the USE matrix, all of the \$1478793million of commodity 310Housing is consumed by 390PersConsExp. We assign all of industry “312RealEstate” in the investment matrix to industry “311OthRealEst”, and all of commodity “311RealEstate” in the investment matrix to commodity “311OthRealEst”.

line 1746: While for any individual commodity, the sum over all industries in the investment matrix is generally very close to the investment entry in the USE matrix, there are very large discrepancies for margin commodities. The following table lists all cases where the difference between total investment by commodity between the USE matrix and the investment matrix is greater than \$0.5million:

20 OilGasDrill	8.83	274 WholesaleTr	129088.78
21 OthMineSupp	8.59	275 AutoDealers	11097.79
29 PowComStruc	0.53	276 FoodBev	533.42
32 ComFarmStruc	0.91	277 GenMerch	2855.73
34 SFamResStruc	2.00	278 RetailTr	29005.45
36 OthResStruc	1.16	279 AirTrans	2364.90
137 HshldFridge	0.99	280 RailTrans	1684.21
139 OthHshldApp	1.00	281 WaterTrans	23.82
151 LightTruck	0.60	282 TruckTrans	20229.21
177 NonUpHhlfurn	1.01	311 OthRealEst	1.11
181 ShcaseShlv	1.04	317 CustCptrProg	1.25
		325 ResDevelSvc	1.69

At line 1779, each row (commodity) of the Investment matrix is scaled so that for each commodity, the sum over all industries in the investment matrix is equal to the corresponding investment entry in the USE matrix.

Spreading private investment by 64 sectors to 493 private sector industries

A correction was made in the previous version since the shares used to disaggregate investment across industries had been based on the “share of six-digit IO industry j in the other value added of the sector j-hat to which sector j belongs”. Since it was estimated as a residual, other value added was not sufficiently reliable so investment was redistributed using labor inputs as a basis for shares.

In the file “Input Adjustment for USAGE 2007” from Matt Barkell, the end of the Investment section reads: “We expand to 6 digit industry disaggregation using a similar “share of 2-digit” procedure, but we use the sum of V00100 (Compensation of employees), V00200 (Taxes on production and imports, less subsidies), and V00300 (Gross operating surplus) to calculate the shares.”

See MFId1.tab – lines 1810

$$\text{BAS24}(i,j,s) = \text{PV23}(i,s) * [\text{Invstmnt}(i,j) / \text{sum}(jj, \text{IND380}, \text{Invstmnt}(i,jj))]$$

Step 7: Accounting for capital creation in the public sector (p.38)

See MFId1_tax.tab – line 819

The government final demand vectors BAS54(i,s) were created in file MFId1.tab at line 1815 from the sum of the 12 government final demand vectors:

$(all,i,COM387)(all,s,src) \quad BAS54(i,s) = \text{sum}(g, \text{govt}, PV53(i,g,s));$

where the set GOVT # 12 GOVT final demand Use #
(NatDfCE, NatDfGInvStr, NatDfGInvEqp, NatDfGInvIP,
NonDfCE, NonDfGInvStr, NonDfGInvEqp, NonDfGInvIP,
SLGCE, SLGGInvStr, SLGGInvEqp, SLGGInvIP);

This is inappropriate since nine of these 12 government final demand vectors belong in the investment matrix BAS2(i,j,s), where for the following industries:

j=(381FedGovDef,
382FedGovNonDef, 384FedElecUtil, 385OthFedGEnt,
386SLG, 387SLGPassTrans, 388SLGElecUtil, 389OthSLGEnt),

BAS2(i,j,s)=0 (note that BAS2(i,"383PostalSvc",s) is populated with non-zero entries).

To resolve this problem, we follow D&R (June2002:38-40) and move input data for these 9 investment activities, including associated imports and margins, from the demand part of the database to the relevant investment part. For example, we subtract the sum of PV53(i,g,s) over $g=(\text{NatDfGInvStr}, \text{NatDfGInvEqp}, \text{NatDfGInvIP})$ from BAS5(i,s) and add it to BAS2(i,"381FedGovDef",s). We also subtract the sum of PV53(i,g,s) over

$g = (\text{NonDfGInvStr}, \text{NonDfGInvEqp}, \text{NonDfGInvIP})$ from BAS5(i,s). But these investment activities need to be distributed across the three Federal Government non-defense industries 382FedGovNonDef, 384FedElecUtil, 385OthFedGEnt, which we do using weights given by each industry's total output as a share of total Federal non-defense output. The same treatment is adopted for the three state and local government investment activities (SLGGInvStr, SLGGInvEqp, SLGGInvIP) which are distributed across the four state and local government industries 386SLG, 387SLGPassTrans, 388SLGElecUtil, and 389OthSLGEnt.

Note that this generates 4 small negatives in the 4 SLG investment industries for usage of 119AudVidEquip which was initially a negative government demand. This is resolved at line 1161 of MFId1.tab by adding the small negative (-0.201660) back to PM51("AudVidEquip", "SLGGInvEqp").

Step 8: Eliminating some unwanted negatives: dealing with Scrap (C480) and Used and 2nd hand (C481)

In the previous version, there were negative entries in the rows for “Scrap” and “Used2HndGds” in investment and household consumption which were dealt with by rebalancing these to the inventory vector.

In the current version, there were again negative entries in the rows for “Scrap” and “Used2HndGds”. There were two negative entries for “Scrap” by users “391PersConsExp” and “392NRPFixInvEqp”. Those for “Used2HndGds” are listed in the following Table:

5 GreenNursPrd	-46		
17 CopNickMine	-27	391 NRPFixInvStr	-2923
280 AirTrans	-206	392 NRPFixInvEqp	-79269
282 WaterTrans	-54	394 ResPFixInv	-3980
283 TruckTrans	-221		
314 GenrlRentl	-25	399 NatDfGInvStr	-4
357 PerfArts	-67	404 NonDfGInvEqp	-33
381 FedGovDef	-8	408 SLGGInvEqp	-3311

To eliminate negative use of commodity “Scrap” by users “390PersConsExp” and “392NRPFixInvEqp”, we follow Dixon and Rimmer (2002) by setting PV21(“386Scrap”)=0 and PV31(“386Scrap”)=0, and adding the sum of the two negative entries to PV61(“386Scrap”).

In “Step 1” above, these were dealt with using different methods:

- eliminate negative use of commodity “Used2HndGds” in 7 abcde industries by subtracting from OVA(abcde) and PV31(“387Used2HndGds”) and setting PV11(“387Used2HndGds”,abcde)=0
- eliminate negative use of commodity “Used2HndGds” in industry “381FedGovDef” by adding 8 to MAKE1(“381FedGovDef”, “387Used2HndGds”) and setting PV11(“387Used2HndGds”, “381FedGovDef”)=0
- eliminate negative investment in PV21(i) for “387Used2HndGds” by adding (2923+79269+3980) to OVA(“381FedGovDef”) and MAKE1(“381FedGovDef”, “387Used2HndGds”) and setting PV21(“387Used2HndGds”)=0.
- eliminate negative government demand in PV51(i) for “387Used2HndGds” by subtracting (4+33+3311) to PV31(“381FedGovDef”) and setting PV51(“387Used2HndGds”)=0.

This resolution is inadequate since for most of these entries, there is accompanying usage of margin commodities in the file “Margins_Before_Redefinitions_2007_Detail.xlsx” which also needs to be reallocated. We also thought it more appropriate to rebalance these negative entries to the inventory vector, consistent with the treatment in Dixon and Rimmer (2002). So for the negative entries in the table above, the entry in the corresponding PV(.) matrix was set equal to zero, and the sum of all values in the table above was added to PV61(“Used2HndGds”):

$$PV61(“Used2HndGds”) = PV61(“Used2HndGds”) - (46+27+206+54+221+25+67+8+2923+79269+3980+4+33+3311)$$

To ensure that the column sums for the industries on the left-hand-side of the table remained balanced, the values in the column on the left side of the above table were subtracted from OVA(.) in the corresponding industry.

Also, any non-zero margins associated with these transactions were rebalanced to household consumption, reasoning that the majority of these transactions ultimately involved sales of used and second-hand goods (the majority of which were likely used autos) to private households.

Finally, any non-zero imports associated with these transactions were rebalanced to inventory imports.

Appendix 2: Further work on Creating an Updated 2007 Benchmark Input-Output Database for the USAGE Model

This appendix covers:

1. The Government accounts
2. The balance of payments
3. Foreign assets and liabilities
4. Sales tax matrices
5. The splitting up of value added
6. Capital stocks and investment
7. Special industries: Vacation; Foreign vacation; Export tourism; Export education; and Other non-residential expenditure
8. The treatment of Air international and Water international

1. The Government accounts

DATA FOR GOVERNMENT ACCOUNTS

The data in the table below were derived from NIPA Tables 3.1 and 3.12. The data in row 1 were taken from Table 3.1, line 21. The data in row 2 were taken from Table 3.1, row 39, and the data in row 5 were obtained by adding entries from Table 3.12, rows 6, 13-15 and 17 and Table 3.1, row 26.

Government outlays and revenue from Tables 3.1 and 3.12

row		Year	2007	2014	Model concept
	Source	OUTLAYS			
1	1.21	Public consumption	2209.7	2556.6	AGGOTH
2	1.39	Public investment	592.2	595.8	AGGINVG
3	1.22	Transfer	1753.1	2559	TRANS
		Made up of			
4	12.7+25+28	Unemploy benefits	109.5	166.5	UNEMPBEN
5	12.6+13-15+17 plus 1.26	Age benefits	671.9	984.9	AGEBEN
6	12 rest	Other personal bens	971.7	1407.5	OTHBEN
7	1.30	Grants	54.6	57.9	GRANTS
8	1.27	Int on pub. sector debt	529.8	621.4	NETINT_G
9	1.40+41	Other capital expend	35.4	18.8	OTHCAPGOV
10	Rows 1+2+3+7+8+9	Public expenditure	5174.8	6409.4	
		RECEIPTS			NET_TAXTOTG
11		Taxes	3929.9	4655.9	NET_TAXTOTG
		Made up of			
12	1.4	Indirect taxes	1034.6	1213.7	
13		Direct taxes			
14	1.3	Labor	1493.2	1780.2	
15	1.5+6	Capital + land	436	497.9	
16	1.7	Social insurance	966.1	1164.1	
17	1.10+15+19+36	Govt rent	310.4	363.3	GOVRENT (GOS from Gov inds)
18		Other revenue	0	0	OTHGOVREV
18		Tax Correct	0	0	TAX_CORRECT
19	Rows 11+17	Total revenue	4240.3	5019.2	
20		Public sector deficit	934.5	1390.2	
21	1.42	CFC	399.4	516.8	
22	1.43	Net borrowing requirement	535.1	873.4	

Source: NIPA Table 3.1 Government consumption receipts and & Table 3.12 expenditure and Government social benefits

(<http://www.bea.gov/iTable/iTable.cfm?ReqID=9#reqid=9&step=1&isuri=1>)

2. The balance of payments

DATA FOR THE BALANCE OF PAYMENTS

Prepared by Peter Dixon and Maureen Rimmer, July 7, 2016

The data in the table below were derived from NIPA Table 4.1. All of the items are self-explanatory except for Net pay to fgn workers. This is Table 4.1, row 24 *less* row 8.

Balance of payments data for 2007 and 2014 (\$billion)

Year	2007	2008	2014	
OUTLAYS				
Imports	2383.2	2565	2871.9	
Servicing of fgn liab	734.4	667.9	574.8	
Made up of				
interest	577.3	492.6	302.8	
dividends	157.1	175.3	272.0	
Net pay to fgn workers	10.5	11.7	9.4	FGNWORK
Transfers to fgners	201.2	232	279.4	TRNOTHFGN
Total outlays				
RECEIPTS				
Exports	1664.6	1841.9	2341.9	
Income receipts	870.4	851.6	847.4	
Made up of				
iInterest	360.0	269.6	157.1	
dividends	510.4	582	690.1	
Transfers from fgn to hhlds	55.0	64.7	101.2	TRNFGNHH
Taxes paid by fgners to US	21.1	26.9	44.0	TAXFGNGOV
Current account deficit	718.1	691.5	401.1	

Source: NIPA Table 4.1 Foreign Transactions in the National Income and Product Accounts

(<http://www.bea.gov/iTable/iTable.cfm?ReqID=9&step=1#reqid=9&step=3&isuri=1&903=128>)

3. Foreign assets and liabilities

DATA FOR FOREIGN ASSETS AND LIABILITIES

Prepared by Peter Dixon and Maureen Rimmer, July 7, 2016, expanded August 18, 2016

The data in the table below were derived from NIPA IIP Table 1.2.

Net international investment position (\$billion)

	Year	2007	2008	2014	
Source, rows in NIPA IIP Table 1.2					
1	Net foreign liab	1808.5	1279.493	5372.6	NETFLT
35	U.S. Fgn liab	18218.3	21983.996	29517.4	FL_T
0.001*56	Fgn debt in fgn curr	4.4	5.034923	5.2	FDFC
40+43+50+0.999*56	Fgn debt in dom curr	12526.5	15649.797	19204.4	FDDC
39+42	Fgn equity in US	5687.4	6329.164	10307.8	FE_A
4	U.S. fgn assets	16409.9	20704.503	24144.8	FA_T
12+22+27	Fgn credit in fgn curr	3814.1	4549.016	5023.9	FCFC
9+15+23+25+(26-27)	Fgn credit in dom curr	3972.5	5816.53	6593.8	FCDC
8+11	US equity in fgn	8623.3	10338.958	12527.1	AE_F

Source: IIP Table 1.2 in International Investment Position

<http://www.bea.gov/iTable/iTable.cfm?ReqID=62&step=1#reqid=62&step=6&isuri=1&6221=0&6220=3,4,5,6,7,8,9,10,11,12,13,14&6210=5&6200=144&6224=&6223=&6222=0&6230=1>

In combination with the balance of payment table we can calculate implied interest rates.

Implied interest rates

	2007	2014	
Fgn debt	0.046	0.016	Rate of interest on debt liabilities
Fgn equity in US	0.028	0.026	Rate of interest on equity liabilities
Fgn credit	0.046	0.014	Rate of interest on debt assets
US equity in fgn	0.059	0.055	Rate of interest on equity assets

In moving from 2007 to 2014 we enforce the numbers shown in these tables. This produces a sizable residual in our equation that defines movements in net foreign liabilities over the long run. Using data from NIPA table IIP 1.3, we will be able to resolve this problem in future research. The table gives relevant data on revaluation effects. A summary of these effects is shown below. We will also need to work out the relationship between the accumulated

current account deficit for the years 2007 to 2013 and what is implied by our smooth growth assumptions for capital and saving. In particular, we should check out whether our simulated growth in capital stock over the period is in line with accumulated investment over the period.

	beginning position, 20	Change in position in 2007						
end of		Total	Official-account transac	Attributable to:				end of
				Other changes in position				
				Total	Price changes	Exchange-rate changes	Volume and valuation	
	-1808474	528981	-617251	1146232	/4/	/4/	/4/	
2006	-1868310	517345	-611029	1128374	316030	641094	171250	-1350965
2007	-1350965	-2803973	-763519	-2040455	-1831554	-698693	489792	-4154938
2008	-4154938	1400976	-186146	1587122	885413	406322	295387	-2753962
2009	-2753961	131791	-422896	554686	71838	-14202	497050	-2622170
2010	-2622170	-1918866	-480753	-1438113	-1277771	-19100	-141242	-4541036
2011	-4541036	-35039	-447605	412566	445003	27441	-59878	-4576075
2012	-4576076	-874136	-393208	-480928	-128919	-242596	-109412	-5450212
2013	-5450211	-1681444	-233031	-1448413	-463611	-1153575	168773	-7131655
2014	-7131655							
		2581902	3305156		1519960	100266	1142947	276747

4. Sales tax matrices

CREATING SALES TAX MATRICES

Prepared by Peter Dixon and Maureen Rimmer, July 12, 2016

The BEA benchmark input-output table for 2007 shows indirect tax collection as a row (id V00200) in the industry section of the USE matrix.

For USAGE we create sales tax matrices that show collection of taxes associated with the flow of good (c,s), that is commodity c from source s to each user u.

This work started from a situation in which we had already disaggregated the direct flows in the BEA tables into direct flows of imports valued at landed duty paid (no sales taxes) and direct flows of domestic goods valued at basic plus sales taxes on both the domestic flow and the imported flow.

In theory, the j th component of a tax row in a producer value table, such as that published by the BEA, shows taxes on the sales of the commodity produced by industry j (say commodity j) *plus* taxes on production in industry j *plus* sales taxes (not tariffs) on imports of j . In practice, there are exceptions to this. One exception in the BEA tables is that import duties appear in the Wholesale component of the tax row. We have removed these import duties, about \$28 billion, and recorded them in a tariff vector. To rebalance the table, we remove \$28b from the Wholesale diagonal element in the MAKE matrix. We also remove the positive import entry in the Wholesale sales row of the negative import column.

At this stage, the wholesale entry in the tax row is \$146b. We also note that the retail entry (summed over four retail industries) is \$184b. We know that a considerable proportion of these entries refer to taxes collected by the Wholesale and Retail industries on their sales of Alcohol, Tobacco and Motor fuels. By consulting the BEA's NIPA Table 3.5, we find the following data.

Table 1. Sales tax collections in 2007

	2007
GasDiesel	69.200
Alcohol	13.800
Tobacco	24.300
Total	107,300

We assume that these taxes are embedded in the BEA's input-output table in the Wholesale and Retail entries of the tax row, and also form part of the Wholesale and Retail margins associated with the sales of these products. We move the tax collections shown in Table 1 out of Wholesale and Retail into the tax cells for Breweries, Wineries, Distilleries, Tobacco and Refined petroleum products. We moved \$47.5b ($=107.3 \times 146 / (146+184)$) out of Wholesale and \$59.8b out of Retail. In splitting the \$69.2b for Alcohol across Breweries, Wineries and Distilleries we used their shares in the total use of Wholesale and Retail margins in their delivery to all users.

To rebalance the table we undertook the following steps. (1) scaled down Wholesale and Retail margin flows on deliveries of Breweries, Wineries, Distilleries, Tobacco and Refined petroleum products and made corresponding increases in the direct domestic flows of Breweries, Wineries, Distilleries, Tobacco and Refined petroleum products. (2) scaled down the diagonal MAKE entries for Wholesale and Retail and increased the diagonal MAKE entries for Breweries, Wineries, Distilleries, Tobacco and Refined petroleum products.

Next, we allocated the data from the tax row to the tax matrices by assuming that the same tax rate applies to all sales of domestic and imported good j . There were some exceptions. We did not move negative entries from the tax vector. Thus, for example we left the large negative entry for Passenger rail as a production subsidy. We also left the remaining Wholesale and Retail entries in place. This is not entirely satisfactory. It means that there are about \$223b ($= 146+184 -107$) or about 23% of total indirect collection that are treated as if they are production taxes on Wholesale and Retail. In effect we are assuming that all users of all goods pay a small tax in proportion to the Wholesale and Retail services required to deliver their purchases to them.

In making the sales tax matrices we recalled that sales taxes on domestic and imported flows are all embedded with the domestic flows. Consequently, having worked out the tax rate that should apply to the combined domestic plus import flow, we subtracted the implied tax collection just from the domestic flow. [This procedure assumes that all of the taxes that we are now moving out of the tax row are embedded in direct flows, unlike the earlier procedure for Wholesale and Retail where we assumed that the taxes we were moving were embedded in margin flows.] This led to problems (negative domestic flows) when the domestic flow was an atypically small fraction of the combined domestic-import flow. Initially we tackled this problem by adding small amounts to domestic flows where required and rebalancing via inventories and labor input. This approach didn't prove adequate in the case of Air transport. We suspect that there must be some sales taxes on Air transport embedded in the margin flows whereas our procedure assumes that the sales taxes are all in the direct flows of Air transport. To solve the problem we moved only 43% of the Air transport taxes into the sales tax matrices. This corresponds to the direct use share in the sales of Air transport.

5. Splitting up value added

SPLITTING UP VALUE ADDED *July 15, 2016*

The BEA tables show value added for each industry split into 3 parts:

Compensation to employees

Other value added

Taxes

We have already dealt with taxes. In USAGE we want measures for each industry of returns to labor, returns to capital and returns to “land” for agriculture and oil and gas exploration.

We could interpret compensation to employees as returns to labor and other value added as returns to capital and land. The main problems with this are: (1) self-employment, particularly in agriculture; (2) the distinction between land and capital, again a problem particularly for agriculture; and (3) atypical profits and losses in the database year.

In work undertaken for the Department of Agriculture we estimated returns to land in 16 agricultural industries for 2014. These 16 industries map in a straight forward manner to the 10 agricultural industries in the BEA input-output table. Total returns to land in 2014 were 10 per cent of value added in agriculture. Having made the mapping from 16 to 10, we assumed that the 2014 distribution of returns to land across the 10 agricultural industries applies in 2007 and that total returns to land in agriculture represent 10 per cent of agricultural value added. With the returns to agricultural land settled for 2007, we distributed the remaining value added (excludes taxes) in agricultural industries between labor and capital in the shares suggested by our work for the Department of Agriculture. These shares reflect allowances that we made for the Department of Agriculture for self-employment.

For Oil and gas we assumed that the share of land in primary factors is the same in 2007 (38 per cent) as we used for 2014 in our energy baseline study for the ITC. We split the remaining value added in Oil and gas (excluding taxes) between capital and labor in the same way that they were split in our energy baseline.

For all other industries, at this stage we have simply accepted the BEA’s split between compensation to employees and Other value added as representing returns to labor and capital. In simulations we often need to interpret returns to capital as normal returns to physical capital. Consequently, further adjustments will be required.

6. Capital stocks and value added

CAPITAL STOCKS AND INVESTMENT

We inspected the available data. It appears that the BEA is no longer publishing estimates of capital stock and investment on an activity basis at a detailed industry level. They are focusing on either capital and investment by the commodities (e.g. different types of equipment) that make up capital and investment or by the industries that own the capital (as distinct from those that use it). For us, the ownership basis is unsatisfactory. For example, given the size of value added in construction, \$707b in 2007, we know that the industry must be using capital worth about \$600b. This estimate is based on our data for 2014 used in the energy baseline project. The BEA data for 2007 show construction investment at \$46.9b (on an ownership basis) If we used this figure and combined it with a realistic depreciation rate of 12.2% in construction, we would reach the conclusion that capital in the construction industry declined in 2007 by about 4% [$=100*(46.9/600 - 0.122)$]. While this rate of decline

is possible for a single year we notice that the level of construction investment in the BEA data was sustained around the \$40b level for about 5 years up to 2008, which would imply an unrealistic loss of capital stock.

For 2007 we have realistic estimates of investment and capital stock on a use basis at the 70-order sectoral level derived from our earlier detailed work on USAGE simulations for the period 1998-2010. See Appendix of “A new Baseline for USAGE2 incorporating forecasts from the Energy Information Administration”, by Dixon and Rimmer, April 28, 2015.

We proceed as follows.

- (1) To estimate capital stocks we applied the formulas

$$K^{(1)}(j, 2007) = \left[\frac{K^{(0)}(\text{sec}(j), 2007)}{VA^{(0)}(\text{sec}(j), 2007)} \right] * VA(j, 2007)$$

$$K^{(2)}(j, 2007) = \left[\frac{K^{(1)}(j, 2007)}{\sum_{jj} K^{(1)}(jj, 2007)} \right] * KNRBEA(2007)$$

for all j not in Realestate = SEC(Housing)

In these equations $K^{(0)}(\text{sec}(j), 2007)$ and $VA^{(0)}(\text{sec}(j), 2007)$ are the 70-order sectoral capital and value added estimates from our work of April 28, 2015. $VA(j, 2007)$ is the value added for industry j (excludes taxes) in the 2007 Benchmark input-output table.

$KNRBEA(2007)$ is the total value of start-of-year 2007 non-residential capital stock from NIPA Fixed Asset Table 1.1, \$25969b.

- (2) The two industries that get mapped to Real estate are Housing and Other real estate. For Housing we are prepared to use the BEA numbers for capital stock and investment (\$16,538b, NIPA Fixed Asset Table 1.1; and \$696b NIPA Fixed Asset Table 1.5). For Other real estate, we assume that the industry has the average capital/output ratio over all service industries. We assume that $D(j) = D(\text{sec}(j))$ for all j except $j \in \text{Sec}(\text{Housing})$. For $j = \text{House}$ we use $D(\text{sec}(\text{House}))$. For $j = \text{Other real estate}$ we use an average depreciation rate across service industries. $D(\text{sec}(j))$ is taken from the April 28, 2015 work. For government industries we use the investment numbers given in the 2007 benchmark input-output table.

- (3) To estimate the investment by commodity and industry matrix, we start by forming a preliminary version by computing the purchasers' value matrix from the matrix developed by Robert Waschik using the ownership basis data in BEA Table Detailresidential_inv.xls and detailnonres_invs.xls at <http://www.bea.gov/national/FA2004/Details/Index.htm>. We believe the row totals of this matrix. We make new column totals according to:

$$\frac{I(j)}{K(j)} - D(j) - SH2NDH(j) = G, j \notin \text{Housing \& Gov}$$

$$\sum_{j \notin \text{Housing, Gov}} I(j) = I_{\text{NonHousNonGov}}(2007) = 2002b$$

In these equations, $D(j)$ is the depreciation rate for industry j (derived in an obvious way from the sectoral depreciation rates used at the 70-order level). $SH2NDH(j)$ is the share of j 's capital stock that is sold as secondhand each year (significant only for Auto rental). The \$2002b is total investment of \$3292b (slightly inconsistent with NIPA Fixed Asset Table 1.1.5 which shows \$3192b) less \$696b for housing and \$594b for government (both these latter numbers are consistent with Table 1.1.5).

7. Special industries

SPECIAL INDUSTRIES

We include in USAGE 5 special industries: Vacation, FgnVac, ExpTour, ExpEdu and OtherNonRes (expenditure in the U.S. by diplomats etc). Each of these is a mixing industry (it purchases a bundle of goods and services but has no primary factors).

We estimate the size of these industries (column total for their inputs) by discounting from our estimates for 2014. For the three vacation industries we draw on expenditure data in Benjamin J. Hobbs "U.S. Travel and Tourism Satellite Accounts for 1998-2014", *Survey of Current Business*, June 2015, pp. 1-16, available at https://www.bea.gov/scb/pdf/2015/06%20June/0615_travel_and_tourism_satellite_account.pdf. This source indicates that expenditure by domestic travelers in the U.S. was approximately the same in 2014 and 2007 (2.50 per cent extrapolated Table D). For export tourism Table D shows an increase of 56 per cent between 2007 and 2014. For Foreign vacation Table E shows an increase of 18.8 per cent between 2007 and 2014.

In forming the inputs for the Vacation and FgnVac industries, expenditures are relocated from Private consumption. The output of Vacation is sold entirely to households. Foreign vacation is entirely exported with a matching import of Vacation. In forming the inputs for the Export tourism industry expenditures would normally be expected to be relocated from exports. However, in processing the input-output tables no account has yet been taken of "Rest of world adjustment to final use". This item contributes -\$125b to private consumption and an approximately offsetting positive number in exports. The reason for the adjustment is to remove the total amount of foreigner expenditure in the U.S. that is currently embedded in private consumption.

Using data from Table 2.1 international accounts in NIPA (a zip of the *Tourism Satellite Accounts 1998-2014* available at http://www.bea.gov/industry/tourism_data.htm) and using Hobbs above together with Table 14.1 from our documentation of the building of the 1992 input-output table, we generated Tables 1 and 2 below.

The data sources provide an estimate of foreign provided international air services supplied to U.S. residents. We assumed that 60 per cent of this is tourism expenditures and assign the resulting numbers (\$14132mi in 2007) to row 2, column 2 in Tables 1 and 2. The data also provide estimates of personal consumption expenditure by U.S. residents on international passenger air transport services (row 3, column 2). This allows us to immediately deduce

row 1, column 2. We obtain row 1, column 3 by assuming that 0.6 of exports of international passenger air transport services refers to flying foreign tourists into and out of the U.S. We deduce row 2, column 3 by assuming the same ratio of foreign to U.S. provided air transport services for export tourism as in earlier data. The entry in row 3, column 3 is a total. For row 4 we have a total (“private consumption expenditure” on domestic air passenger services) for each year from the data. We split this total between columns 1 and 3 of row 4 in the ratio apparent in earlier data. Row 7, columns 1 & 2 and row 9, column 3 are data. Thus we can deduce row 5, column 1 and row 6, column 2, and row 5 column 3. This gives us row 7, column 3.

Table 1. Tourism industries in USAGE-ITC, 2007 (purchasers’ values, \$ million)

		<i>I507 Holiday</i>	<i>I508 FgnHoliday</i>	<i>I509 ExpTourism</i>
1	International air fares – US-provided		13088	15112.2
2	International airfares – foreign-provided		14131.8	23798
3	Total (rows 1 & 2):		27220	38910
4	Domestic airfares – US provided	37113		10034
5	Other purchases in US	668804		67688
6	Other purchases in foreign countries		104068	
7	Total output (rows 1, 2, 4, 5 & 6):	705917	131288	116633
8	Tourism expenditure of US households	837205		
9	Tourism expenditure in US by nonresident households (rows 1, 4, & 5)			92835

Table 2. Tourism industries in USAGE-ITC, 2014 (purchasers’ values, \$ million)

		<i>I507 Holiday</i>	<i>I508 FgnHoliday</i>	<i>I509 ExpTourism</i>
1	International air fares – US-provided		7686	29011
2	International airfares – foreign-provided		34890	45685
3	Total (rows 1 & 2):		42576	74695
4	Domestic airfares – US provided	77576		20974
5	Other purchases in US	645989		95015
6	Other purchases in foreign countries		113424	
7	Total output (rows 1, 2, 4, 5 & 6):	723565	156000	190685
8	Tourism expenditure of US households	879565		
9	Tourism expenditure in US by nonresident households (rows 1, 4, & 5)			145000

EXPORT EDUCATION

The number of foreign students in the U.S. is available at <http://www.iie.org/Services/Project-Atlas/United-States/International-Students-In-US#.V46LnEZf2Uk> . There were 582 thousand in 2007 and 886 thousand in 2014.

Total spending by these students on Education Services is available from BEA NIP International trade Table 3.1 available at <http://www.bea.gov/iTable/iTable.cfm?ReqID=62&step=1#reqid=62&step=6&isuri=1&6210=1&6200=51>. This spending was \$15,956m in 2007 and \$30,966m in 2014.

These figures suggest per foreign student spending on Education services of \$27,415 in 2007 and \$31,950 in 2014.

Within these costs, tuition fees and board average \$15,483 per student in 2007 and \$21,003 in 2014 (see National Center for Educational Statistics fact sheet available at <http://nces.ed.gov/fastfacts/display.asp?id=76>).

We assume that students on average make one international return flight per years costing \$2,500 in 2007 and \$2,700 in 2014. This gives total international air travel expenditure of \$1455m in 2007 and \$2,392m in 2014. We assume these air fares are split evenly between international and U.S. airlines.

Expenditure of foreign students in the U.S. (\$m)

		2007	2014
1	Spending excluding air travel	15,956	\$30,966
	<i>made up of</i>		
2	Tuition and board	9,001	18,688
3	General spending	6,955	12,278
4	Air travel	1,455	2,392
	<i>made up of</i>		
5	U.S. provided air transport	727.5	1,196
6	Foreign provided air transport	727.5	1,196
7	Total spending	17,411	33,358

OTHER NON RES

Expenditure for OthNonRes in 2007 is worked out as follows.

Rest of world adjustment is shown in the 2007 input-output table as \$125b. We assume that \$77,722m (= 67688 general and 10034 dom air fares) of this is accounted for by Export tourism and \$17,411m (9001 Educ serv, 727.5 dom AirTrans, 727.5 imp of AirTrans, 6955 general) is accounted for by Export education. These numbers are total expenditure on Export tourism less all international air fares and total expenditure on export education. This leaves \$29,867m (= 125000-95133) as total expenditure on OthNonRes.

For 2014, Rest of world adjustment is shown in the 2014 input-output table as \$229.028b. We assume that \$121.246b (=\$77,722m*1.56, Export tourism grows by 1.56 per cent) of this is accounted for by Export tourism and \$33.358b (=\$17,411m*1.9159, Export education grows by 91.95 per cent) is accounted for by Export education. These numbers are total expenditure on Export tourism less all international air fares and total expenditure on export education. This leaves \$74.424b (= 229.028-154.604) as total expenditure on OthNonRes. Thus we assume that OthNonRes grows by 149% between 2007 and 2014

8. The treatment of Air international and Water international

GROWTH IN AIR INTERNATIONAL AND WATER INTERNATIONAL BETWEEN 2007 AND 2014

For Air international we assume that the share of AirInt in FgnHol, ExpTour, ExpEdu and OthNonRes is maintained from 2007 to 2014. Thus for these 4 industries the growth in use of AirInt from 2007 to 2014 was 40.26% (see output shocks sheet of C:\runmon\USAGE2007\data\2007\ITC090816.xlsx). For these industries the use of AirInt in 2007 was \$28980.5m, growing to \$40649.06m in 2014. Total output of AirInt in 2007 was \$49543, leaving sales to users other than industries FgnHol, ExpTour, ExpEdu and OthNonRes as \$20562.5m. We assume that this use of AirInt grows with nominal GDP (18.8% between 2007 and 2014) to \$28,428m in 2014. Thus total growth between 2007 and 2014 of sales of AirInt is 31.35% ($=100 * \{ (40649.06 + 28428) / 49543 - 1 \}$).

Robert Waschik's output data shows combined AirTrans and AirInt growing by 20.917%. The Share of AirInt in 2007 was 0.2785%. So the growth of AirTrans is: 16.89% (see output shocks sheet of C:\runmon\USAGE2007\data\2007\ITC090816.xlsx).

We let WatInt grow at the same rate as merchandise trade: 17.0298 % (see output shocks sheet of C:\runmon\USAGE2007\data\2007\ITC090816.xlsx).

Air International

We need to split AirTrans into AirTrans and AirInt. A reasonable estimate for the output of AirInt is \$55b made up of: \$29b of sales to FgnVac, ExpTour, ExpEdu and OthNonRes (already worked out); \$5.5b of international travel by U.S. business people on U.S airlines (worked out from the imports of air transport by non-special industries by assuming that 50% of international business travel is U.S. provided); \$10.5b of U.S. provided port services to foreign airlines; and \$11b in U.S. provide international freight services. These last two

numbers can be found in Table 2.1 in *U.S. Trade in service by type of service*. An estimate quite close to \$55b can also be derived by assuming that all U.S. exports of Air transport (\$15b, Table 2.1) are an output of AirInt and adding to this business and tourist use by U.S. residents of international air services, about \$18b.

Total output of Air transport is \$150b. With output of AirInt at \$55b we see that output of AirTrans is \$95b.

The sales pattern of AirInt is clear from the above except for port services and freight. We treat these as \$21.5b of sales to export. The problem is that after allowing for the exports of AirInt that go via the tourism industries, we don't have enough exports of Air Transport to accommodate \$21.5b of export sales. The not very satisfactory solution that we implemented was to inflate imports of AirInt by \$21.5b and inflate intermediate use of imported AirInt by the AirInt industry by \$21.5b. This solution leads to total import and export numbers for AirTrans that are broadly consistent with Table 2.1. It also gives us freedom to model exports of AirInt in a way that is consistent with them being freight and port charges. On the other hand, we have the unsatisfactory implication that expansion of AirInt leads to a strong expansion of imported AirInt. This needs to be fixed in future research, possibly by creating separate activities for freight and port charges. We suspect that the input-output tables understate the true value of both imports and exports of AirInt.

For Water transport we assume that all imports of water transport are imports of WaterInt and all exports of water transport are exports of WaterInt. We make the appropriate split of the costs and output of WaterTrans into WaterTrans and WaterInt.