The US economy from 1992 to 1998: results from a detailed CGE model

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November 3, 2003

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Abstract

USAGE is a 500 industry/commodity dynamic computable general equilibrium model of the US. In common with the MONASH model of Australia, USAGE is designed for historical studies and for forecasting and policy analysis. This paper reports an historical study. Such studies are used: to update input-output tables; to make detailed estimates of changes in consumer preferences and industry technologies; to provide a basis a basis for technology/preference scenarios in forecasting; and to explain structural developments in the economy. Here we describe US preference and technology changes for 1992 to 1998 and explain rapid growth in US trade for this period.

Key words: technological change, preference change, trade growth, dynamic CGE modelling, US structural change

JEL classification numbers: C68, D68, F14

1. Introduction

USAGE is a 500 industry, dynamic, computable general equilibrium (CGE) model of the US developed by the Centre of Policy Studies (CoPS) in collaboration with the US International Trade Commission (ITC). As with Australia's MONASH model (Dixon and Rimmer, 2002), USAGE can be used for historical studies, forecasting and policy analysis. Here we present an historical study. We apply USAGE to estimate changes in US industry technologies and household preferences for 1992 – 1998. We then use these estimates, together with information on other naturally exogenous variables, to explain the rapid growth between 1992 and 1998 in US trade relative to GDP.

Section 2 describes the historical closure usesd in estimating changes in technologies and preferences and the decomposition closure used in explaining structural developments including growth in trade. Sections 3 and 4 describe our historical and decomposition results. Concluding remarks are in section 5.

2. Historical and decomposition closures of USAGE

In describing historical and decomposition closures, we start by representing USAGE for any year as

$$F(X) = 0 \tag{2.1}$$

where F is an m-vector of differentiable functions of n variables X, and n>m. X includes prices and quantities for a given year and the m equations impose the usual CGE conditions such as: demands equal supplies; demands and supplies reflect optimising behaviour; prices equal unit costs; and end-of-year capital stocks equal depreciated opening capital stocks plus investment.

In applying USAGE we have available a solution ($X_{initial}$) of (2.1) derived mainly from input-output data for a particular year. In simulations, we compute the movements in m variables (endogenous) away from their values in the initial solution caused by movements in the remaining n – m variables (exogenous) away from their values in the initial solution. In the simulations considered here, the initial solution is for 1992 and the movements in the exogenous variables are changes over the six years to 1998. Thus, the movements in the endogenous variables refer to the six-year period 1992 - 1998.

USAGE allows many closure choices, that is choices of the n - m variables to be treated exogenously. In a decomposition closure we set as exogenous all variables not normally explained in a CGE model. These may be observables such as tax rates or unobservables such as technology and preference variables. In an historical closure the main criterion for exogeneity is observability. We exogenise a wide array of macro and industry variables for which movements can be readily obtained from statistical sources .

With reference to the two closures we can partition USAGE variables into four categories: (I) exogenous in both ; (II) endogenous in both; (III) exogenous in historical and endogenous in decomposition; and (IV) exogenous in decomposition and endogenous in historical.

As indicated in Table 1, variables in category (I) include population size, foreign currency prices of imports and policy variables. Their values are observable and not normally explained in CGE models.

Examples of category (II) variables are demands for intermediate inputs and demands for margins services (e.g. transport) to facilitate commodity flows from producers to users. In the absence of end-of-period input-output tables, movements in these variables are not observable but are explained in CGE models.

Category (III) variables include, at the industry/commodity level, outputs, employment, capital, investment, exports, imports, private consumption and numerous price deflators. Also included in (III) are numerous macro variables e.g., the exchange rate and the average wage rate. CGE models normally explain the effects on these variables of policy changes and technology or other changes in the economic environment. At the same time, their values are observable.

Category (IV) contains the same number of variables as category (III) with each variable in (III) having a corresponding variable in (IV). These corresponding variables are predominantly unobservable technological and preference variables. Such variables are not normally explained by

CGE models and are therefore exogenous in the decomposition closure. However in the historical closure they are endogenous, giving USAGE enough flexibility to explain the observed movements in the category (III) variables. Table 1 shows examples of corresponding pairs from (IV) and (III). As indicated, in our historical simulation we use shifts in household preferences [a3com(i)] to accommodate observations on consumption by commodity, twists in import-domestic preferences [ftwist(i)] to accommodate observations on import volumes, etc.

Having allocated the USAGE variables to the four categories, we can compute historical and decomposition solutions, starting with the historical solution of the form:

$$X(\overline{H}) = G^{H}(X(H)) \tag{2.2}$$

where $X(H)$ and $X(\overline{H})$ are the exogenous and endogenous variables in the historical closure and G^{H} is the solution function. By observing X(H) for two years, s and t, we can use (2.2) to estimate percentage changes between s and t, $x_{st}(\overline{H})$, in the variables in $X(\overline{H})$. Thus we combine disaggregated information [movements in the X(H)variables] with a CGE model to estimate movements in a wide variety of technological and preference variables [category (IV)], together with movements in more standard endogenous variables [category (II)].

Next we move to the decomposition closure which gives a solution of the form

$$X(\overline{D}) = G^{D}(X(D)) \quad . \tag{2.3}$$

where $X(D)$ and $X(\overline{D})$ are the exogenous and endogenous variables in the decomposition closure. Following the method pioneered by Johansen (1960), we express (2.3) in percentage change form as

$$x(\overline{D}) = B\, x(D) \tag{2.4}$$

where $x(\overline{D})$ and x(D) are vectors of percentage changes in the variables in $X(\overline{D})$ and $X(D)$, and B is an m by (n-m) matrix in which the ij-th element is the elasticity of the i-th component of $X(\overline{D})$ with respect to the j-th component of X(D), that is

$$B_{ij} = \frac{\partial\ G_i^D(X(D))}{\partial\ X_j(D)} \frac{X_j(D)}{X_i(\overline{D})} \quad . \tag{2.5}$$

With the completion of the historical simulation, the percentage changes in all variables are known. In particular the vector x(D) is known. Thus we can use (2.4) to compute values for $x(\overline{D})$ for s to t.

We work with (2.4) rather than (2.3) because (2.4) gives a decomposition of the percentage changes in the variables in $X(\overline{D})$ over s to t into the parts attributable to movements in the variables in X(D). This is a legitimate decomposition to the extent that the variables in X(D) are genuinely exogenous, that is, vary independently of each other. In setting up the decomposition closure, the exogenous variables are chosen with this property in mind. Thus, in X(D) we find policy variables, technology and preference variables and international variables all of which can be considered as independently determined and all of which can be thought of as making their own contributions to movements in endogenous variables such as incomes, consumption, exports, etc. Via (2.4), we can compute the contribution of the movement in the jth exogenous variable to the percentage movement in the ith endogenous variable as

$$cont_{ij} = B_{ij} * x_j(D) \quad . \tag{2.6}$$

Because (2.3) is a non-linear system, the effect on endogenous variable i over the period s to t of movements in exogenous variable j cannot be computed unambiguously. The effects of movements in an exogenous variable depend on the values of other exogenous variables. In terms of (2.6), the problem is to decide at which values of the exogenous variables to evaluate B_{ij}. In the decomposition analysis in section 3 we use a procedure (Harrison *et al.*, 2000) which in effect evaluates B_{ij} as the average of the values generated as we move the exogenous variables in the decomposition simulation in small steps along a straight line from their values in s to their values in t.

Table 1. Categories of Variables in the Historical and Decomposition Closures

	(I) Exogenous in both historical and decomposition	
	Population	
	C.i.f. import prices in foreign currency	
	Policy variables, e.g. tariff rates	
	(II) Endogenous in both historical and decomposition	
	Demands for intermediate inputs and margin services	
	(III) Exo in historical & Endo in decomposition	**(IV) Exo in decomposition & Endo in historical**
1	Real private consumption by commodity	Shifts in household preferences, a3com(i)
2	Real imports by commodity	Domestic/import twist shift, ftwist(i)
3	Real exports by commodity	Shifts in foreign demand curves, fep(i)
4	Employment by industry and capital inputs by industry	Primary-factor-saving technical change, a1prim(j), and capital/labour bias in technical change, twistlk(j)
5	Output by commodity	Commodity-using technical change in production and capital creation, ac(i)
6	Real private and public investment	Investment/capital ratios, ikratio(j)

3. Historical simulation for 1992 to 1998

Detailed results from our historical simulation are in Dixon and Rimmer (2003). These include values for 1992 to 1998 at the 500 industry/commodity level for:

a3com(i), the percentage movement in a preference variable accounting for the difference between the actual percentage change in consumption of commodity i and the percentage change explained by movements in income, population and prices;

fep(i), the percentage vertical movement in the foreign demand curve for exports of i;

ftwist(i), the percentage movement in an import-domestic preference-twist variable accounting for the difference between the actual percentage change in the import/domestic ratio of sales of i in the

US and the percentage change explained by movements in purchasers' prices of the imported and domestic varieties;

a1prim(j), the percentage movement in a primary-factor-saving variable accounting for the difference between the actual percentage change in primary factor input to industry j and the percentage change explained by the movement in j's output;

twistlk(j), the percentage movement in a capital-labour technology-twist variable accounting for the difference between the actual percentage change in the capital/labour ratio in industry j and the percentage change explained by the movements in the unit costs to j of using capital and labour;

ac(i), the percentage movement in an input-using variable accounting for the difference between the actual percentage change in the sales of commodity i to US industries and the percentage change explained by movements in the production and capital-creating activities of industries that use i; and

ikratio(j), the percentage movement in the ratio of investment to capital in industry j.

Our results for a3com(i) showed increasing interest between 1992 and 1998 by US households in health and lifestyle issues. There were strong shifts in household preferences against Cigarettes, Malt beverages, Wine and spirits, and Distilled liquors. Lifestyle items such as Boatbuilding, Luggage, Travel trailer, Sporting clubs and Cable TV all had positive preference shifts. Fashion changes left Bowling centres and Newspapers with negative preference shifts.

For most commodities, fep(i) was positive for 1992 to 1998. The major exceptions were computer commodities, showing sharp downward movements in foreign demand curves. With world prices of computers plummeting, the historical simulation shows that if US export prices had been held constant, then US computer exports would have been severely reduced.

Import-domestic twists [ftwist(i)] were in favour of the imported variety for some commodities and the domestic variety for others. For footwear commodities there were large twists towards imports and for computer commodities there were large twists against imports. Overall there was a small twist in favor of imports.

The results for twistlk(j) show an overall small twist in technology in favour of labour, against capital. The results for a1prim(j) and ac(i) imply technological progress (reductions in overall inputs per unit of output) in the production of 410 out of the 503 USAGE commodities. For 232 commodities, technical progress was more than 5 per cent and for 8 commodities it exceeded 20 per cent. Five commodities with very rapid technical progress (>20 per cent) were in the computer equipment area. Reflecting the introduction of computer-assisted transfers of financial securities, security brokers also showed very rapid technical progress.

For 93 commodities, the historical results indicated technical regress. In some cases, e.g. Bowling centres, this may reflect sluggish adjustment, especially of capital. Between 1992 and 1998 output and employment in Bowling centres declined but its capital stock was almost constant. In other cases, e.g. Child day care and State and local government health, technological regress may have resulted from increasing complexity of service provision (e.g. legal requirements and proliferating variety) leading to increases in labour and capital requirements per unit of service provided.

The outstanding winners from input-using technical change [ac(i)] between 1992 and 1998 were the computer equipment products and computer services. Various types of business services where also strongly stimulated by commodity-using technical change e.g. Personnel supply, Job training, Management services and Other business services.

Losers from input-using technical change included Glass, Sawmill products and Brick and clay tiles while the winners included Concrete products and Ready-mix concrete. It appears that between 1992 and 1998, US building methods became more basic rather than artistic.

Another loser from input-saving technical change was Water transport. This may reflect two factors: improvements in container packing procedures and miniaturization of products such as computers. Both these factors have the effect of reducing water transport services per unit of freight.

Between 1992 and 1998, investment in most industries grew rapidly relative to their capital stock. Consequently, for most industries our historical simulation generated a strongly positive value for ikratio(j).

4. Decomposition simulation for 1992 to 1998

Having completed the historical simulation, we now adopt the decomposition closure in which technology and taste variables [e.g. a3com(i), ftwist(i), a1prim(j), twistlk(j), and ac(i)] are exogenous. By setting these variables at their values estimated from the historical simulation, we obtain results in the decomposition simulation for output, employment and other endogenous variables identical to those in the historical simulation. However, with technology and tastes exogenous in the decomposition simulation we can answer questions about the effects of changes in these variables. More generally, we can decompose history into the parts attributable to changes in variables such as those identified in the column headings of Tables 2.

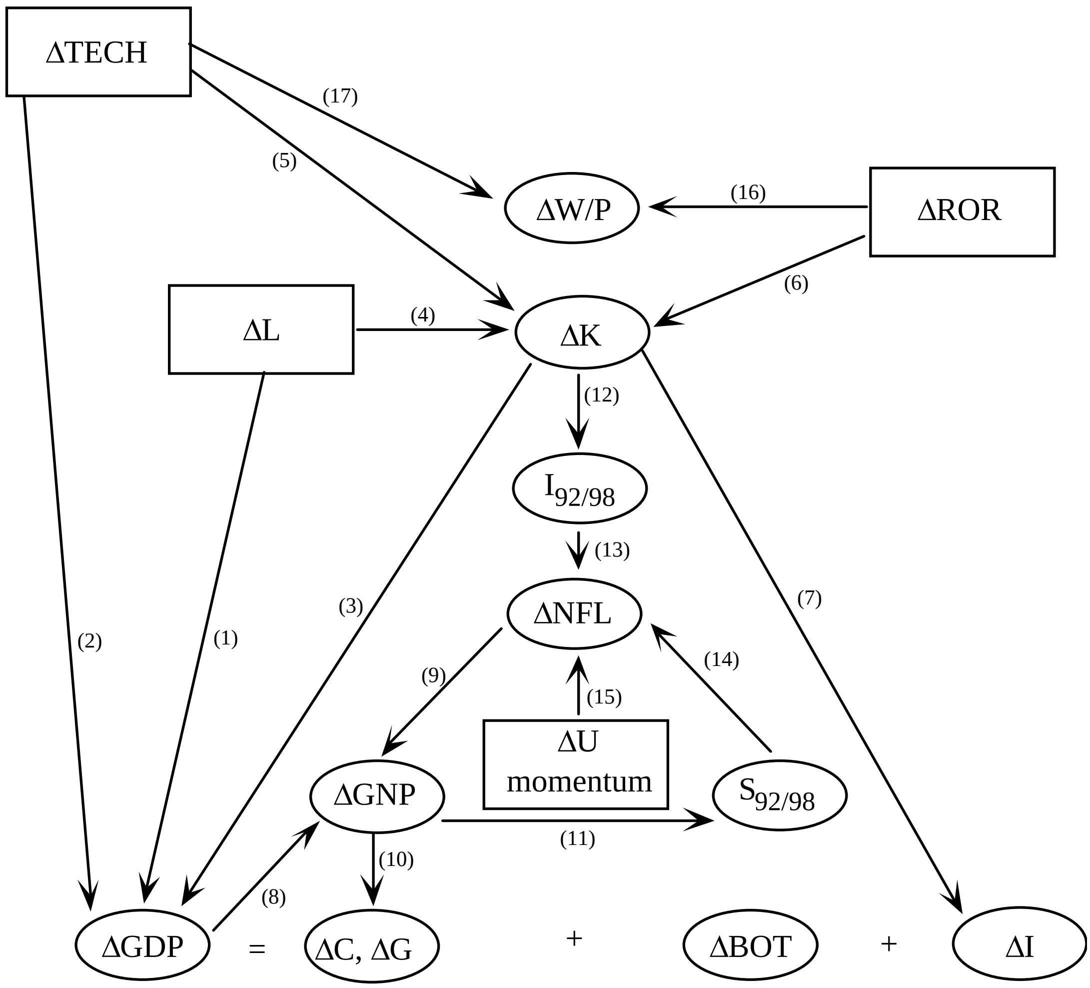
We present the decomposition analysis in three subsections. The first provides necessary background on the macroeconomic assumptions underlying the decomposition simulation. The second explains the results in Table 2 column by column. In the third we look across the columns to provide a case study on the factors underlying growth in US trade.

4.1 Macroeconomic assumptions in the decomposition simulation

For understanding the results in Table 2, it is useful to work through Figure 1. This is a flow diagram for a one-commodity CGE model.

Exogenous variables in the decomposition closure are represented by rectangles while endogenous variables are shown in ovals. The change in aggregate employment between 1992 and 1998 (ΔL), for example, is exogenous. Thus we assume that changes in technology (ΔTECH) and changes in other exogenous variables between 1992 and 1998 did not effect aggregate employment in 1998. As is conventional in macro modelling, we assume that employment effects are eliminated over the medium term by adjustments in wage rates.

Figure 1. Macro connections in the decomposition simulation for 1992 to 1998



Lines (1), (2) and (3) in Figure 1 impose a production function: the change in output (ΔGDP) between 1992 and 1998 is a function of ΔTECH, ΔL and the change in start-of-year capital (ΔK).

We assume that capital earns the value of its the marginal product, i.e. MPK is the ratio of the capital rental price to the price of the product. In a one-commodity model, the product price represents the asset price of capital. Consequently, MPK is the rate of return (ROR). Under constant-returns-to-scale, MPK is a function of K/L and TECH. Thus, ΔK is determined by ΔL, ΔTECH and ΔROR [lines (4), (5) and (6)].

As indicated in the figure, in our decomposition simulation ΔROR is exogenous. In analysing the effects of particular shocks over periods as long as six years (1992 to 1998) it is conventional to assume that capital adjusts to restore rates of return.

With capital earning the value of its marginal product, labour also earns the value of its marginal product. Thus, via the factor-price frontier (the relationship between MPK, MPL and TECH), ΔROR and ΔTECH determine the real wage rate [lines (16) and (17)].

Exogenization of ROR ties down capital stocks in 1998. This ties down aggregate investment *between* 1992 and 1998, but not *in* 1998. We link investment in 1998 to capital in 1998 [line (7)]. In isolating the effects of changes in technology etc., we assume that such changes have no impact on business confidence. Thus we treat the investment/capital ratio (a reflection of business confidence) as exogenous.

Lines (8) and (9) encapsulate the change in gross national product (ΔGNP) between 1992 and 1998. This is ΔGDP less the change in net interest/dividend payments to foreigners (a proportion of the change in start-of-year net foreign liabilities, ΔNFL).

We assume in line (10) that the changes in private and public consumption (ΔC, ΔG) are exogenously given proportions of ΔGNP. With ΔGDP, ΔC, ΔG and ΔI now determined, the change in the balance of trade (ΔBOT) is a residual.

Line (11) links accumulated excess savings ($S_{92/98}$) to ΔGNP. $S_{92/98}$ is the difference between the value of accumulated saving over the period 1992 to 1998 and the value it would have had in the absence of any change over this period in GNP. In deriving the link between $S_{92/98}$ and ΔGNP, we assume that saving in each year between 1992 and 1998 is a fixed proportion of GNP. A smooth growth assumption applied to GNP makes accumulated excess saving a function of ΔGNP.

The excess cost of investment between the beginnings of 1992 and 1998 ($I_{92/98}$) is the difference in the value of accumulated investment and the value it would have had in the absence of any change in capital (ΔK). By again invoking a smooth growth assumption, we specify $I_{92/98}$ as a function of ΔK [line (12)].

The final set of relations in Figure 1, lines (13), (14) and (15), determine ΔNFL as $I_{92/98}$ minus $S_{92/98}$ plus momentum (ΔU). Momentum is the change in NFL which would have occurred in the absence of excess accumulated savings and investment, that is the change that would have occurred with $\Delta GNP = \Delta K = 0$. Momentum consists of accumulated interest payments between 1992 and 1998 on NFL of 1992 *plus* depreciation investment (accumulated investment with $\Delta K = 0$) *minus* static saving (accumulated saving with $\Delta GNP = 0$).

4.2 Decomposition simulation: macro results

The last column of Table 2 shows outcomes for macro variables between 1992 and 1998. Columns 1 - 8 decompose these outcomes via (2.4) with the closure illustrated in Figure 1.

Column 1: momentum

Column 1 shows momentum effects, i.e. what would have happened to the US economy between 1992 and 1998 with no changes in other exogenous variables.

With ΔL, $\Delta TECH$ and ΔROR fixed at zero in the momentum column, Figure 1 indicates that there should be no change in K, I and GDP. That there are small changes in I and GDP and a larger change in K reflects structural effects (to be discussed shortly) not captured in a one-commodity representation of USAGE.

Consistent with Figure 1, column 1 shows a large effect for NFL (row 2), with significant consequences for GNP, C and G (rows 10, 11 and 12). With almost no growth in K (1.83 per cent over six years, row 6), investment expenditures would have covered little more than depreciation. US saving would have outstripped investment leading to a decline in NFL relative to GDP (14.32 per cent), allowing increases in GNP, C and G (0.84, 0.82 and 0.77 per cent) without improvements in TECH or growth in L, K and GDP.

The structural effects in column 1 which produce changes in K, I and GDP follow from the GDP identity across the bottom of Figure 1. With little change in I relative to GDP and significant increases in C and G relative to GDP, the balance of trade (BOT) deteriorates (row 1). The mechanism is real appreciation (1.47 per cent, row 3) which increases imports and reduces exports. For exports we assume that the US faces downward-sloping foreign demand curves. Thus, export contraction improves the terms of trade (0.37 per cent, row 21) with a consequent fall in the investment-goods price index (P_i) relative to the price deflator (P_g) for GDP[1]. With ROR held constant, a decrease in P_i/P_g reduces MPK:

$$\text{MPK} = \frac{\text{Rental}}{P_g} = \frac{\text{Rental}}{P_i} * \frac{P_i}{P_g} = \text{ROR} * \frac{P_i}{P_g} \quad . \qquad (4.1)$$

With L and TECH fixed, a reduction in MPK requires an increase in K (row 6), producing increases in GDP and I (rows 9 and 7). The real wage rate rises (row 5) reflecting the increase in the K/L ratio and the consequent increase in MPL.

Column 2: shifts in foreign export demands and import prices

The second column of Table 2 shows the effects of changes in US international trading conditions. In the historical simulation we deduced shifts, fep(i), in the export demand curves. For imports we assume that the US is a price taker and we treat c.i.f. foreign-currency import prices as exogenous in both the historical and decomposition closures. Because our data are for f.o.b. export prices and c.i.f. import prices, column 2 captures the effects of changes both in traded-goods prices on major world markets and of changes in the costs of transport services used in facilitating flows of commodities into and out of the US.

The decomposition simulation shows that shifts in export demand curves and changes in import prices were favourable to the US. This is an almost inevitable consequence of growth in the rest-of-world economy. In column 2 these changes in international trading conditions improved the

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[1] P_i/P_g falls because P_i contains import prices and P_g contains export prices.

terms of trade by 18.79 per cent (row 21). As in the momentum column, the terms-of-trade improvement generates increases in K, GDP, I and the real wage rate (rows 6, 9, 7 and 5).

By generating an increase in the price deflator for GDP relative to the price deflator for private and public consumption (P_g / P_c), the terms-of-trade improvement causes an increase in "purchasing-power" GNP (=GNP*P_g / P_c) relative to real GDP. This explains the sharp increases in real private and public consumption relative to real GDP (compare rows 11 and 12 with 9). Via the GDP identity, the sharp increases in consumption, together with the increase in I, leads to a deterioration in the real BOT (row 14 less 13), facilitated by real appreciation (row 3). This deterioration is offset by the terms-of-trade improvement, leaving the change in the nominal balance of trade slightly positive (row 1).

Consistent with the standard two-good trade model, the improvement in the terms of trade produces an increase in imports, a relatively small change in exports (here negative) and an overall increase in trade (rows 13 – 16).

Column 3: changes in protection

Between 1992 and 1998, there were small reductions in most tariffs. As shown in column 3, these had only minor macroeconomic effects.

Reductions in protection, stimulated imports and exports (rows 13 and 14). Export expansion caused a reduction in the terms of trade (row 21) leading to a contraction in consumption (rows 11 and 12).

We assume that lost tariff revenue is replaced by a tax on labour. With a reduction in indirect taxes (tariffs) that fall partly on intermediate inputs, there is an increase in the price of value added (P_g). In column 3 this is sufficient to reduce P_i / P_g despite terms-of-trade reduction. With ROR fixed, there is a decrease in MPK [see (4.1)] with associated increases in K/L and the real pre-tax wage rate (rows 6, 8 and 5). Because L is fixed, K increases, explaining the increases in GDP (row 9) and investment (row 7).

Column 4: technical change

The macro effects of movements in technology variables (ac, a1prim and twistlk) are shown in column 4. Overall, technology improved. With fixed L and ROR, this increased real wages (8.90 per cent) and increased GDP (6.67 per cent), directly via the production function (line 2, Figure 1) and indirectly via increases in K (lines 5 and 3). The increase in K (1.11 per cent) was subdued relative to the increase in GDP because technology twists favored labour. With technical change having only a minor impact on K, NFL is reduced (row 2). The extra investment induced by technical change over the period 1992 to 1998 was outweighed by the extra induced savings.

Imports and exports increased sharply relative to GDP (rows 13 – 16). The increase in exports causes a decline in the terms of trade, explaining the reductions in private and public consumption relative to GDP. Investment also declined relative to GDP, reflecting subdued growth in capital. The declines in C, G and I relative to GDP explain the movement in BOT towards surplus and the declines in the real and nominal exchange rates.

Technology changes were strongly trade-favoring for two reasons: (a) export-oriented industries experienced the largest increases in total factor productivity; and (b) the movements in technology happened to favor the use of inputs that are heavily imported, particularly computers.

Column 5: changes in import/domestic preferences

Import/domestic twists increased imports by 2.8 per cent (row 13, column 5). With L, ROR and TECH held constant, there is little effect on K and I. With little impact on I there is little impact on BOT (row 1). Thus the increase in imports is accompanied by an increase in exports requiring real devaluation. The percentage increase in export volumes exceeds that in import volumes because export expansion causes a decline in the terms of trade. This reduces purchasing-power GNP and real private and public consumption.

Via (4.1), the terms-of-trade decline causes MPK to rise, thereby reducing MPL and the real wage rate. With an increase in MPK, there are small decreases in K and I.

Column 6: changes in consumer preferences

Column 6 shows that the macroeconomic effects of preference shifts [a3com(i)] were small.

Because production of cigarettes and other commodities suffering adverse shifts is capital intensive relative to production of travel trailers and other commodities enjoying favourable shifts, we find small reductions in K, I and GDP.

Cigarettes are heavily taxed. Shifts in consumption against heavily taxed commodities tend to reduce GDP. This explains the relatively large GDP reduction (0.49 per cent)[2]. Another effect of the preference shift away from heavily taxed goods is an increase in the real pre-tax wage rate.

A final interesting feature of the preference changes is that they favoured commodities that happened to be intensively imported. This explains the increase in imports in row 13. With C, I and G all falling by about the same percentage as GDP, and with imports increasing, exports must increase (row 14), generating a reduction in the terms of trade.

Column 7: employment growth

Between 1992 and 1998, L grew by 13.7 per cent. With constant returns to scale, fixed ROR, fixed I/K ratios and no change in TECH, we would expect the system depicted by lines (1) - (7) and (16) - (17) in Figure 1 to transform a 13.7 per cent increase in employment into 13.7 per cent increases in K, I and GDP with no change in the real wage rate. However, a larger domestic economy produces more exports with an associated decline in the terms of trade. This increases P_i/P_g (rows 19 and 17), restricting the increases in K and GDP to 12.59 and 13.53 per cent [see (4.1)]. With a reduction in the K/L ratio, there is a reduction in MPL and in the real wage rate.

Terms-of-trade deterioration limits the growth in C and G to well below that of real GDP. Another limiting factor is accumulation of NFL, reflecting rapid growth in K. The increase in NFL restricts consumption by restricting the growth in real GNP.

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[2] With the capital share in GDP being 30 per cent, the reduction in capital suggests a GDP reduction of about 0.22 per cent.

With subdued growth in C and G relative to GDP, column 7 shows an 11.4 percentage point gap between export and import growth, facilitated by real devaluation.

Column 8: other factors

With decomposition simulations we can look at the effects of an overwhelming number of exogenous variables. Inevitably, we must terminate the process by having an “other column”, here column 8.

The main shocks in column 8 are to macro ratios. Recall from lines (7) and (10) in Figure 1 that in the decomposition simulation we exogenize I/K ratios and the average propensities to consume (C/GNP, G/GNP). In columns 1 to 7, these ratios were fixed. In column 8 we introduce, as exogenous shocks, the changes in the ratios that were endogenously determined in the historical simulation.

For most sectors, the I/K ratio was higher in 1998 than in 1992, explaining the strongly positive result for real investment (row 7). The C/GNP ratio was higher in 1998 than in 1992, explaining the positive result for real private consumption (row 11), but the G/GNP ratio fell, explaining the negative result in row 12. Overall there was a slight fall in total consumption (private and public) relative to GNP. This was easily outweighed by the increase in investment relative to GNP. Thus we find a strong movement to balance-of-trade deficit (row 1), facilitated by real appreciation (row 3). Real appreciation explains sharp contraction in exports (row 14), improvement in the terms of trade (row 21) and expansion in imports (row 13).

Column 8 shows a reduction in NFL as a per cent of GDP (row 2). As well as changes in macro ratios, column 8 includes the effects of the overall increase in the price level (a 12.16 per cent increase in P_C, row 18). Because a considerable fraction of US foreign liabilities is repayable in US dollars, general domestic inflation has the effect of reducing US foreign liabilities relative to GDP.

4.3 Cross-column analysis: growth in US trade between 1992 and 1998

Why did US trade grow so fast between 1992 and 1998?

The final entry in row 16 of Table 2 shows that trade as a share of GDP increased by 37.16 per cent. Well over half of this (20.62 percentage points) was contributed by technology. As explained in our discussion of column 4, technological change was strongly trade-favouring because total-factor-productivity growth was relatively rapid in export-oriented industries and movements in technology favoured the use of inputs that are heavily imported, particularly computers.

The second largest entry in row 16 is for changes in trading conditions (6.38 percentage points). To a large extent, this entry gives the effects on US trade of growth in the rest of the world. With growth in the world economy, the US benefited from outward shifts in foreign demand curves for its exports and from outward shifts in foreign supply curves for its imports. These demand and supply shifts generated a sharp improvement in the US terms of trade This was trade expanding because it allowed strong import growth with only a small contraction in exports.

Twists in industry and household preferences towards imports (column 5) and changes in household preferences between commodities (column 6) each contributed about 4 percentage points to growth in the trade/GDP ratio. Preference twists towards imports directly increased imports and indirectly increased exports via real devaluation. Changes in household preferences stimulated trade by increasing demand for some commodities that heavily imported (e.g. computer products) while decreasing demand for some other commodities that are lightly imported (e.g. cigarettes).

The remaining entries (those in columns 1, 3, 7 and 8) in row 16 have absolute values of less than one percentage point. These entries include the effects of tariff reductions, often cited as a major cause of trade growth. However, for the US between 1992 and 1998 their contribution to growth in the trade/GDP ratio was only 0.87 percentage points. As mentioned in our discussion of column 3, tariff cuts over this period were small.

5. Conclusion

The most up-to-date US input-output table available in 2000 when we started work on the USAGE model was that for 1992, published by the Bureau of Economic Analysis (BEA). By generating prices and quantities for all input-output flows for 1998, our historical simulation provides an update of the BEA's data to 1998. The update incorporates detailed data on: industry and commodity outputs; prices and quantities for exports and imports; quantities for private and public consumption; and quantities for capital, investment and employment by industry. By using an historical simulation for updating, we not only incorporate all the available detailed data, but we also use data on one variable to fill gaps in our knowledge of other variables. For example, in the historical simulation for 1992 to 1998, we had Bureau of Labor Statistics data for movements in consumption disaggregated to 192 commodities. For imports, our observations were at the 500-level. These import observations not only informed our estimates of flows of imports to industries and final users in the updated input-output table, but also our estimates of consumption at the 500-level.

Updated input-output data are important for policy analysis and essential in forecasting. Policy analysis based on outdated data is too easily dismissed by critics and may sometimes genuinely miss important aspects of the issue under investigation. For example, an analysis of the stevedoring industry based on 1992 data would underestimate the benefits of cost-reducing reforms by understating the current importance in the US economy of international trade. In forecasting, up-to-date input-output data are an unavoidable requirement if we want to say anything about likely developments in investment-related industries. From projections of demographic and income variables, we may be reasonably confident that a nation's housing stock will grow by about 2 per cent a year over the next five years. However, unless we have a database which reflects the current year's construction activity, we have little basis for deciding whether 2 per cent housing growth implies strong or weak growth in the construction sector and related industries.

A co-product of the updated input-output data produced by an historical simulation is detailed estimates of changes in technologies and consumer preferences. In further development of USAGE, extrapolations of the changes estimated for 1992 to 1998 will be important for giving forecast simulations convincing industrial detail.

Having completed an historical simulation for 1992 to 1998, we were immediately able to conduct a decomposition simulation. Such simulations can be used to explain movements in an enormous variety of macro and micro variables. In this paper we illustrated the application of the decomposition technique in a discussion for 1992 to 1998 of growth in US trade.

References

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Table 2 Macroeconomic variables: Decomposition of changes from 1992 to 1998

		1 ***Momentum***	***2*** ***Shifts in foreign demands & import prices***	***3*** ***Changes in tariffs***	***4*** ***Technical change***	***5*** ***Changes in import/ domestic preferences***	***6*** ***Changes in H'hold tastes***	***7*** ***Growth in employ-ment***	***8*** ***Other factors***	***Total***
1	Change in balance of trade, % of GDP	-0.21	0.57	-0.01	0.79	-0.07	-0.02	0.46	-2.64	-1.13
2	Change in net foreign liabilities, % of GDP	-14.32	6.30	0.25	-0.08	-2.53	-2.37	31.79	-9.11	9.94
	Percentage changes									
3	Real exchange rate	1.47	24.66	-0.49	-6.49	-2.55	-0.83	-7.77	7.81	15.82
4	Nominal exchange rate	1.30	31.59	-0.45	-4.92	-2.32	-0.86	-6.97	-3.84	13.53
5	Real wage rate (P_g deflated)	1.32	3.13	0.18	8.90	-0.16	0.12	-0.68	-2.28	10.55
6	Capital stock (K)	1.83	4.75	0.10	1.11	-0.95	-0.67	12.59	-1.19	17.57
7	Real investment (I)	0.60	5.65	0.12	5.41	-1.05	-0.61	14.04	24.85	49.01
8	Employment (L)	0.00	0.00	0.00	0.00	0.00	0.00	13.70	0.00	13.70
9	Real GDP	0.48	2.09	0.03	6.67	-0.64	-0.49	13.53	-1.21	20.45
10	Real GNP (P_g deflated)	0.80	1.94	0.03	6.63	-0.59	-0.44	12.82	-1.00	20.19
11	Real private consumption (C)	0.82	3.96	-0.03	4.43	-0.80	-0.47	12.27	1.43	21.61
12	Real public consumption (G)	0.77	3.58	-0.03	3.93	-0.74	-0.43	11.35	-14.96	3.48
13	Imports, volume	1.85	18.77	0.66	15.58	2.80	2.64	8.81	16.67	67.76
14	Exports, volume	-1.01	-1.83	1.13	38.99	4.92	3.43	20.21	-18.40	47.45
15	Total trade, volume	0.42	8.47	0.90	27.29	3.86	3.04	14.51	-0.86	57.61
16	Trade/GDP	-0.06	6.38	0.87	20.62	4.50	3.53	0.98	0.35	37.16
17	GDP price deflator (P_g)	0.20	2.39	-0.04	-1.57	-0.25	0.03	-0.83	11.74	11.66
18	Price deflator for consumption (P_c)	0.18	0.52	0.02	0.67	-0.05	0.05	-0.18	11.41	12.62
19	Price deflator for investment (P_i)	0.02	-3.68	-0.05	-3.39	0.20	0.38	0.55	8.27	2.30
20	Price deflator for public consumption	0.90	2.61	0.10	3.35	-0.24	0.24	-0.91	7.28	13.32
21	Terms of trade	0.37	18.79	-0.34	-10.87	-2.04	-0.54	-5.74	5.68	5.31