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THE EXTENT AND CONSEQUENCES OF RECENT STRUCTURAL CHANGES IN THE AUSTRALIAN ECONOMY, 1997-2002:

RESULTS FROM HISTORICAL/DECOMPOSITION SIMULATIONS WITH MONASH

by

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The Centre of Policy Studies (COPS) is a research centre at Monash University devoted to quantitative analysis of issues relevant to Australian economic policy.

Abstract

The paper describes historical and decomposition simulations of the Australian economy undertaken with the MONASH model. The simulations cover the period 1996/97 to 2001/02. The paper first describes the historical simulation. In the historical simulation, many of those sectoral variables in MONASH which represent observable features of the economy are determined exogenously. This allows the model to calculate the outcomes for sectoral variables describing (typically unobservable) features of the economy's structure, such as industry production technologies and household tastes. The estimates for these structural and taste variables play a key role in explaining the observable features of the economy over the study period. To isolate the contribution of each of these structural features to observed economic outcomes, they are fed back into the model as exogenous shocks in the decomposition simulation. The decomposition simulation is then used to explain the causes of major changes in the Australian economy over the period 1996/97 - 2001/02 in terms of changes in technologies, tastes and other structural variables.

CONTENTS

1. INTRODUCTION

A large-scale computable general equilibrium model such as MONASH contains many economic relationships linking observable features of the economy (such as macroeconomic aggregates, commodity prices and outputs, household consumption by commodity) with structural features of the economy (such as production technologies and household tastes). Dixon and Rimmer (2002) describe how these relationships can be exploited to both analyse in detail a period of economic history, and to provide plausible values for the model's structural variables in forecasting simulations. Such analysis requires two sequential simulations: firstly an "historical" simulation, the output of which is then input to a "decomposition" simulation. Dixon and Rimmer (2002) investigate the period 1986/97 – 1992/93. In this paper I use the same techniques to examine the period 1996/97 – 2001/02.

In the historical simulation, observed changes in economic variables over the period 1996/97 – 2001/02 are imposed on the model as exogenous shocks. These variables include industry employment, sectoral capital stocks, wages and value-added prices, consumption by commodity, and consumer prices. While these variables are normally endogenous in a standard closure of the model, in the historical simulation they are exogenous. This requires that variables describing the structure of the economy be endogenous. These endogenous structural variables include such things as primary factor productivity by industry, household taste changes by commodity, shifts in foreign demand schedules by commodity, changes in industry rates of return and propensities to invest, shifts in import / domestic preferences by commodity, and shifts in export supply schedules by commodity. Next, in the decomposition simulation, the estimates for these structural variables are fed back into the model as exogenous shocks under a standard closure of the model. This allows the changes in observed economic outcomes over the period to be explained in terms of changes in industry technologies, household tastes, import / domestic preference shifts, shifts in foreign trading conditions, and so forth. The results for the structural variables also form a key input into other applications of Centre of Policy Studies models. Typical applications of models like MONASH and MMRF include the investigation of such things as a policy change, a new project, or a shift in foreign trading conditions. The effects of such shocks are measured as deviations in the values of economic variables away from their basecase forecast values. Hence a prior step to that of evaluating the effect of such shocks is to first undertake a forecast simulation. In creating the basecase forecast we extrapolate the historical shifts in tastes and technologies deduced from the historical simulation. Experience with MONASH and MMRF has shown that plausible shifts in sectoral tastes and technologies are an important input to the generation of basecase forecasts, since conclusions about the impacts of policy and other changes on such things as welfare and adjustment costs can be sensitive to basecase forecast assumptions (see for example Dixon and Rimmer 1999).

The remainder of this paper is structured as follows. Section 2 outlines the nature of the historical and decomposition simulations. Firstly, the MONASH model is briefly described. The closure of MONASH in the historical and decomposition simulations is then discussed. The historical and decomposition simulations incorporate a lot of detail about the economy, and MONASH is relatively large and complex. To cut through this detail and complexity, Section 2 concludes by outlining a simple “back-of-the-envelope” (BOTE) model that illustrates most of the major mechanisms at work in MONASH during the historical and decomposition simulations. This model is used to explain the results of the historical simulation (Section 3) and the decomposition simulation (Section 4). Section 5 concludes the paper.

2. METHOD

2.1 Overview of the MONASH model

MONASH is large and detailed, making it impractical to provide a full description of its theoretical structure and database in a paper of this size. However, the discussion of results in Section 3 relies on both a BOTE model and familiar economic mechanisms, so that the reader need not know every detail of MONASH to understand the simulation results. The remainder of this section provides a brief overview of MONASH. The reader is referred to Dixon and Rimmer (2002) for a detailed discussion of the model.

MONASH is a dynamic computable general equilibrium model of the Australian economy, and is descended from the earlier comparative-static model ORANI (Dixon et al., 1982). The model features detailed sectoral disaggregation, with the version employed in this paper featuring 107 industries and commodities. Familiar neoclassical assumptions govern the behaviour of the model's economic agents. Decision-making by firms and households is assumed to be governed by maximising behaviour. Each representative industry is assumed to minimise costs subject to constant returns to scale production technologies and given input prices. Household commodity demands are modelled via a representative utility-maximising household. Investors allocate new capital to industries on the basis of expected rates of return. Units of new capital are assumed to be a cost minimising combination of inputs sourced from Australia and overseas. Imperfect substitutability between the imported and domestic varieties of each commodity are modelled using the CES assumption of Armington. The demand for any given Australian commodity by foreigners is assumed to be inversely related to its foreign-currency export price. The model recognises both the consumption of commodities by government, and a variety of direct and indirect taxation instruments. In general, markets are assumed to clear and to be competitive. Purchasers' prices differ from producer prices by the value of indirect taxes and margin services. Dynamic equations describe stock-flow relationships, such as those between capital and investment, and debt and savings. Dynamic adjustment equations allow for the gradual movement of a number of variables towards their long-run values. For example, in year-on-year deviation simulations, real wages are assumed to be sticky in the short-run, adjusting over a period of about five years to return the number of unemployed to its base-case level following some economic shock. Other features of the model allow it to produce time-paths for a large number of economic variables under a variety of scenarios. In particular, the model contains many relationships that facilitate the use of extraneous data from official statistical publications and forecasting organisations during simulations designed to either track history or forecast the future. The model is solved with the GEMPACK economic modelling software (Harrison and Pearson, 1996).

2.2 The historical and decomposition closures described

Following Dixon and Rimmer (2002: 10-13), we can describe the MONASH model for each year of the period of history under study by F(X) = 0; where F is an *m*-vector of differentiable functions of *n* variables, X. Since *n*>*m*, *n*-*m* variables are determined exogenously. X includes such variables as prices, quantities, tax rates, production coefficients, and household tastes. The *m* equations of F(X) embody the theoretical structure of the model as described briefly in Section 2.1 above and discussed in full in Dixon and Rimmer (2002). An initial solution to F(X)=0 is provided for the year 1996/97. In simulating the model, deviations from this initial solution are calculated for *m* endogenous variables given the user-specified values of *n*-*m* exogenous variables. There are many economically sensible choices of which of the *m* variables can be determined exogenously by the model user. Two choices among the possible sets of *n*-*m* exogenous variables are relevant to the present project: that defining the "historical closure"; and that defining the "decomposition closure". In defining these two closures more precisely, it is convenient to partition the variables of the model into four sets: $X(\bar{H}\,\bar{D})$, $X(\bar{H}\,D)$, $X(H\,\bar{D})$, and $X(H\,D)$, where $\bar{H}$ denotes endogenous in the historical simulation, $\bar{D}$ denotes endogenous in the decomposition simulation, H denotes exogenous in the historical simulation, and D denotes exogenous in the decomposition closure. Hence $X(\bar{H}\,\bar{D})$ is comprised of those variables that are endogenous under both the historical and decomposition closures, $X(\bar{H}\,D)$ is comprised of those variables that are endogenous under the historical closure but exogenous under the decomposition closure, $X(H\,\bar{D})$ is comprised of those variables that are exogenous under the historical closure but endogenous under the decomposition closure, and $X(H\,D)$ is comprised of those variables that are exogenous under both the historical and decomposition closures. Table 1 describes selected elements of $X(\bar{H}\,\bar{D})$, $X(\bar{H}\,D)$, $X(H\,\bar{D})$, and $X(H\,D)$.

$X(\bar{H}\,D)$ and $X(H\,\bar{D})$ contain the same number of elements, and a readily apparent economic relationship exists between the individual elements of each. These relationships are exploited in this paper to allow the elements of $X(H\,\bar{D})$ to be determined exogenously during the historical simulation (with corresponding elements of $X(\bar{H}\,D)$ determined endogenously) and endogenously during the decomposition simulation (with corresponding elements of $X(\bar{H}D)$ determined exogenously equal to their values under the historical simulation). $X(H\bar{D})$ contains variables that we normally would expect to find among the endogenous variables in a standard closure of a CGE model. Hence they belong in the set $\bar{D}$. However, it is also possible to directly observe the historical values for these variables, so they also belong in the set H. Examples of variables in $X(H\bar{D})$ include industry and commodity level variables (employment by industry, investment by industry, commodity exports and imports), and macro variables (such as real consumption, real government consumption). $X(\bar{H}D)$ contains variables that we would normally expect to find among the set of exogenous variables in a standard closure of a CGE model. Hence they belong in the set D. However in historical simulations, these variables are endogenous, providing the model with enough flexibility to allow for the exogenous determination of the variables in $X(H\bar{D})$. The variables in $X(\bar{H}D)$ predominantly relate to production technologies and household tastes. Examples of these variables include: intermediate-input saving technical changes, changes in household tastes, primary-factor-saving technical change by industry, and the average propensity to consume.

Having partitioned MONASH's variables into the above four sets, the first application of the model (the historical simulation) involves finding a solution to $X(\bar{H}) = G^H(X(H))$, where $X(\bar{H}) = X(\bar{H}D) \cup X(\bar{H}\bar{D})$, $X(H) = X(HD) \cup X(H\bar{D})$, and G^H is an *m*-vector of differentiable functions. By assigning the variables in $X(H)$ their historically-observed values, G^H is used to calculate the values for $X(\bar{H})$. Having calculated these values, we then move to a decomposition closure, giving a solution to the model of the form: $X(\bar{D}) = G^D(X(D))$. This equation is then re-expressed in log-differential or percentage change form as $x(\bar{D}) = Bx(D)$, where $x(\bar{D})$ and $x(D)$ are vectors of percentage changes in the variables $X(\bar{D})$ and $X(D)$, and B is a *m* x (*n*-*m*) matrix of elasticities. The values for $x(D)$ are known from the historical simulation, allowing $x(\bar{D}) = Bx(D)$ to be used to decompose the movements in $x(\bar{D})$ into the individual contributions of each of the movements in $x(D)$.

2.3 A stylised version of MONASH – the BOTE model

Dixon and Rimmer (2002: 243) use a stylised representation of the MONASH model to describe the development of the historical closure and to explain the results from the historical simulation. The stylised model (hereafter the "back-of-the-envelope", or BOTE model) assumes a single domestically produced good that is used domestically and exported, and a single imported good. The equations of the BOTE model are described below.

The GDP identity in constant price terms is given by (E1).

(E1) $Y = C + I + G + X - M$

Real GDP is determined by inputs of primary factors and technology via a CRS production function:

(E2) $Y = A\,F(K, L)$

In MONASH, private consumption is linked to gross national product via an assumption of a given propensity to consume. The ratio of public consumption to private consumption is typically assumed to be given. These ideas are represented in the BOTE model by (E3) and (E4). However the BOTE model does not contain an equation for GNP. Hence the total of public and private consumption spending is instead related to GDP via:

(E3) $C + G = APC \times Y$

The ratio of private to public consumption spending (Γ) is defined by (E4):

(E4) $C / G = \Gamma$

In the absence of changes in preferences for imports, import volumes in MONASH are positively related to economic activity and the ratio of domestic to imported prices. This is reflected in the BOTE model by (E5), which assumes that imports are related positively to GDP (Y), the terms of trade (TOT), and import/domestic preferences (T):

(E5) $M = H(Y, TOT, T)$

Commodity exports in MONASH are inversely related to their foreign currency prices via constant elasticity demand functions. This is reflected in the BOTE model by (E6), which relates the terms of trade to the volume of exports (movements along foreign demand schedules) and a shift variable (movements in foreign demand schedules):

(E6) $TOT = J(X, V)$

Long-run investment / capital ratios by industry are assumed in MONASH to be a reflection of business confidence, and hence determined exogenously. This is reflected in the BOTE model by (E7), which defines the investment capital ratio:

(E7) $\Psi = I / K$

Like MONASH, the BOTE model assumes CRS. Hence the profit maximising capital / labour ratio can be related to rates of return on capital (ROR), technological change (A) and the terms of trade (TOT) via (E8)[1]:

(E8) $K / L = N(ROR, A, TOT)$

The BOTE model can now be used to describe the MONASH decomposition and historical closures. These are summarised in Table 2. Under the decomposition closure, L, ROR, A, Ψ, V, T, Γ, and APC are determined exogenously. While this is clearly a system of simultaneous equations, most equations can be readily identified with the determination of a specific endogenous variable. Hence, under this closure, we might think of (E8) as largely determining capital supply (K). This fixes investment (I) and GDP (Y) via equations (E7) and (E2) respectively. Private (C) and public (G) consumption spending are determined by equations (E4) and (E5). Equation (E5) determines import volumes (M) leaving (E1) to determine export volumes (X). Finally, equation (E6) determines the terms of trade (TOT). The endogenous / exogenous status of the variables of the BOTE model under the historical closure is discussed in Section 3.

3. THE HISTORICAL SIMULATION

3.1 Introduction

Starting with the decomposition closure, the historical closure is developed in thirteen steps (steps 0 through 12). A step-by-step approach is adopted for two reasons. Firstly, it emphasises the economic relationships between the elements of $X(H\bar{D})$ and $X(\bar{H}D)$. This facilitates the interpretation of the results from the historical simulation. It also allows a natural progression to justifying the particular partitioning of history adopted in the decomposition simulation. Secondly, as Dixon and Rimmer (2002) explain, the historical closure is complicated and unusual. Hence the step-by-step approach allows the size of $X(H\bar{D})$ to be potentially much larger (thereby allowing us to use a large amount of observable data from statistical agencies) than it would be if a step-by-step approach to its development had not been adopted. Such an approach to the development of this complicated closure also assists in trouble-shooting. The following discussion follows closely that in Dixon and Rimmer (2002: 244-261). Table 3 reports the results of the piece-wise application of the historical shocks at each step in the development of the historical closure. As discussed below, at each step in Table 3 we have a valid closure of the MONASH model.

3.2. Step 0: naturally exogenous variables, momentum in initial NFL conditions

This step begins with the decomposition closure. A number of naturally exogenous variables (not appearing in the BOTE model) are shocked under this closure:

- the consumer price index (the numeraire)
- tariff rates
- the number of households
- the homotopy variable, U

The effects of these shocks on selected macroeconomic variables are reported in Table 3. The most important of these shocks is that given to the homotopy variable, described by ΔU in Figure 1 (and explained in more detail in Section 4). The effect of the shock to U is to ensure that the value for net foreign liabilities (NFL) in 2001/02 reflects two things. Firstly, in the absence of any other changes to the economy over the period, the 1996/97 database indicates that there would have been changes in NFL over the period 1996/97 – 01/02. These changes would reflect the accumulated net interest and dividends on the initial

1996/97 stock of NFL, and the increments to NFL (plus accumulated net interest) that would have occurred had GNP and K remained at their initial (1996/97) levels. Secondly, changes *do* occur to the economy over the period 1996/97 – 01/02. Both K and GNP in 2001/02 will differ from their initial 1996/97 values. A path for S and I, and hence NFL, is derived by assuming that K and GNP grow smoothly over the simulation period. The shock to U ensures that the 2001/02 value for NFL reflects accumulated interest and dividends on the initial stock of NFL and any changes arising from the path of I and S implied by the changes in GNP and K over the simulation period.

The results in column 1 indicate that in the absence of changes in employment or technology, domestic savings would have been more than sufficient to finance investment and net interest over the period, leading to a fall in the ratio of net foreign liabilities to GDP. This causes real GNP to be higher. In Equation (E3) of the simple BOTE model, consumption is linked to GDP via a constant APC. Similarly in MONASH consumption is linked to GNP via a constant APC out of GNP. This is reflected in Figure 1 by arrow (10). With GNP higher and the APC out of GNP unchanged, MONASH projects that real private and public consumption would be 1.9 per cent higher. Our BOTE model suggests that in the absence of changes in technology, employment or rates of return, the capital stock should be unchanged. However, whereas the BOTE model is a single sector model, MONASH is multisectoral and so allows for the possibility that changes in the composition of aggregate activity can affect macro variables like K. In Step 0, the small increase in private consumption spending leads to a small increase in household demands for the output of the capital-intensive sector *Ownership of Dwellings*. The resulting expansion in activity in this sector causes a small increase in K (up by 1.3 per cent). Via (E2) of the BOTE model, we can see that an increase in K with L and A fixed causes Y to be higher. In the MONASH results this is reflected in a small (0.3 per cent) rise in real GDP. In MONASH, as in the BOTE model (Equation E7), investment / capital ratios in the decomposition closure are assumed to be exogenous. However in MONASH investment / capital ratios are exogenous at the sectoral level, not the national level as in the BOTE model. Since capital / investment ratios differ across sectors, the results for aggregate investment and aggregate capital stock need not be the same. Indeed in Step 0 real investment falls despite the rise in the aggregate capital stock. This reflects the fact that the rise in the capital stock is concentrated in the *Ownership of Dwellings* sector, which has a relatively low investment / capital ratio. At the same time, capital stocks are falling in the agricultural and mining sectors, which have relatively high investment / capital ratios. Despite the fall in investment, the rise in real public and private consumption spending is sufficient to cause real GNE to rise by more than the increase in real GDP. Hence, via the GDP identity given by BOTE equation (E1), the balance of trade must move towards deficit. The movement towards deficit is achieved largely through a contraction in X, since, as described by (E5) of the BOTE model, import volumes are supported somewhat by the increase in Y. The movement in the balance of trade towards deficit is achieved via a small appreciation of the real exchange rate (0.6 per cent). There is a small improvement in the terms of trade, reflecting the contraction in national export volumes, a mechanism described by (E6) of the BOTE model. Note that the GDP deflator, the investment price deflator, and the average nominal wage all rise significantly in Step 0. This reflects the shock to the CPI, the model's numeraire. The Australian CPI increased by 11.3 per cent over the period.

3.3 Step 1: Real public consumption spending

In Step 1 real public consumption spending by commodity is determined exogenously, and shocked equal to historically observed values. In the BOTE model, as in MONASH, this requires that the ratio of private to public consumption spending (Γ in equation E4) now be determined endogenously and G be determined exogenously. In addition to shocks to the composition and level of public consumption spending, the shocks administered to the model in Step 0 are also administered to the model in Step 1. However no other shocks are administered – in terms of the BOTE model L, ROR, A, Ψ, V, T, and APC remain exogenous and zero. In Step 1 the aggregate of C and G continues to be indexed to GNP in MONASH (represented by E3 in the BOTE model), hence in the absence of any movement in the aggregate of C + G any increase in G must be matched by a decrease in C. Aggregate real public consumption spending grew by 16.7 per cent over the period. The ratio of private to public consumption spending is approximately 3, so the 14.8 per cent increase in public consumption spending between Step 0 and Step 1 (16.7 – 1.9) reduces private consumption spending by approximately 5.3 percentage points (–3.4 – 1.9) between Step 0 and Step 1. In terms of the single sector BOTE model, this is the only change we anticipate when moving from Step 0 to Step 1. However, unlike the BOTE model, the MONASH macro results also reflect changes in the sectoral composition of economic activity. In particular, public consumption is relatively labour intensive. Hence the movement of labour towards sectors producing primarily for public consumption (*public administration, defence, community* *services, health and education*) causes the national capital stock to contract. The decrease in K causes real GDP to fall. It also causes the contraction in investment to be larger than in Step 0. As (E5) of the BOTE model describes, the fall in GDP causes a fall in import volumes. Real appreciation (reflected in an increase in TOT in the BOTE model) should cause import volumes to expand, but a compositional effect in MONASH acts to counter this. In particular, G is not as import intensive as C and I, so that the shift in the composition of domestic absorption towards public consumption acts to reduce imports. The sum of real public and private consumption spending rises by approximately 1.3 per cent. Two effects (neither of which are captured in the BOTE model) allow real consumption to rise despite the fall in real GDP. Firstly, the terms of trade rise sharply. Secondly, with the capital stock lower net foreign liabilities are lower, allowing GNP to be higher. With real consumption up by 1.3 per cent and real investment down by 4.2 per cent, real GNE rises by 0.1 per cent. With real GDP falling by 1.1 per cent but real GNE rising by 0.1 per cent, the balance of trade must move towards deficit. This requires that the real exchange rate appreciate. The resulting contraction in export volumes causes the terms of trade to improve.

3.4 Step 2: The composition and level of real private consumption spending

The Australian Bureau of Statistics provides data on movements in real household consumption for 45 commodities. These are mapped within the model to the 107 commodities recognised in MONASH. In Step 2 of the historical simulation variables describing the consumption of the 45 national accounts commodities are moved to the exogenous list, and variables describing shifts in household tastes for these commodities are moved to the endogenous category. The model then calculates the shifts in household tastes required to accommodate the observed movements in household consumption by commodity. Having determined real private consumption spending by commodity in this way also effectively determines aggregate real private consumption spending. Hence the average propensity to consume out of GNP must be determined endogenously. This aspect of the historical closure can be represented in the BOTE model by moving C to the list of exogenous variables and moving APC to the list of endogenous variables.

Aggregate real private consumption spending grew by 24.5 per cent over the period. This is significantly faster than GNP, requiring that the average propensity to consume increase by 17.0 per cent. With real private consumption spending up, households increase their demands for the output of the capital-intensive sector *Ownership of Dwellings*. This causes the aggregate capital stock to expand (approximately two-thirds of the increase in the capital stock in Step 2 is attributable to expansion of *Ownership of Dwellings*). With the aggregate capital stock higher, so too is real investment. With employment and productivity still exogenous and zero in Step 2, the increase in the capital stock alone causes only a small (relative to the increase in consumption) rise in real GDP. Since the increase in real GDP is significantly smaller than the increase in real GNE, the balance of trade must move sharply towards deficit. Both private consumption spending and investment spending are relatively import intensive, hence part of the movement towards deficit is achieved by increased import volumes. The remainder of the movement towards deficit requires a sharp contraction in export volumes, which in turn requires a substantial appreciation of the real exchange rate. The contraction in export volumes also accounts for the large improvement in the terms of trade. Via (E8) of the BOTE model this adds to the expansion in the capital stock. With national savings falling and the capital stock higher, NFL rises substantially from its value in Step 1.

3.5 Step 3: The composition and level of import volumes

In Step 3 import volumes by commodity are added to the list of exogenously determined variables. In terms of the BOTE model, prior to this step in the incremental development of the historical closure, import volumes (M) have been determined endogenously by (E5) through movements in income (Y) and relative prices (TOT) with given preferences for imports (T). The closure swaps undertaken within MONASH in Step 3 can be represented in the BOTE model by moving M to the list of exogenous variables and T to the list of endogenous variables. While only one such swap is required in the single commodity BOTE model, in the MONASH simulation the volume of imports is determined exogenously for any commodity for which ABS data on movements in import volumes are available, and a corresponding variable measuring movements in import / domestic preferences in the Armington nests of all (non government) domestic users of that commodity is determined endogenously. The movement from Step 2 to Step 3 requires that aggregate import volumes expand by approximately 16.3 percentage points. In terms of the BOTE model, with Y largely determined by (E2), real consumption exogenous, and I effectively exogenous via (E7), the increase in M must be accommodated by an increase in X. This explains the MONASH result for export volumes, with export volumes expanding from their Step 2 value of –75.0 to their Step 3 value of –60.3. This movement is facilitated by a real devaluation of 5.2 per cent (–29.0 – –34.2). The increase in export volumes also explains why the improvement in the terms of trade is smaller in Step 3 than in Step 2.

3.6 Step 4: The composition and level of aggregate investment

In Step 4 of the MONASH historical simulation, investment by sector is determined exogenously, and investment / capital ratios by sector are determined endogenously. This can be represented in the BOTE model by moving I to the list of exogenous variables and allowing the model to determine the economy-wide investment / capital ratio (Ψ). Essentially the same type of swap is undertaken in MONASH, but the swap is undertaken for each sector for which ABS data on movements in real investment are available. In the MONASH simulation, the information on investment added in Step 4 increases real investment by 20.3 per cent compared with its Step 3 value. In the BOTE model, with Y effectively given by (E2), and with C, I, G, and M now determined exogenously, (E1) must calculate the movement in X. This explains why the contraction in export volumes becomes larger in Step 4. With I higher in Step 4, with C, G, and M equal to their Step 3 values, and with Y largely unchanged from its Step 3 value, the increase in I can only be accommodated by a contraction in X. The movement towards deficit in the balance of trade between Step 4 and Step 3 requires that the real exchange rate appreciate between the two steps. The contraction in export volumes also accounts for the improvement in the terms of trade in Step 4. The improvement in the terms of trade raises real GNP, which explains why a smaller increase in the APC is required in Step 4.

3.7 Step 5: The composition and level of export volumes

In Step 5 of the MONASH historical simulation, export volumes by commodity are determined exogenously. In terms of the BOTE model, there are a number of options available for determining aggregate export volumes exogenously. This can be seen by substituting (E8) into (E2), and then substituting the result into (E1); and by considering (E6):

(E9) $X = Y(\overline{A}, \overline{L}, TOT, \overline{ROR}) - (\overline{C} + \overline{I} + \overline{G} - \overline{M})$

(E6) $TOT = J(X, \overline{V})$

By Step 4, this system of equations is determining X and TOT. In Step 5 we wish to move X to the set of exogenous variables. Closure options for doing so are to either endogenise the supply of exports by allowing for movements in Y (by endogenising A, L, or ROR), or endogenise the demand for exports (endogenise V). Information relating to L and ROR will be introduced later, in Steps 6 and 8, hence they are not good candidates for endogenisation in Step 5. This leaves one supply-side variable (A) and one demand-side variable (V). However as Dixon and Rimmer explain, endogenisation of neither variable on its own represents a satisfactory way of exogenously determining X. Between Step 4 and Step 5, X must increase by 110 percentage points. Accommodating this through technical change (A) alone would require a very large reduction in TOT via (E6). Alternatively, accommodating the increase in X through shifts in foreign demand alone would require a very large improvement in TOT in order to lift the capital stock (via E8) by an amount sufficient to raise Y to its required level. These swings in the terms of trade did not occur over the historical period. In terms of the BOTE model, we must simultaneously determine X and TOT exogenously, by endogenously determining shifts in foreign demands (V) and shifts in domestic primary factor productivity (A). A similar approach is adopted in MONASH. Export volumes for individual commodities are determined exogenously via the endogenous determination of commodity-specific shifts in positions of export demand schedules (V in the BOTE model). Movements in the terms of trade[2] are controlled by exogenously determining the nominal exchange rate (not in the BOTE model) at its observed change over the period, and endogenously determining primary factor productivity. The nominal exchange rate depreciated by approximately 15.5 per cent over the historical period. Hence between Step 4 and Step 5 the nominal exchange rate must depreciate by approximately 40 per cent. With the ratio of the price of exports to the price of non-traded goods largely given, and with the price of non-traded goods largely given by the exogenous status of the CPI, the depreciation of the nominal exchange rate produces a reduction in the terms of trade. This causes the capital stock to fall between Steps 5 and Step 4. Hence the increase in export volumes between Steps 5 and 4 must be accommodated through technological improvement. This accounts for the economy-wide reduction in per unit output requirements of primary factor inputs of 21.7 per cent. This causes GDP to rise relative to its Step 4 value. With C, I, and G still exogenously fixed at their Step 4 values, the rise in real GDP produces a large fall in net foreign liabilities.

3.8 Step 6: Employment

Information on movements in employment for 159 sectors is introduced to MONASH in Step 6. In terms of the BOTE model, since L is already exogenous, this simply involves increasing L by its historically observed amount. However in MONASH we introduce information on movements in employment by industry. This is introduced in two steps. First, variables describing employment by industry are determined exogenously, and corresponding variables describing primary factor technical change in each industry are determined endogenously. This introduces two conflicts with the closure inherited from Step 5. Firstly, with primary factor technical change endogenous in each industry, it is not possible for a variable describing economy-wide technical change to also be endogenous. Secondly, with employment in each industry determined exogenously, it is not possible for employment at the national level to also be determined exogenously. This potential closure conflict is removed by determining aggregate employment endogenously and setting the economy-wide shift variable on primary factor technical change exogenous. Under this closure of MONASH, aggregate employment is now determined as the weighted sum of movements in industry employment, and economy-wide primary factor technical change is now determined as the weighted sum of changes in industry-specific primary factor technical change terms. This explains why, when we look at Table 3, we see that from Step 6 onwards movements in *a1primgen* are zero and we see instead movements in *ave_aprim*.

We can see from the BOTE model that by Step 6 we have effectively fixed Y by the exogenous determination of C, I, G, X and M. In the BOTE model TOT is also exogenous (and in MONASH largely tied down by the exogenous determination of the exchange rate). Hence together (E2) and (E8) determine K and A:

(E2) $\overline{Y} = (1/A)\, F(K, \overline{L})$

(E8) $K/\overline{L} = N(\overline{ROR}, A, \overline{TOT})$

The shocks to sectoral employment levels in Step 6 cause aggregate employment to rise by 10.9 per cent. Initially we might expect the capital / labour ratio to remain unchanged, leading to an increase in K via (E8). However with both K and L increasing in (E2), the required shift in A is now lower in Step 6. Via (E8) this lowers the capital / labour ratio, damping the responsiveness of K to the movement in L. We see this reflected in the MONASH results. In Step 5, a 21.7 per cent improvement in primary factor productivity was required to accommodate the exogenous determination of export volumes and the exchange rate at their historically observed values. Now, with factor supplies greater in Step 6, a smaller improvement in primary factor technical change is required. With L higher so too is K, but the deterioration in A causes the K / L ratio to fall: while L rises by 10.9 per cent, K only rises by 7.5 per cent. With real consumption and real GDP fixed, there is little change in national savings between Step 5 and Step 6, hence the increase in K must be financed by an increase in net foreign liabilities. This reduces GNP, requiring the APC to increase from its Step 5 value.

3.9 Step 7: Capital

In Step 7 of the MONASH simulation, sectoral capital stocks are determined exogenously. In MONASH, this is accommodated by offsetting movements in variables describing shifts in labour and capital technical change by sector that are locally cost-neutral. In terms of the BOTE model, K is switched to the exogenous category and parameters governing the functional relationship between K, ROR, A, and TOT given by (E8) are determined endogenously (that is, E8 is effectively removed from the BOTE model). In the MONASH simulation the effect of determining sectoral capital stocks exogenously is to lift economy-wide capital by 0.5 per cent above its Step 6 value. With L and Y largely given in Step 7, the value of A must be lower. Hence in the MONASH simulation *ave_aprim* rises by about 0.2 percentage points. With C and Y fixed, there is little change in national savings between Step 6 and Step 7, hence the increase in K must be financed by an increase in net foreign liabilities. Note that the increase in net foreign liabilities is relatively large compared to the movement in K. This is because percentage movements in K in Table 3 are measured as the rental weighted sum of the percentage changes in industry capital stocks. However changes in net foreign liabilities driven by changes in capital quantities depend on the asset prices of those quantities, not their rental prices. Between Step 6 and 7 the asset value weighted sum of the percentage changes in industry capital stocks (not shown in Table 3) rises by 3 per cent. This reflects a change in the composition of the national capital stock between Steps 6 and 7 towards sectors with lower rates of return (that is, relatively high asset prices compared with rental rates). The increase in net foreign liabilities causes GNP to fall relative to its Step 6 value. This requires the APC to increase from its Step 6 value

3.10 Step 8: Profitability and wage rates

In this step, prices of value added for 48 sectors and wagebills for 48 sectors are determined exogenously. By this stage in the decomposition simulation, employment by industry has been exogenous since Step 6, hence the exogenous determination of wagebills in this step effectively determines industry wage rates. However in the MONASH simulation the national real wage rate is also determined exogenously, and a scalar shift on the (otherwise exogenous) sectoral wagebills is determined endogenously – effectively, this sets both the national real wage and sectoral wage relativities exogenously. With prices of sectoral value added determined exogenously, and sectoral wage rates effectively determined exogenously, movements in capital rental prices must now be determined endogenously. Setting sectoral value added prices and wagebills exogenously at their historical values has a relatively small impact on the macroeconomic variables reported in Table 3. The main effect is to reduce slightly capital rental rates in export sectors. This reduces the amount of outward movement in export demand schedules required to account for the historically observed movements in export quantities. This causes a small fall (1.5 percentage points) in the terms of trade between Steps 7 and 8. The decrease in the terms of trade causes net foreign liabilities to be higher, which in turn reduces GNP. With GNP now lower in Step 8, and consumption exogenous, the propensity to consume out of GNP must be higher than its Step 7 value.

3.11 Step 9: Output volumes and export prices for agricultural commodities

For the historical period under study, the Australian Bureau of Statistics is able to provide data on the changes in output and export prices for agricultural commodities. In this step, output quantities and foreign currency export prices are determined exogenously for the four MONASH agricultural commodities which are major exporters[3] (sheep, grains, beef cattle, and other agriculture).

Foreign currency export prices are determined exogenously by endogenously determining demands for agricultural commodities. Export demands for these commodities have been determined exogenously since Step 5, hence this step allows for endogenous movements in domestic demands for these commodities. The commodity “sheep” is an aggregate of both wool and sheep meat. For this commodity, the endogenous demand-side shifts required to support the exogenous determination of the sheep export price were split one-third towards input-using technical change (reflecting the proportion of sheep production representing sheep meat) and two-thirds towards stock adjustment (reflecting the proportion of sheep production representing wool). For grains, the required demand-side freedom was provided by endogenous adjustments to stock demands. For the remaining two agricultural commodities (beef cattle and other agriculture), foreign currency export prices were determined exogenously by endogenous economy-wide movements in input requirements of the two commodities.

Commodity outputs were determined exogenously by endogenous movements in supply. For all four commodities, the required supply shifts were secured via endogenous movements in production taxes. This ensures that the basic prices for these commodities, which are faced by all agents in the model, reflect the exogenous historical data on foreign currency prices that are input to the model in this step. This is reasonable given that a high proportion of the output of each of these commodities is exported.

There is little change in the macroeconomic variables reported in Table 3 between Steps 8 and 9. The endogenous calculation of sheep (wool) and grain stocks in this step leads to a small overall increase in stock demands. This causes real GDP to be slightly higher (0.2 percentage points) in Step 9. Since inputs of K and L are exogenous in Step 9, the increase in stock demand must be accommodated through a small improvement in technical change. The largest difference between the two simulations is in the terms of trade. These decline by 0.7 percentage points. This reflects the exogenous determination of foreign currency export prices for agricultural commodities in this step. Compared to their values in Step 8, the weighted average of these prices is slightly lower in Step 9.

3.12 Step 10: Import prices and prices of non-agricultural exports

Step 10 adds to the historical simulation the exogenous determination of foreign currency import prices by commodity and foreign currency export prices for the remaining commodities not already dealt with in Step 9. Foreign currency import prices are exogenous in the decomposition closure, and so their exogenous determination at their historically observed values poses no closure issues in Step 10. The foreign currency export price of each commodity (not otherwise dealt with in Step 9) is determined exogenously through endogenous movements in an indirect tax. Effectively these taxes drive a wedge between the domestic currency price of a given commodity and its foreign currency price. For each commodity the export price of which is thus determined exogenously, there is a choice of one of two taxes: a tax that falls only on export sales of the commodity, or a tax that falls on all sales of the commodity. Unlike the commodities that are the focus of Step 9, most of the commodities considered in Step 10 tend to either export relatively small proportions of their output or there is evidence that the versions of the commodity that are exported differ from those that are used locally. For these commodities there is a reasonable expectation that domestic and foreign prices can diverge, and so the indirect tax falling only on export sales is endogenised for these commodities. However five of the commodities (Coal, oil and gas; Iron ore; other metal ores; iron and steel; and basic non-ferrous metal products) dealt with in this step either export large proportions of their output (Coal, oil and gas; Iron ore; other metal ores; and basic non-ferrous metal products) or there is little difference between domestic and export varieties of the good (iron and steel). For these five commodities, the exogenously determined foreign currency prices are allowed to determine domestic prices. This is achieved via the endogenous determination of an indirect tax affecting all (domestic and export) sales of each commodity.

The exogenous determination of foreign currency import prices and foreign currency export prices in this step effectively fixes the terms of trade. Hence between steps 9 and 10 the main change is in the terms of trade, which rise by 1.2 per cent. The improvement in the terms of trade lifts GNP slightly, hence the movement in the APC out of GNP is slightly lower than its Step 9 value. The other major change is in the real exchange rate, which devalues by 4.7 percentage points relative to its Step 9 value. The real exchange rate in MONASH (*realdev* in Table 3) is defined as the ratio of foreign prices (measured by the import price index) to domestic prices (measured by the GDP deflator). There is little change in the GDP deflator between Steps 9 and 10. This reflects the fact that most of the GDP deflator (the CPI) is exogenous, and much of the remainder (the terms of trade) changes little between Steps 9 and 10. However the import price deflator is now effectively determined exogenously in Step 10 (since import prices by commodity are determined exogenously). The exogenous determination of import prices by commodity in Step 10 lifts the import price index by approximately 4.7 per cent above its Step 9 value. This accounts for the real devaluation between Steps 9 and 10.

3.13 Step 11: Outputs of non-agricultural commodities

In this step outputs of those commodities not already dealt with in step 9 are determined exogenously. For each commodity, this is achieved through one of two mechanisms.

For most commodities, exogenous determination of domestic output is achieved through endogenous movements in input requirements for the commodities on the part of producers, capital creators, and households. The impact that these movements in commodity input requirements would otherwise have on production costs and the cost of capital are then neutralised via endogenous movements in all input using technical change on the part of producers and capital creators. Note however that for margin commodities (trade, transport, insurance) the endogenous movements in the input requirements of these commodities operate on both direct and margin demands. While the consequences for costs of movements in input requirements of margin commodities for direct input to current production and capital formation are neutralised in the way just outlined, this is not the case for use of the commodities as a margin service. As discussed later in this section, this has implications for the productivity of the economy in this step.

For commodities where sales to producers, capital creators and households represent a relatively small share of demand, endogenous movements in input requirements are clearly not a satisfactory way of accommodating the exogenous determination of commodity outputs. These are typically commodities for which we have already fed into the model a large part of the demand and supply side stories: public consumption (step 1), household consumption (step 2), import supply (step 3), and export demands (step 5). For these commodities[4], the information on total domestic output introduced to the model in step 11 is reconciled with what the model would otherwise have calculated to be total output through endogenous scaling of the exogenous demand and supply side information already fed into the model in this and earlier steps. For example, assume that in step 11 we exogenously introduce information to the model on the output of commodity *j* that is greater than what the model would otherwise have calculated the output of commodity *j* to be. The adjustment mechanism that is endogenised to accommodate this in Step 11 sets in train the following adjustments: the exogenous information on the output of commodity *j* will be scaled down slightly; the exogenous information on public demand for *j* (step 1), private demand for *j* (step 2), and export demand for *j* (step 5), will each be scaled up slightly; the exogenous information on imports of *j* (step 4) will be scaled down slightly. In short, the conflicting historical information on the demand and supply of commodity *j* are reconciled through uniform scaling of the historical information. It is this scaling that accounts for the small increase in private and public consumption and the small decrease in import volumes between Steps 10 and 11.

The increase in consumption and decrease in imports that occurs between Steps 10 and 11 causes real GDP to be slightly higher than its Step 10 value. Despite inputs of primary factors being largely unchanged[5], the improvement in primary factor productivity is less than its Step 10 value. Recall that, unlike the movements in other commodity-saving technical change generated in Step 11, the movements in input requirements of margin commodities for use as margin services are not cost neutral. The information fed into the model in this step on the output of margin commodities implies significant input-saving technical change in the use of wholesale and retail trade margins and air and water transport margins. The improvement in productivity that these savings represented were more than enough to account for the increase in real GDP. This allowed the improvement in primary factor technical change in Step 11 to be lower than its Step 10 value.

3.14 Step 12: Consumer prices

The ABS provided information on movements in consumer prices for 45 national accounts commodities. Recall that the consumer price index is exogenous, and shocked in Step 0. Hence to avoid inconsistency with the exogenous value of the CPI, the ABS information on the consumer prices of national accounts commodities is used in this step to exogenously determine movements in the relative prices of consumer goods. The information on relative consumer prices introduced to the simulation in this step has little affect on the macroeconomic results reported in Table 3. With consumption by national accounts commodity determined exogenously in Step 2, the main effect of the price information introduced to the model in this step is to allow MONASH to better calculate taste-induced shifts in household demands for particular commodities. The historical simulation revealed shifts in household tastes away from non bank finance, household appliances, publishing, personal and other services, transport equipment and dwellings services. At the same time, there were positive shifts in household preferences towards consumption of more pharmaceuticals, restaurants and hotels, communication services, electronic equipment, meat products, air transport and road transport.

4. THE DECOMPOSITION SIMULATION

4.1 Overview of the decomposition closure

While the closure of the model in the historical simulation is unusual, in the decomposition simulation a more natural closure of the model is adopted. Broadly, variables describing structural features of the economy (technology, tastes, taxes) are returned to the exogenous category, and variables describing observable features of the economy (commodity outputs and prices, macro aggregates) are returned to the endogenous category. In terms of the BOTE model, the decomposition closure is described by column (1) of Table 2. In terms of the notation outlined in Section 2.2, the elements of $X(\bar{H}D)$ and $X(HD)$ are exogenous and shocked equal to their values in the historical simulation. Table 1 provides a detailed description of the MONASH variables in these two sets. Figure 1 further expands on the nature of the decomposition closure by outlining the direction of macroeconomic causation under this closure. The results of the decomposition simulation are reported in Table 4. Before proceeding with the discussion of these results, it is useful to consider Dixon and Rimmer's (2002: 47-49) discussion of the MONASH decomposition closure. This is explained with the aid of the BOTE model and Figures 1 and 2.

Figure 1 describes the direction of macroeconomic causation among the key macroeconomic variables of MONASH. Variables that are endogenous in the decomposition closure are represented by an oval, while those that are exogenous are represented by a rectangle.

The first thing to note in Figure 1 is that employment (ΔL), technology (ΔA) and rates of return (ΔROR) are all exogenous under the decomposition closure. Likewise, turning to the BOTE model, we see that L, A, and ROR are exogenous. The exogenous status of ΔA and ΔROR ties down the MP_K[6]. Sectoral production functions in MONASH are CRS, hence MP_K functions are homogeneous of degree 0 and so can be expressed as functions of K / L ratios and A. Hence the exogenous status of ΔROR and ΔA fixes $\Delta(K / L)$. With ΔL exogenous, this is sufficient to determine ΔK. These mechanisms are represented by connections (4) (5) and (6) in Figure 1. In the BOTE model they are represented by (E8).

As already described, with ΔROR and ΔA exogenous, MP_K is largely given. The production function and given technology fixes the relationship (the factor price frontier) between MP_K

and the efficient MP_L. Hence with MP_K given, so too is MP_L and along with it the real wage. This accounts for connections (16) and (17) in Figure 1.

With ΔK, ΔL and ΔA determined, so too is real GDP (ΔY). This is represented by connections (3) (1) and (2), which clearly describe a production function relationship. In the BOTE model the same relationship is expressed by (E2). In the BOTE model, with L, ROR, and A fixed, (E8) can be thought of as largely determining K. With K determined by (E8) and with A and L exogenous, (E2) must determine Y.

The bottom "row" of Figure 1 represents the GDP expenditure identity, which in the BOTE model is given by (E1). Notice in Figure 1 that real consumption (ΔC) and real investment (ΔI) are determined elsewhere in the model: real consumption via an assumption of an exogenous average propensity to consume out of GNP (connection 10), and real investment via an assumption of exogenous investment/capital ratios. This leaves the balance of trade (ΔBOT) as the slack variable in the bottom row of Figure 1. In the BOTE model the same connections are represented by (E3) and (E7). However unlike Figure 1, the BOTE model does not define a variable describing GNP. Hence (E3) simply links private and public consumption to GDP. In Figure 1 ΔGNP, as in MONASH, is determined by ΔY via connection (8) and movements in net foreign liabilities (ΔNFL) via connection (9) under an assumption that the interest rate on NFL is exogenous[7].

Movements in ΔNFL are determined by three connections: the domestic savings / investment imbalance between 1996/97 and 2001/02 (connections 13 and 14) and "momentum" (ΔU, connection 15). The two variables $I_{97/02}$ and $S_{97/02}$ require further explanation. $S_{97/02}$ is the accumulated savings that occur over the simulation period less that amount of savings that would have occurred had their been no change in GNP over the period (Figure 2). To calculate this, two assumptions are made. Firstly, savings in each year between 1997 and 2002 are assumed to be a fixed proportion of GNP. Secondly, the path of GNP between its initial 1997 value and its final 2002 value is assumed to exhibit smooth growth. This allows the accumulated value of savings (above what they would have been if GNP had remained at its 1997 value) to be calculated as a simple function of ΔGNP (connection 11). Similarly, $I_{97/02}$ is the accumulated investment that occurs over the simulation period less that amount of investment that would have occurred had their been no change in the capital stock over the period (connection 12). The effect of the investment / savings balance on NFL is straightforward: if investment requirements exceed savings over the period then NFL must rise by the difference plus accumulated interest. Momentum or ΔU takes account of the fact that even if there were no changes in the economy over the period 1996/97 to 01/02 then NFL in 01/02 would still nevertheless differ from its 1996/97 value. The amount by which it would differ from its base value would be the sum of two items: (i) accumulated net interest on the initial stock of NFL and (ii) the difference between the amount of investment that would have had to occur between 96/97 and 01/02 to keep the capital stock at its 96/97 value, and the amount of savings that would have occurred (S_U in Figure 2) over the period had GNP remained at its 96/97 level.

The change in the capital stock over the simulation period (ΔK) must have implications for the amount of investment that took place over the simulation period ($I_{97/02}$), but not the level of investment at the end of the period (ΔI). The latter will be determined by expectations of future profitability, ie. business confidence. Nevertheless Figure 1 describes ΔI as being related to ΔK (connection 7). This reflects an assumption that business confidence is exogenous. The exogeneity of business confidence is reflected in the MONASH decomposition closure by linking investment in each sector to sectoral capital stocks via an assumption of exogenous investment / capital ratios. This is reflected in the BOTE model by (E7). ΔK also enters the NFL accumulation calculation via connection 12: the change in K over the simulation period has implications for the amount of investment that took place over the simulation period ($I_{97/02}$) and hence ΔNFL (connection 13).

4.2 Results of the decomposition simulation

Table 4 reports the results of the decomposition simulation. Over a thousand MONASH variables are shocked in this simulation, so reporting the results necessarily requires some summarisation. Hence the individual effects of each of the exogenous shocks are aggregated within 10 sets of like variables. Using the decomposition algorithm of Harrison, Horridge and Pearson (2000)[8] the sum of the contributions made by the 10 sets of exogenous variables is exactly equal to the total effect given in column 11 of Table 4. Note that the results in Column 12 of Table 4 do not exactly equal the results for Step 12 of Table 3. While the results in Column 12 of Table 4 represent an exact solution to the model, the results in Table

3 were calculated using single-step Johansen approximations of the true solution. This is because, in constructing the historical simulation, we were concerned with analysing the step-wise introduction of new historical information under an increasingly complex closure. That is, we were not concerned with decomposing the total results of the historical simulation into the individual contributions of the shocks applied in Steps 1 through to 12 under one common closure.

Column 1: Momentum

The results in Column 1 isolate the effect of the momentum shock, that is, it shows what would have happened to the Australian economy if none of the shocks represented by Columns 2 through 10 had occurred. Recall from the preceding discussion that the momentum shock measures the change in NFL that would have occurred over the simulation period had savings remained unchanged from its base period level and investment been just sufficient to maintain the capital stock at its base period level. In the initial database (1996/97) savings is significantly larger than depreciation investment. With little change in K in column 1, the momentum shock generates a large reduction in NFL as a proportion of GDP (row 21). This causes a fall in net foreign interest payments, causing real GNP to increase (row 2). As discussed earlier, movements in real private and public consumption are linked to real GNP via an exogenous APC. Hence with real GNP higher, so too is real consumption (rows 3 and 5)[9]. However the macro closure allows for little change in real GDP (row 1). In terms of the BOTE model, with A, ROR and L exogenous, K is effectively given (equation E8). With L and K given, so too is GDP (equation E2). As equation (E1) of the BOTE model makes clear, with real consumption higher, and real GDP rising only slightly, the balance of trade must move towards deficit (row 20). This is achieved through an appreciation of the real exchange rate (row 11). The appreciation in the exchange rate causes export volumes to contract (row 6). The increase in import volumes (row 7) can be traced to both the real appreciation and the increase in activity (equation E5 of the BOTE model). Via (E6) of the BOTE model the contraction in export volumes causes the terms of trade to increase (row 19). This accounts for the increase in capital (row 9) which in turn explains the small increase in real GDP (row 1). The increase in capital also accounts for the increase in real investment (row 4). With the capital stock higher, but employment unchanged, the marginal product of labour must rise. This accounts for the increase in the real wage (row 10). The movement in the terms of trade also explains the impacts on the price deflators (rows 16 – 18). Recall that the CPI is the numeraire, and so is unaffected by the momentum shock. The investment price deflator (row 18) is relatively import intensive, so it declines relative to the CPI as the terms of trade improve. The GDP deflator (row 16) includes the prices of exports but not the prices of imports. Hence the terms of trade improvement causes the GDP deflator to rise.

The sectoral results largely follow from the macroeconomic results. With real private and public consumption higher, so too is the activity of those sectors that sell relatively large proportions of their output to households and government. This accounts for the expansion in the activity of sectors 19 through to 25. However the appreciation of the real exchange rate hurts service exports. Hence export-oriented service sectors such as Education (foreign students) and Restaurants and hotels (foreign tourists) do not gain to the same extent from the expansion in domestic consumption spending. Agricultural, mining, and manufacturing exports also contract with the appreciation in the real exchange rate. This largely accounts for the impacts on sectors 1 through 10.

Column 2: Foreign factors

Column 2 isolates the effects of shifts in foreign demands for Australian exports and shifts in foreign currency import prices. These shifts are considered to be an expression of changes in foreign activity and relative prices, and so are considered simultaneously in Column 2. Shifts in foreign demands and import prices were slightly favourable to Australia over the period, lifting the terms of trade by 5.1 per cent (row 19). Via (E8) of the BOTE model, with technology and rates of return unchanged, the improvement in the terms of trade lifts the capital / labour ratio. With employment exogenous, this causes capital to increase (row 9). The increase in capital causes the real wage to rise (row 10). The increase in K also causes real GDP to be higher (row 1). Notice however that real GNP (row 2) rises faster than real GDP (row 1). This is due to the improvement in the terms of trade: consumer prices (used to deflate GNP in row 2) include import prices but not export prices, while the GDP deflator (used to deflate GDP in row 1) includes export prices but not import prices. With GNP rising faster than real GDP, so too does private and public consumption (rows 3 and 5). Also, since the capital stock is higher, so too is real investment (row 3). Hence real GNE rises faster than real GDP, requiring the real balance of trade (rows 6 and 7) to move towards deficit. This requires the real exchange rate to appreciate (row 11). Despite this, the balance of trade as a proportion of GDP (row 20) increases slightly, reflecting the improvement in the terms of trade.

While changes in foreign trading conditions have little impact on total exports, the composition of exports (rows 13 to 15) change significantly. Reversing the historical trend for Australia, shifts in foreign demands for traditional export commodities (particularly mining) over the study period were larger than those for non-traditional and tourism exports. Since the latter commodities experienced relatively weak shifts in their foreign demand schedules, the real exchange rate appreciation generated by the terms of trade improvement causes a contraction in their export volumes.

The sectoral results reflect the macro results. The mining sector (row 2) expands sharply, reflecting large favourable shifts in foreign demand for Australian mining output. However real appreciation hurts the other trade-exposed sectors: Agriculture (row 1), textiles (row 4), chemicals (row 6), metal products (row 7), transport equipment (row 8), other manufacturing (row 10). Contraction in tourism exports is reflected in falls in activity in entertainment (row 20) and restaurants and hotels (row 22). Sectors providing margin services on non-traditional exports (transport and finance, rows 15 and 16) contract because of the fall in volumes of non-traditional exports. The increase in real private and public consumption spending is reflecting in increased output of service sectors such as education, health, personal services, ownership of dwellings, public admin and defence. The construction sector (row 12) expands because of the increase in real investment.

Column 3: Tariffs

There were small falls in protection across most commodities over the study period. Textiles, clothing, footwear, and motor vehicles were subject to the largest reductions in protection: for textiles, clothing and footwear, reductions in protection reduced the landed duty paid price by approximately 7 per cent, while for motor vehicles the reduction was approximately 3 per cent. Reduced protection had relatively small effects on the macro-economy, and small negative effects on prospects for the protected sectors. The first thing to note about the macro results is that there is a small increase in the capital stock (row 9). This is due to reductions in tariffs on imported inputs to capital formation. Investment is relatively import intensive. Hence the reductions in protection cause the investment price deflator (row 18) to fall relative to the GDP deflator (row 16). This causes the marginal product of capital to fall, requiring that the capital / labour ratio rise. This explains the small increase in the capital stock (row 9). The reductions in protection reduce relative prices of imported goods, causing an increase in import volumes (row 7). With real GDP and real GNE largely unaffected by the reductions in protection, the increase in import volumes must be associated with an increase in export volumes (row 6). This causes the terms of trade to decline (row 19). The decline in the terms of trade, and the small increase in capital, account for the small rise in NFL. This causes a small contraction in GNP, and hence real consumption. This reinforces the increase in export volumes and the decline in the terms of trade.

The reduction in protection had minor adverse effects on output of the more highly protected sectors (rows 4 and 8). The increase in national export volumes is reflected in increased output of agriculture and mining, and the more export-oriented manufacturing sectors.

Column 4: Technical change

The results in Column 4 isolate the effects of changes in:

- primary factor productivity by industry;
- per-unit of output input requirements of each commodity for use in current production and capital formation;
- all-input using technical change in current production by industry; and
- all-input using technical change in capital formation by industry .

Overall, the changes in sectoral technology variables lifted economy-wide productivity (A in Figure 1 and the BOTE model). This caused the capital stock, real wages, and real GDP to be higher. The increase in real GDP causes real GNP to be higher. However the resulting increase in domestic savings is not sufficient to pay for the investment required to generate the higher capital stock. Hence NFL as a proportion of GDP rises (row 21). Real private and public consumption rises less quickly than the increase in real GNP. This is because the increase in the real wage causes the government price deflator to rise relative to the consumer price deflator (government consumption spending is relatively labour intensive). The rise in real investment tracks the rise in capital. With L fixed and A rising, the increase in K is necessarily less than the increase in Y. Hence so too is the increase in I. With C and I rising less than the increase in Y, the balance of trade must move towards surplus. This is facilitated by real depreciation (row 11). Despite the large increase in domestic activity generated by technical change, growth in imports is subdued (row 7). Via a relationship such as that given by (E5) of the BOTE model, we would typically expect to see imports exhibit more response to an increase in domestic activity than that exhibited in column 4. Part of the reason for this is real depreciation (row 11), which is required to move the balance of trade towards surplus. However the main reason is technical change away from the usage of commodities that are relatively import intensive. In particular, the results of the historical simulation suggested that requirements per unit of output for *clothing*, *motor vehicles*, *electronic equipment*, *agricultural machinery* and *other machinery* fell over the study period. At the same time however this effect was slightly offset by commodity-using technical change towards the usage of pharmaceuticals, which has a relatively high import share.

The sectoral results reflect both the macro results and the details of the sectoral technical change shocks. Most sectors expand, reflecting the relatively uniform expansions in private and public consumption spending, investment spending, and exports. Two of the largest expansions in activity are experienced by Finance and insurance (row 16), and Other business services (row 17). This reflects both productivity improvements in the production of these goods, and shifts in input requirements towards the usage of more of their output. *Other property services*, *banking*, *financial services*, *insurance*, and *law*, *accounting and marketing* all experienced relatively large improvements in productivity over the study period. This reduces the prices of the output of these industries, inducing increases in the quantity of their output demanded. At the same time, there were large autonomous shifts towards requirements for more of the output of *financial services*, *insurance*, *non bank finance*, *other business services*, *law accounting and marketing*, and *other property services*. Together, these supply and demand side shifts account for the strong growth in the output of the Finance and insurance (row 16) and Other business services (row 17) sectors.

Other MONASH industries to experience relatively large improvements in productivity were *wholesale trade*, *mechanical repairs*, *other repairs*, *air transport* and *rail transport*. Unlike Finance and Other business services (sectors 16 and 17), the improvement in the productivity of these industries do not show up as obvious increases in the output of the corresponding aggregated sectors contained in Table 4. This so for two reasons. Firstly, *wholesale trade*, *air transport* and *rail transport* sell relatively large proportions of their output as margin services. Demands for these commodities as margin services are not modelled as being (directly) price-sensitive in MONASH. Secondly, in Table 4 the results for MONASH industries *mechanical repairs* and *other repair*s are aggregated with results for the much larger industry *retail trade* in sector 14 (Retail trade and repairs). The results for sector 14 are dominated by prospects for the retail trade industry. There were reductions in per-unit input requirements of *retail trade* margins over the study period.

Output of Basic metal products (row 7) and Construction (row 12) fall because of both deteriorations in productivity in these sectors and reductions in per-unit input requirements for their output. The increase in Ownership of Dwellings output (row 23) reflects the increase in real consumption spending (spending on Ownership of Dwellings is income elastic) and a reduction in the price of capital inputs to Ownership of Dwellings (reductions in per-unit input requirements of Construction translates to lower prices for housing capital). Wholesale trade (row 13) and particularly retail trade (row 14) expand by less than the increase in real GDP. This reflects reductions in per unit requirements of these commodities (particularly retail trade) as margin services.

Column 5: Preferences for imported / domestic varieties of each good

The results in Column 5 isolate the effects of shifts in commodity-specific import / domestic twist variables. As Dixon and Rimmer 92002) note, a typical demand equation for source-specific commodity *i* in MONASH has the form[10]:

$$(x_{i,imp} - x_{i,dom}) = -\sigma_i (p_{i,imp} - p_{i,dom}) + twist_i$$

where:

$x_{i,imp}$ is the percentage change in the demand for imported *i*;

$x_{i,dom}$ is the percentage change in the demand for domestic *i*;

σ_i is the elasticity of substitution between domestic and imported *i*;

$p_{i,imp}$ is the price of the imported variety of *i*;

$p_{i,dom}$ is the price of the domestic variety of *i*; and

$twist_i$ is a cost-neutral shift in imported / domestic varieties of good *i*.

In the historical simulation the $twist_i$ variables are determined endogenously by the above equation, with $x_{i,imp}$ and $p_{i,imp}$ exogenous and $x_{i,dom}$ and $p_{i,dom}$ determined elsewhere in the model. Thus movements in $twist_i$ account for that part of the historically observed movement in the import / domestic ratios for commodity *i* not explained by the movement in the relative prices of the imported and domestic varieties of *i*. In the BOTE model, twists are represented by the variable T in (E5). Over the study period, the twists tended to be in favour of imports, that is, in (E5) they acted to increase M. With L and A exogenous, and K tied down by (E8), via (E1) an increase in M must be associated with an increase in X. This accounts for the increase in exports (row 6). The increase in exports causes the terms of trade to decline (row 19), which causes the capital stock to fall (row 9). The fall in the capital stock causes a small fall in real GDP. This, and the decline in the terms of trade, causes real GNP to fall. With real GNP lower, so too is public and private consumption (rows 3 and 5). Real investment (row 4) is also slightly lower, reflecting the fall in the capital stock. With real GNE falling relative to GDP, the increase in X required by the increase in M is somewhat lower than it would otherwise need to be. Nevertheless, with the terms of trade declining, the increase in export volumes (row 6) must exceed the increase in import volumes (row 7). Turning to the sectoral results, the largest impacts from the movements in the twist variables are felt by two sectors: textiles, clothing and footwear; and transport equipment. In the historical simulation, the twists for the commodities produced by these sectors were relatively large, reflecting shifts in preferences away from the domestic version of each good towards the imported version of each good.

Column 6: Household tastes

In MONASH, the percentage changes in household commodity demands are given by equations of the form:

$$x3_i - q = \varepsilon_i (c - q) + \Sigma_j \eta_{i,j} p3_j + a3_i - \Sigma_k S3_k a3_k$$

where $x3_i$ is the percentage change in household demand for *i*; q is the percentage change in the number of households; ε_i is the expenditure elasticity for commodity i; c is the percentage change in household income; $\eta_{i,j}$ is the cross price elasticity of demand for good *i*; $p3_j$ is the percentage change in the price of good *j*; $a3_i$ is a shift in tastes towards commodity *i*; $S3_k$ is the share of commodity *k* in the household budget. In the historical simulation, $x3_i$ and $p3_j$ were exogenous, and the above equation determines movements in household tastes, $a3_i$. In the decomposition simulation, the $a3_i$ are exogenous and shocked equal to their historical simulation values. Column 6 isolates the effects of these taste change shifts. Some of the more important shifts in household tastes were away from Ownership of Dwellings (row 23) and Transport equipment (row 8), which account for the contractions in the activity of these sectors recorded in this column. At the same time, there were strong shifts in household tastes towards communication services (row 15), restaurants and hotels (row 22) and clothing and footwear (row 4). There were also strong shifts towards usage of more pharmaceuticals, but the impact of this on output of the chemicals and petroleum sector (row 6) was offset by a shift away from petroleum and coal products. The macroeconomic effects of the shifts in household tastes are relatively minor. The fall in Ownership of dwellings output causes the aggregate capital stock (row 9) to fall. This accounts for the fall in real GDP (row 1). With the capital stock lower, NFL as a proportion of GDP falls (row 21). This, and a small improvement in the terms of trade, accounts for why GNP is unchanged (row 2), despite the fall in GDP. The real wage (row 10) rises slightly because of the improvement in the terms of trade and the fact that most of the decline in the national capital stock is confined to the dwellings sector (which does not employ labour). The increase in the real wage causes the government price deflator to rise relative to the CPI, causing a small decline in real consumption (rows 3 and 5) relative to real GNP (row 2).

Column 7: National employment and the number of households

The results in Column 7 isolate the effects of employment and population growth over the simulation period. Leaving aside for the moment changes in TOT, it is apparent from (E8) of the BOTE model that, under the decomposition closure, an n% increase in L must generate an n% increase in K. This accounts for the strong growth in the capital stock in column 7. However capital does not increase by as much as employment, causing the capital / labour ratio to fall, and with it, the real wage (row 10). The fall in the capital / labour ratio is due to the decline in the terms of trade (TOT in the BOTE model). The strong increase in K causes NFL to increase (row 21) which causes the growth in real GNP (row 2) to be less than the growth in real GDP (row 1). Growth in real GNP relative to real GDP is also restricted by the decline in the terms of trade. While real investment moves in line with real GDP (because real investment moves in line with capital which, along with the increase in employment, accounts for the increase in real GDP), real consumption growth is less than real GDP growth because the growth in real GNP lags that of real GDP. Hence the increase in real GNE is less than the increase in real GDP. This requires the balance of trade to move towards surplus (rows 6 and 7), which is facilitated by real depreciation (row 11). The movement towards surplus is achieved primarily through a large expansion in exports (row 6) because, while real devaluation makes imports relatively more expensive than their Australian substitutes, import volumes are buoyed by the increase in domestic activity. The expansion in export volumes causes the terms of trade to decline (row 19). Consistent with the nearly uniform expansion in K and L, and the nearly uniform expansions in the demand side components of GDP, the sectoral outcomes (rows 1-25) are relatively uniform. Sectors that sell primarily to households and have relatively high expenditure elasticities (dwellings (row 23), restaurants and hotels (row 22)) do relatively well. The depreciation in the exchange rate assists the expansion of trade exposed sectors such as mining (row 2) and transport equipment (row 8). Despite its trade exposure, the expansion in agriculture (row 1) is relatively limited. This is because of an assumption of fixed agricultural land supplies to this sector.

Column 8: Changes in required rates of return

The historical simulation revealed that, on average, required rates of return on capital increased over the simulation period. In terms of the BOTE model, the point of initial impact of an increase in required rates of return is (E8). Assuming for the moment no change in the investment price index relative to the GDP deflator (summarised by TOT in E8), with A and L given, an increase in ROR must cause the marginal product of capital to rise: that is, K must fall. This accounts for the sharp reduction in the capital stock (row 9) in column 8. This in turn causes the marginal product of labour to fall, explaining the sharp decline in the real wage (row 10). The fall in capital means that domestic savings are more than sufficient to finance the required investment over 1996/97 – 01/02, hence NFL as a share of GDP is lower in 2001/02 (row 21). This reduces net interest payments, tending to increase real GNP (row 2). However real GNP declines sharply. Part of the explanation for the fall in real GNP is the reduction in real GDP (row 1), which falls because of the decrease in capital supply (row 9). Despite the fall in net interest payments, real GNP declines faster than real GDP. This reflects sectoral features of the MONASH model that are not captured by single commodity models such as those described by the BOTE model and Figure 1. In particular, the changes in required rates of return feed through into output prices, on which they have diverse impacts. Of particular importance in explaining the divergence between the real GDP and real GNE outcomes is the divergence between the investment price deflator (row 18) and the CPI (row 17). The sharp fall in the investment price deflator relative to the CPI causes the GDP deflator (row 16) to fall sharply relative to the CPI. This accounts for the relatively large gap between the outcome for real GNE (which is deflated by the CPI) and the outcome for real GDP (which is deflated by the GDP deflator)[11]. The fall in the investment price deflator is largely due to falls in required rates of return in the construction sector. The fall in the real wage (row 10) causes the government price deflator to fall relative to the CPI. This explains why real private and public consumption spending (rows 3 and 5) decline by less than the fall in real GNP (row 2). Real investment spending declines sharply (row 4) because of the fall in the capital stock. Together, the falls in consumption spending and investment spending almost match the fall in real GDP, so only a small movement towards surplus in the balance of trade is required (rows 6 and 7). The sectoral results broadly follow the macro results. With C, I and G contracting, most sectors experience reductions in activity. A notable exception is Basic metal products (row 7). Required rates of return in this sector fell over the period, causing the price of its output to fall. Since the sector exports a high proportion of its output, which is modelled as a traditional export commodity, the sector's activity is relatively sensitive to its output price. One of the largest contractions in activity was experienced by the Ownership of dwellings sector (row 23). This reflects both the contraction in real consumption spending, and an increase in the consumer price of dwellings services. There was little change in required rates of return on dwellings capital over the period. Nevertheless, the consumer price of dwellings services rises because of an increase in required rates of return in the property services industry, the output of which is an intermediate input to the ownership of dwellings sector. Output of the finance and insurance sector (row 16) contracts because of a sharp increase in required rates of return in this sector, particularly in the insurance industry. The output of this sector is also an intermediate input to Ownership of dwellings, and so adds to the cost pressure imparted by the rise in property service costs.

Column 9: Shifts in export supply curves

Recall that in Steps 9 and 10 of the historical simulation, phantom taxes on production (for producers of traditional agricultural export commodities) and sales (for other export commodities) were endogenised to facilitate the exogenous determination of foreign currency export prices. Column 9 of Table 4 isolates the effects of imposing the movements in these phantom taxes as exogenous shocks under the decomposition closure. On average, the movements in these taxes were slightly positive over the simulation period. The resulting upward shifts in export supply schedules results in an improvement in the terms of trade (row 19). Normally an improvement in the terms of trade is associated with an increase in the capital stock. However the increase in phantom taxes reduces the post-tax value of the marginal product of capital[12], causing the capital stock to contract (row 9). With the capital stock lower, so too is real GDP (row 1). This causes real GNP to be lower (row 2), although the fall in real GNP is less than the fall in real GDP because the fall in the capital stock allows NFL to be lower (row 21). The fall in the capital stock also reduces the marginal product of labour, requiring that the real wage be lower (row 10). This allows the falls in real private and public consumption spending (rows 3 and 5) to be less than the fall in real GNP, by depressing the labour-intensive government price deflator relative to the CPI. The contraction in the capital stock causes real investment to be lower (row 4). The contraction in investment is sufficiently large that, even though consumption falls by less than real GDP, the overall contraction in real GNE is about the same as the contraction in real GDP. Hence there is little change in the balance of trade (rows 6 and 7). However the composition of aggregate export volumes (rows 13 – 15) changes significantly. This reflects differences in the direction of change in the phantom taxes imposed on the commodities that make up the aggregates in rows 13 – 15. In particular, phantom taxes on traditional export volumes tended to rise strongly over the period. Increases in phantom taxes on Meat Products, Coal Oil and Gas, Other Metal Ores, and Iron Ore added between 12 and 25 per cent to the margin-exclusive export prices of these commodities. This caused exports of these commodities to contract. Overall, exports of traditional export commodities contracted by approximately 14.1 per cent (row 13). Traditional exports account for approximately half of total exports. As discussed above, the balance of trade is largely unchanged in this column.

However import volumes contract by approximately 1.4 per cent (row 7) because real GDP is lower. Hence total exports must contract by approximately the same amount (row 6). With total export volumes contracting by only 1.8 per cent but traditional export volumes contracting by 14.1 per cent, volumes of other exports must rise strongly. This accounts for the increase in volumes of non-traditional and tourism exports (rows 14 and 15). The required increase in these exports is secured by real exchange rate depreciation (row 11).

The sectoral results in Column 9 tend to follow the prospects for the major export categories discussed above. The mining sector (sector 2) is largely comprised of industries producing traditional export commodities. In particular, Coal Oil and Gas, Iron Ores, and Other Metal Ores all experience phantom tax induced upward shifts in their export supply schedules over this period. This accounts for the large reduction in the output of Mining in Column 9. Similarly, sector 3 (food processing) and sector 7 (basic metal products) also subsume a number of traditional export sectors (respectively: meat products, sugar, seafood, wines and spirits; and basic non-ferrous metal processing) which experience upward shifts in export supply. Real depreciation assists import competing sectors such as textiles clothing and footwear (sector 4) and transport equipment (sector 8). Construction (sector 12) contracts because it sells primarily to capital creators. Since aggregate investment is lower (row 4) so too is the demand for Construction output. Education (row 18) benefits from an increase in exports of education services.

Column 10: Miscellaneous macroeconomic variables

The results in Column 10 summarise the effects of shocks to a number of mainly macroeconomic variables:

- the ratio of public to private consumption;
- the ratio of total consumption to GNP;
- investment / capital ratios by industry;
- the commodity composition of government consumption demands;
- sectoral wage rates;
- changes in stock demands; and
- changes in consumption taxes.

The shocks to the ratio of public to private consumption (Γ in the BOTE model) and the ratio of total consumption to GNP (APC in the BOTE model) cause little change in total real consumption spending. They do however alter the composition of that spending away from public consumption (row 5) and towards private consumption (row 3). The shocks to industry investment / capital ratios (Ψ in the BOTE model) tended to be positive, leading to a strong increase in real investment (row 4). Also, stock demands for domestic *grains* and imported *other metal ores* were strong. Overall, real GNE in column 10 rises by about 3.7 per cent. This is greater than the increase in real GDP, so the balance of trade moves towards deficit (rows 6 – 7). The movement towards deficit is facilitated by real appreciation (row 11). Shocks to sectoral wage rates led to a small reduction in the wages of construction workers. This accounts for the small reduction in the investment price index (row 18). With rates of return constant, the decrease in the cost of capital causes the marginal product of capital to fall. With employment fixed, this requires the capital stock to rise (row 9). This effect is augmented by the movement of the balance of trade towards deficit. The resulting contraction in export volumes (row 6) causes the terms of trade to increase (row 19). This adds to the upward pressure on the capital stock (row 9). With the capital stock higher, but employment given, the marginal product of labour must rise. This accounts for the increase in the real wage (row 10).

The sectoral results can be explained in terms of both the macroeconomic shifts outlined above, and the shocks to sectoral variables in Column 10 (government demands by commodity, sectoral wage rates, changes in stock demands, and changes in consumption taxes). The positive result for Construction (sector 12) reflects the strong increase in aggregate investment spending (sector 4). Transport equipment (sector 8) also benefits from the increase in investment. It also benefits from the rise in consumption spending and a reduction in the rate of consumer taxation of transport equipment. Similarly, Ownership of Dwellings (sector 23) and Finance (sector 16) benefit from both the increase in real private consumption spending and negative movements in phantom consumption taxes. Chemicals (sector 6) contracts because of a large positive movement in the phantom taxation of the MONASH commodity Pharmaceuticals. Over the period under study the ABS records substantial increases in the prices faced by households for pharmaceutical products. This is accommodated in the MONASH historical simulation by a large positive movement in the phantom tax on household consumption of Pharmaceuticals. The sharp contractions in the output of the education and health and welfare sectors (sectors 18 and 19) reflects not only the decline in real public consumption spending (row 5) but also a shift in the commodity composition of government consumption away from these sectors and towards public administration and defence (sectors 24 and 25). Finally, real appreciation leads to contractions in export and import competing sectors such as agriculture (sector 1), food processing (sector 3) and textiles (sector 4). Despite the real appreciation, output of the export-oriented sector mining (sector 2) expands slightly. This is so for two reasons. Firstly, wages in the sector decline over the period. Secondly, the sector is relatively capital intensive, and so benefits from the reduction in the cost of capital.

5. CONCLUSIONS

Column 12 of Table 4 converts the observed outcomes in column 11 to annual average percentage changes. These are compared to the annual average outcomes over the period investigated in the previous historical study (Dixon and Rimmer 2002) in column 13. Comparing the first 9 rows of columns 12 and 13, it is clear that the second half of the 90's was a period of rapid growth for the Australian economy. For example real GDP grew at an annual average rate of 4.5 per cent in the latter period, compared with 2.6 per cent in the earlier period. Compared to the period 1986/87–93/94, the later period has also been one of relatively balanced growth, with all demand-side aggregates (other than public consumption) tending to move in line with real GDP, and the economy wide labour / capital ratio remaining relatively unchanged. One of the distinguishing features of the earlier period was the rapid growth in trade (rows 6 and 7) as a proportion of GDP (see Dixon Menon and Rimmer 2000). However over 1996/97–01/02 export and import volumes have grown broadly in line with growth in real GDP. While aggregate export volumes grew broadly in line with real GDP, the composition of aggregate exports did not. Like the earlier period, non-traditional export volumes (row 14) grew the most rapidly. However unlike the earlier period, growth in tourism exports was relatively slow (1.6 per cent), while growth in traditional export volumes (row 13) was in line with growth in aggregate export volumes.

With the exceptions of Education, Health, and Entertainment (rows 18 – 20) sectoral outcomes were, as in the period 1986/87–93/94, most favourable for the service sectors and least favourable for the traditional export and manufacturing sectors. The top and bottom ranked industries in terms of output growth were the same for 1986/87–93/94 and 1996/97–01/02. Finance (row 16) remained the fastest growing sector. This was followed by Other business services (row 17), Public administration (row 24), Defence (row 25), and Ownership of dwellings (row 23). Textiles (row 4) remained the lowest-ranked sector in terms of output growth, experiencing an annual average contraction of 2.9 per cent over the period. This was followed by Basic metal products (-0.8 per cent per annum output growth) and Construction (0.1 per cent per annum output growth).

A comparison of columns 1 – 10 of Table 4 provides an explanation of the developments in the Australian economy summarised in column 11. Rapid growth in real GDP is largely explained by technical change (column 4). This accounts for about 75 per cent of the total growth in real GDP, contributing about 3.4 percentage points per annum to real GDP growth. This could perhaps be viewed as being consistent with the expected outcomes from the substantial program of microeconomic reform that Australia has experienced since the mid 90's. Employment grew by about 11 per cent over the period, generating an expansion in capital of about the same amount (column 7). This increase in primary factor supply explains about 45 per cent of the total growth in real GDP, or 2.0 percentage points per annum. However there was an apparent increase in required rates of return on capital over the period (column 8), causing the capital stock, and hence real GDP, to be lower than what it might otherwise have been. This reduced the annual average growth rate for real GDP by about 0.9 percentage points per annum over the period. We can compare these results with those of Dixon and Rimmer (2002:51) for the period 1986/87–93/4. Just as in the later period, over 1986/87–93/4 technology and employment growth increased real GDP, while apparent increases in required rates of return reduced real GDP. However the contributions of each were much lower in the earlier period. Productivity growth was slow, contributing only 1.1 percentage points per annum to real GDP growth. Growth in employment was also slow, contributing only 1.3 percentage points per annum to real GDP growth. Increases in required rates of return reduced growth by 0.3 percentage points per annum (see Dixon and Rimmer 2002 : 51).

The improvement in technical efficiency (column 4) also contributed to the relatively balanced growth in the demand-side components of GDP, lifting consumption, investment and exports broadly in line with GDP. However growth in imports relative to exports was not stimulated by technical change, due to shifts in input requirements away from import-intensive commodities such as clothing, motor vehicles, electronic equipment, and machinery. One of the distinguishing features of the earlier period was the rapid growth in trade (rows 6 and 7) as a proportion of GDP (see Dixon Menon and Rimmer 2000). This is not a feature of the more recent history of the Australian macroeconomy. The reason for this lies in changes input requirements for import intensive commodities. In the earlier study period, technical change favoured the use of inputs that are heavily imported, such as electronic equipment and motor vehicles. This lifted aggregate import volumes, and with them, aggregate export volumes. In the more recent study period, technical change favoured the use of pharmaceuticals, which is import intensive. However input requirements for motor vehicles and electronic equipment fell. So too did requirements for other import-intensive commodities such as clothing and machinery. This had a damping effect on import volumes (and hence export volumes).

Despite the damping effect on import volumes of technical change, import volumes nevertheless managed to grow broadly in line with real GDP (column 11). To account for this we must turn to column 10, which explains the largest gap between import and export growth, and hence why, in total, imports were able to grow almost as quickly as exports despite the technical shifts away from import-intensive commodities. In Column 10 real GNE grows significantly faster than real GDP, requiring the balance of trade to move towards deficit. The rapid growth in real GNE relative to real GDP in Column 10 was due largely to positive shocks to investment / capital ratios by industry. Without these apparent improvements in investor confidence, import growth over the study period would not have been as strong, and hence there would have been a greater overall movement towards surplus in the balance of trade. These shifts in investment / capital ratios are also important in explaining why investment grows slightly faster than real GDP (column 14) over the period. The major contributors to the overall growth in investment were technical change (column 4), employment growth (column 7) and macro (column 10). Note however that technical change and employment growth produced relatively balanced growth in the demand-side components of GDP, so they do not explain the relatively rapid growth in real investment over the period. However approximately half of the growth in real investment is accounted for by the shocks summarised in column 10, the most important of which were the increases in sectoral investment / capital ratios.

A clear exception to the balanced macro growth story is real public consumption (row 5). This increased at an annual average rate of 3.1 per cent, or 1.4 percentage points per annum less than the annual growth rates of real GDP and real consumption. MONASH contains no theory explaining real public consumption spending. In columns 1 through 9 movements in public consumption spending are indexed to movements in private consumption spending via an assumption of a constant ratio of public to private consumption. This indexation relationship is shocked in column 10 to ensure that the result for real public consumption corresponds to the historically observed outcome. This shock required the ratio of public to private consumption to fall, opening a gap of 1.4 percentage points per annum between the growth rates for private and public consumption. This can be contrasted with the results of the earlier period studied by Dixon and Rimmer (column 13), where real public consumption spending grew at an annual average rate that was 0.4 percentage points faster than the growth in real private consumption. This result is broadly consistent with the recent tendency of state and federal governments to emphasise fiscal consolidation in their budgetary policy.

The fastest growing sector was Finance and insurance (sector 16). Almost 90 per cent of the growth in this sector is explained by technical change (column 4). The historical simulation revealed large improvements in productivity in the industries that comprise this sector. In particular, *banking*, *non bank finance, financial services*, and *insurance* all experienced large increases in productivity. This translated into lower prices for the output of these industries, and hence increases in their sales volumes. At the same time, there were relatively large increases in per-unit of output input requirements for these commodities. Together, these technical changes account for the bulk of the growth experienced by the Finance and insurance sector.

Other business services (sector 15) was the second fastest growing sector. Like Finance and insurance, much of the growth experienced by this sector is explained by technical change (column 4). Three of the four MONASH industries that comprise this sector – *other property services*, *technical services*, and *law, accounting and marketing* – experienced relatively large increases in productivity. This translated into lower prices for the output of these industries, and hence increases in their sales volumes. At the same time, these three industries, in addition to the fourth MONASH industry in this sector – *other business services* – experienced favourable shifts towards their output in the input requirements of other industries. Together, these technical changes accounted for almost 70 per cent of the growth experienced by the Business services sector.

Public administration (sector 24) and Defence (sector 25) were, respectively, the third and fourth ranked industries in terms of output growth. Together, these two industries sell almost all of their output to public consumption. Since growth in real public consumption spending lagged that of real GDP, it is surprising that these two industries were among those experiencing the fastest rates of growth. However, there was a shift in the commodity composition of government consumption spending over the period, away from the output of the Education and Health and welfare sectors, and towards the output of the Public administration and Defence sectors (column 10).

Textiles, clothing and footwear (sector 4) was the lowest ranked sector in terms of output growth. This was due in part to changes in Australia's foreign trading conditions (column 2) and in part to changes in import / domestic preferences (column 5). The changes in foreign trading conditions summarised in column 2 caused a substantial appreciation in the real exchange rate. The Textiles, clothing and footwear sector is exposed to foreign trade via import competition, and so its domestic sales suffered from the real appreciation. However changes in relative prices were not able to explain all of the observed increase in the import share of the domestic Textiles, clothing and footwear market. The historical simulation revealed a large shift in domestic demands away from the domestic variety of Textiles clothing and footwear and towards the foreign variety (column 5). This explains a substantial proportion of the contraction in activity experienced by this sector.

Basic metal products (sector 7) and Construction (sector 12) were the second and third lowest ranked sectors in terms of output growth. Technical change (column 4) explains most of the slow growth experienced by these sectors. In particular, both sectors were subject to adverse supply side and demand side technical change shocks over the study period. On the supply side, both sectors experienced falls in productivity, leading to higher output prices and hence reduced demand for their output. At the same time, on the demand side, producers and capital creators experienced reductions in the amount of basic metal products and construction required per unit of output.

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Table 1: Description of the elements of $X(\bar{H}\,\bar{D})$, $X(\bar{H}\,D)$, $X(H\,\bar{D})$, and $X(H\,D)$

Components of $X(H\,\bar{D})$	*Corresponding components of* $X(\bar{H}\,D)$
- consumption by commodity	- shifts in consumer preferences
- import volumes by commodity	- import / domestic preference shifts
- investment by industry	- investment / capital ratios by industry
- export volumes by commodity	- shifts in export demand schedules
- employment by industry	- primary factor technical change by industry
- capital stock by industry	- labour/capital bias in technical change
- producer prices by industry	- shifts in rates of return, price of other costs
- outputs of agricultural commodities	- supply (mark-up) shifts by industry
- outputs of non-agricultural commodities	- cost-neutral input-using tech. change
- export prices, agricultural commodities	- demand (stock and tech. change) shifts
- export prices, non-agricultural commodities	- supply (mark-up) shifts by commodity
- consumer prices, by commodity	- supply (mark-up) shifts by commodity

Shocked components of $X(H\,D)$
- consumer price index
- number of households
- tariff rates
- government consumption by commodity
- foreign currency import prices

Selected components of $X(\bar{H}\,\bar{D})$
- demands for source-specific commodity inputs by industry, for current production
- demands for source-specific commodity inputs by industry, for capital creation
- prices of source-specific commodity inputs by industry, for current production
- prices source-specific commodity inputs by industry, for capital creation
- demand for margin *m* by agent *k* to facilitate purchase of commodity *c* from source *s*

Adapted from Dixon, Menon and Rimmer (2000).

Table 2: Decomposition and historical closures of BOTE model

Variable		Closure	
		Decomposition	Historical
L	employment	X	X
ROR	rate of return on capital	X	X
A	primary factor technical change	X	N (5)
Ψ	investment/capital ratio	X	N (4)
V	shift in foreign export demands	X	N (5)
T	preference for imports v. domestic goods	X	N (3)
Γ	ratio of private to public consumption	X	N (1)
APC	average propensity to consume	X	N (2)
Y	real GDP	N	N
K	capital stock	N	X (7)*
I	real investment	N	X (4)
C	real consumption	N	X (2)
G	real public consumption	N	X (1)
M	import volumes	N	X (3)
X	export volumes	N	X (5)
TOT	terms of trade	N	X (5)

** (E8) removed from the model. This leaves 7 equations determining 7 endogenous variables.*

Table 3: Step-wise development of the historical closure from the decomposition closure.
Simulation for 1996/97 - 2001/02[1]

	Description	*Step 0*	*Step 1*	*Step 2*	*Step 3*	*Step 4*	*Step 5*	*Step 6*	*Step 7*	*Step 8*	*Step 9*	*Step 10*	*Step 11*	*Step 12*
							percentage changes between 1996/97 and 2001/02							
1	Real GDP	0.31	-1.12	3.68	3.56	3.41	24.41	24.48	24.48	24.47	24.70	24.75	25.21	25.16
2	Real private consumption	1.94	-3.36	24.49	24.49	24.49	24.49	24.49	24.49	24.49	24.49	24.49	24.64	24.62
3	Real investment	-1.16	-4.23	8.60	8.34	28.56	28.56	28.56	28.56	28.56	28.56	28.56	28.56	28.56
4	Real public consumption	1.94	16.74	16.74	16.74	16.74	16.74	16.74	16.74	16.74	16.74	16.74	17.11	17.03
5	Real exports	-5.01	-9.08	-75.06	-60.30	-84.25	25.90	25.90	25.90	25.90	25.90	25.90	25.88	25.88
6	Real imports	-0.09	-2.73	8.13	24.42	24.67	24.87	24.48	24.49	24.51	24.51	24.24	22.75	22.88
7	Uniform primary-factor saving tech change	0.00	0.00	0.00	0.00	0.00	-21.74	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	Average primary-factor saving tech change	0.00	0.00	0.00	0.00	0.00	-21.74	-12.10	-11.95	-11.62	-11.65	-11.71	-10.16	-10.13
9	Aggregate employment	0.00	0.00	0.00	0.00	0.00	0.00	10.87	10.86	10.86	10.88	10.87	10.99	10.99
10	Aggregate capital	1.34	-2.13	13.36	13.10	12.66	9.25	16.79	17.33	18.32	18.34	18.31	17.87	17.88
11	Real exchange rate	0.58	1.78	34.20	29.01	39.16	-0.31	-1.46	-1.70	-5.30	-5.37	-10.07	-9.84	-9.72
12	Terms of trade	1.41	2.51	20.05	16.22	22.54	0.98	-3.39	-1.54	-3.02	-3.66	-2.48	-2.43	-2.43
13	Nominal exchange rate	-11.90	-11.43	19.02	14.79	23.46	-15.50	-15.50	-15.50	-15.50	-15.50	-15.50	-15.50	-15.50
14	Average propensity to consume out of GNP	0.00	0.00	17.89	18.88	17.44	-4.27	-1.67	-0.90	0.38	0.24	-0.13	0.01	-0.02
15	Price deflator for GDP	12.48	13.21	15.19	14.22	15.71	15.19	14.04	13.80	10.20	10.13	10.07	10.30	10.43
16	Price deflator for investment	12.82	13.47	6.33	6.37	6.09	18.84	17.58	15.38	8.90	9.07	8.78	7.55	7.83
17	Price deflator for consumption	11.34	11.34	11.34	11.34	11.34	11.34	11.34	11.34	11.34	11.34	11.34	11.34	11.34
18	Average nominal wage rate	14.35	15.46	24.70	22.37	26.18	48.67	33.31	31.17	19.32	19.30	19.31	19.19	19.19
19	Ratio of net foreign liabilities to GDP [2]	-27	-38	23	27	16	-28	3	16	20	20	19	19	19

1. Results generated by single-step Johansen computations

2. 100 times the change between 1996/97 and 2001/02

Table 4: Decomposition results, macroeconomic variables, 1996/97 – 2001/02

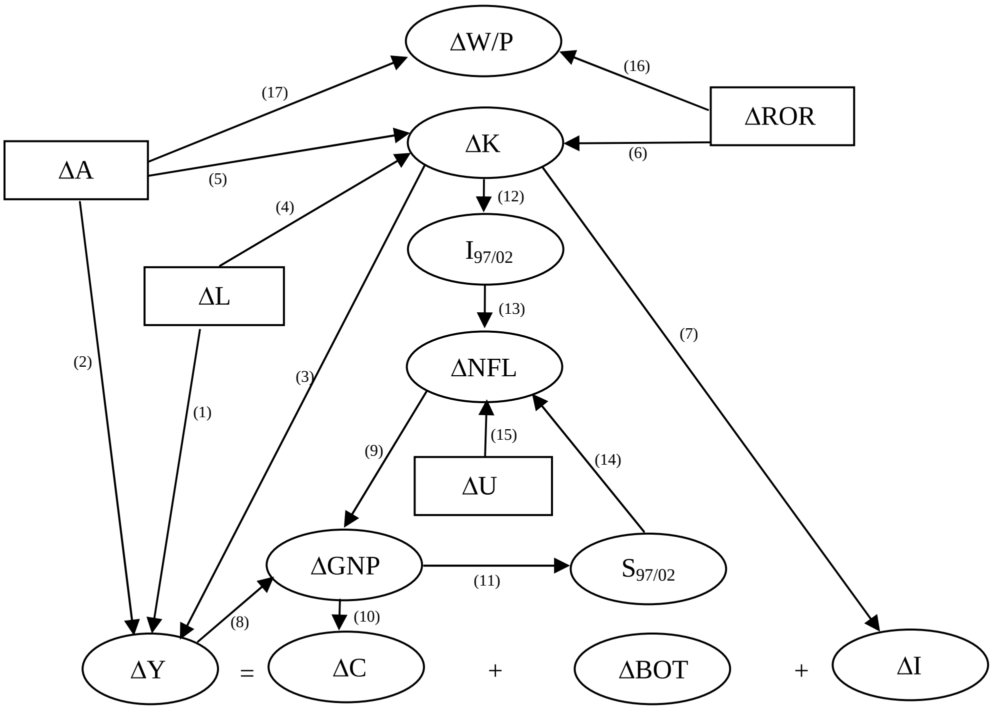
	1 Momentum	2 Foreign demands and import prices	3 Protection	4 Technical change	5 Import / domestic preferences	6 Household tastes	7 Employment growth	8 Required rates of return	9 Export supply curves	10 Macro	11 Total	12 Annual Average 96/97-01/02	13 Annual Average 86/97-93/94
1. Real GDP	0.1	0.8	0.04	18.6	0.0	-1.1	11.2	-4.8	-1.0	0.9	24.8	4.5	2.6
2. Real (CPI deflated) GNP	1.6	1.8	0.00	19.6	-0.7	0.0	8.8	-6.5	-0.9	0.8	24.4	4.5	2.4
3. Real private consumption	1.4	1.5	-0.05	16.2	-0.5	-0.3	8.9	-4.2	-0.4	2.2	24.8	4.5	3.2
4. Real investment	0.4	2.6	0.11	15.0	-0.2	-3.0	10.9	-9.5	-2.5	12.8	26.7	4.8	0.7
5. Real public consumption	1.4	1.5	-0.04	15.6	-0.5	-0.3	8.6	-4.1	-0.4	-5.0	16.7	3.1	2.8
6. Export volumes	-4.9	-4.0	0.83	15.5	10.5	-1.5	18.5	1.0	-1.8	-9.0	25.0	4.6	7.3
7. Import volumes	0.5	0.7	0.58	1.9	8.2	-0.6	9.1	-1.8	-1.4	5.2	22.4	4.1	6.8
8. Employment	0.0	0.0	0.00	0.0	0.0	0.0	11.0	0.0	0.0	0.0	11.0	2.1	1.4
9. Capital stock	0.5	2.5	0.08	14.2	-0.1	-3.2	10.3	-13.7	-2.3	2.9	11.1	2.1	3.7
10. Real wage	0.7	2.2	0.22	20.0	-1.4	0.4	-2.9	-12.8	-3.3	1.5	4.6	0.9	0.8
11. Real exchange rate	2.2	5.8	-0.4	-4.5	-3.7	-0.4	-6.9	-2.7	-4.2	3.8	-10.9	-2.3	2.9
12. Nominal exchange rate	1.8	7.6	-0.4	-5.6	-2.8	-0.7	-5.1	0.2	-3.6	3.2	-5.3	-1.1	3.7
13. Traditional export volume	-3.4	12.7	0.59	12.9	8.7	-2.3	15.1	-3.3	-14.1	-3.4	23.5	4.3	4.6
14. Non-traditional export vol.	-7.1	-20.4	1.17	18.1	13.4	-0.8	23.2	6.8	11.9	-16.2	30.1	5.4	11.4
15. Tourism volume	-5.4	-32.5	0.70	23.7	9.0	-2.0	17.8	-2.1	12.6	-13.5	8.3	1.6	10.1
16. GDP deflator	0.2	0.9	-0.01	2.0	-0.6	0.4	-1.1	-2.9	-0.1	0.2	-0.9	-0.2	-0.1
17. CPI (a)	0.0	0.0	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18. Investment deflator	-0.4	-1.4	-0.03	4.5	0.2	0.8	0.5	-5.5	0.5	-1.8	-2.7	-0.5	-0.9
19. Terms of trade	1.2	5.1	-0.19	-3.3	-2.5	0.4	-4.3	-0.7	0.4	2.2	-1.7	-0.3	0.5
20. % pt. ch. in BOT/GDP ratio	-0.8	0.2	0.01	1.7	-0.1	-0.1	0.8	0.4	0.0	-2.1	0.1	0.0	0.2
21. 100 x Ch. in NFL/GDP ratio	-22.9	1.6	0.46	36.6	1.6	-10.2	29.0	-28.6	-4.4	6.4	9.5	1.9	4.1

(a) With the exception of nominal variables, the results in columns 14 and 15 are the actual percentage changes between 1996/97 and 2001/02. The results for the nominal variables are benchmarked against the consumer price index, which is the numeraire (hence the percentage change in the CPI is 0). By excluding the actual growth in the CPI over the period (11.3 per cent) from Table 4, we are able to abstract from the purely value-scaling effect of changes in the numeraire. To take account of the change in the overall price level over the period, the results for the price indices in Table 4 (rows 16, 17 and 18) must be increased by 11.3 percentage points and the result for the nominal exchange rate (FC/$A) must be reduced by 10 percentage points.

Table 4 (continued): Decomposition results, outputs, 1996/97 – 2001/02

	1 Momentum	2 Foreign demands and import prices	3 Protection	4 Technical change	5 Import / domestic preferences	6 Household tastes	7 Employment growth	8 Required rates of return	9 Export supply curves	10 Macro	11 Total	12 Annual Average 96/97-01/02	13 Annual Average 86/97-93/94
1. Agric., forestry & fishing	-1.6	-3.9	0.2	14.2	2.9	-0.9	10.5	-5.1	1.2	-3.2	14.4	2.7	1.7
2. Mining	-2.2	10.1	0.4	3.5	2.8	-2.0	15.1	-8.6	-10.3	3.0	11.8	2.3	4.7
3. Food processing	-1.2	0.4	0.2	12.2	0.2	1.0	11.1	-0.6	-3.5	-4.4	15.4	2.9	2.1
4. Textiles, clothing, footwear	-1.2	-11.4	-2.0	6.6	-15.7	2.6	11.4	-3.1	2.4	-3.3	-13.7	-2.9	-2.3
5. Paper, printing	-0.1	0.5	0.1	7.7	1.3	-2.2	11.4	-3.6	0.5	0.4	16.0	3.0	1.9
6. Chemical, petroleum, coal	-1.0	-5.7	0.2	14.6	-5.3	0.4	13.1	-1.5	1.4	-2.3	13.9	2.6	3.1
7. Basic metal products	-2.2	-1.8	0.2	-15.4	-7.9	-1.6	14.0	13.6	-4.3	1.7	-3.8	-0.8	3.2
8. Transport equipment	-1.9	-2.3	-1.9	13.8	-10.0	-2.4	15.7	-7.0	2.2	3.1	9.4	1.8	1.2
9. Fabricated metal products	-0.6	-2.6	0.2	10.0	-4.1	-1.1	12.6	-2.9	-0.4	2.1	13.1	2.5	2.5
10. Other manufacturing	-0.7	-4.5	0.1	9.9	-1.6	-2.2	13.0	-4.5	0.5	3.9	14.0	2.7	0.7
11. Electricity, gas, water	0.3	0.8	0.0	5.2	-0.7	-2.9	10.2	-3.0	-1.4	1.4	9.9	1.9	3.0
12. Construction	0.6	2.4	0.1	-8.1	-0.2	-3.2	10.0	-9.6	-2.1	10.6	0.4	0.1	1.5
13. Wholesale trade	-0.4	3.9	0.1	11.5	0.4	-0.4	11.6	-2.9	-0.1	1.0	24.8	4.5	2.1
14. Retail trade, repairs	1.0	0.7	0.0	3.7	-0.3	3.6	8.9	-0.6	0.0	-1.5	15.6	2.9	1.9
15. Transport, stor., communic.	-0.1	-0.4	0.1	12.5	-0.5	2.4	11.2	-2.7	-0.3	-0.2	22.1	4.1	5.0
16. Finance, insurance	0.5	-0.7	0.0	51.8	3.3	-1.1	12.2	-13.2	-0.1	6.7	59.4	9.8	9.5
17. Other business services	-0.1	1.5	0.1	28.9	1.0	-0.3	12.2	-3.9	-0.3	3.1	42.2	7.3	3.3
18. Education	0.2	2.7	0.1	14.0	0.5	-1.1	10.6	-1.5	1.4	-13.3	13.5	2.6	3.4
19. Health, welfare	1.2	0.3	-0.1	11.2	-0.1	0.0	8.8	-0.4	0.1	-12.5	8.6	1.7	4.0
20. Entertainment	0.8	-1.8	0.0	4.2	1.3	0.0	9.6	2.0	0.2	-3.6	12.8	2.4	3.5
21. Personal services	1.1	1.5	-0.1	11.0	-0.2	-7.1	9.5	-0.5	0.0	2.1	17.3	3.2	2.1
22. Restaurants, hotels	0.5	-1.1	0.0	8.7	-0.1	2.2	10.3	-2.0	0.7	1.2	20.3	3.8	2.9
23. Ownership of dwellings	1.3	2.5	0.0	30.7	-0.3	-7.2	11.0	-14.4	-1.6	5.5	27.4	5.0	3.1
24. Public administration	1.3	1.3	0.0	17.2	-0.5	-0.7	9.6	-4.6	-0.5	9.2	32.4	5.8	3.3
25. Defence	1.4	1.0	0.0	17.0	-0.4	-0.3	9.3	-4.2	-0.3	8.6	32.0	5.7	1.2

Figure 1: Macroeconomic connections in the decomposition simulation



(Figure 30.1 from Dixon and Rimmer 2002)

Figure 2: Calculation of accumulated excess savings, 1996/97 – 01/02

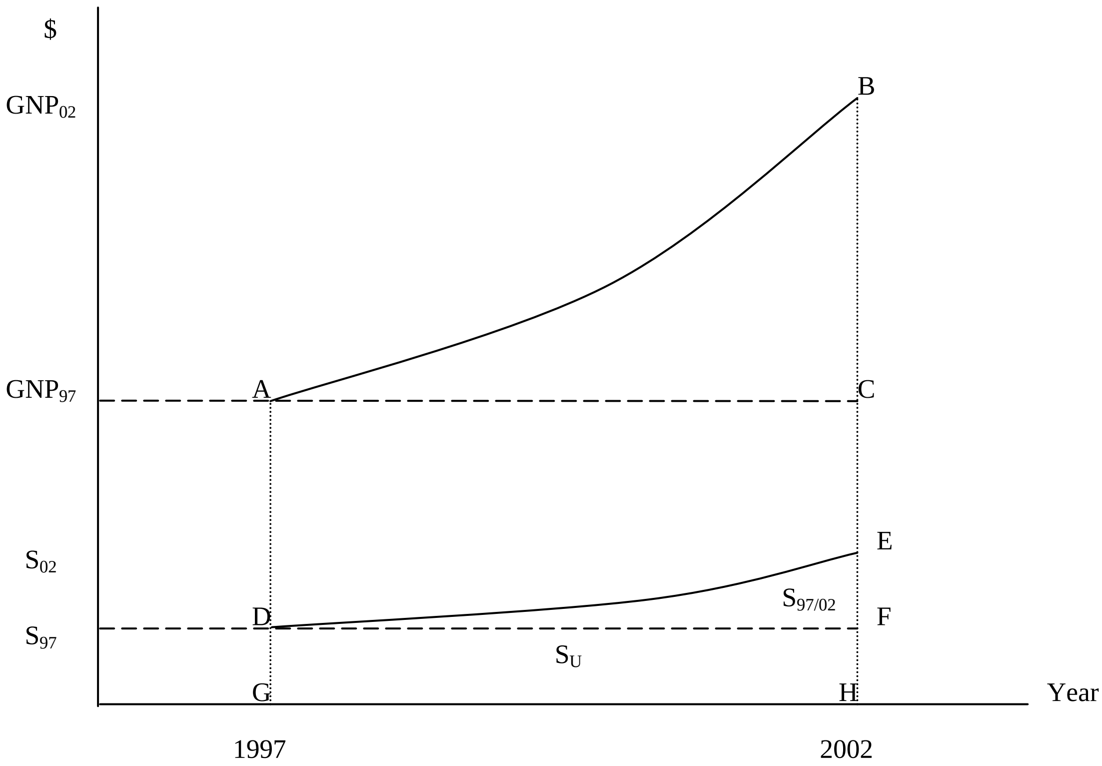


Figure 2. The base period level of GNP is A. GNP in the solution year is B. An assumption of smooth growth in GNP between these years is invoked to generate line A B. Savings in the base period is given by point D. Given the APC out of GNP, the savings path D E can be generated from the path for GNP (A B). If GNP had remained at its 1997 level, then total savings would be given by D F G H, or S_U. The difference between S_U and the path for total savings is accumulated excess savings ($S_{97/02}$).

[1] The origin of (E8) is the first order conditions from the firm's profit maximisation problem. In particular, we assume that the firm's problem is to maximise $\Pi = P.Y - W_L.L - W_K.K$, subject to P and $Y = A\ f(L.K)$ by choosing L and K, then we have the f.o.c. $\Pi_K = P.A.f_K - W_K = 0$, or $f_K = W_K/(A.P)$, or equivalently $f_K = (W_K/P_I)(1/A)(P_I/P)$. Noting that f_K is a monotonically decreasing function of K/L, that (W_K/P_I) is the rate of return (ROR in E8) and that P_I/P is a negative function of the terms of trade (since P_I – the investment price index – includes import prices but excludes export prices, while P – the price of domestic output – includes export prices but excludes import prices) provides (E8). This implies that $N_{ROR} < 0$, $N_{TOFT} > 0$, and $N_A > 0$. (See Dixon and Rimmer 2002: 244).

[2] As Dixon and Rimmer explain, the closure assumptions adopted by Step 5 effectively allow for little change in the ratio of domestic prices of exports and non-traded goods. At the same time, the price of non-traded goods is largely given by setting the CPI as the numeraire. Hence the domestic currency price of exports is largely determined. The foreign currency price of imports are exogenous (and shocked in Step 10). In terms of Step 5, this means we can either set the nominal exchange rate or the terms of trade exogenously. In percentage change form we have:
toft = p4_fc – pm_fc.
p4_fc = p4_dc + phi (phi = FC / $A dollar)
As discussed in Dixon and Rimmer (Figure 31.3, p. 249), the ratio *p4_dc – p_ntg* is largely unchanged when moving between Steps 4 and 5, and is approximately equal to *p4_dc – cpi*, since *p_ntg* is approximately equal to *cpi*)
hence: *toft = cpi + phi – pm_fc*.
With *cpi* and *pm_fc* exogenous, economy-wide supply shifts produced by terms of trade-induced movements in capital supply can be determined in one of two ways: either set *toft* exogenously (as per the BOTE discussion) and let *phi* be determined endogenously by the above equation, or set *phi* exogenously and let *toft* be determined by the above equation (the MONASH approach). Since *p4_dc* and *cpi* will tend to move together, the two approaches will tend to be equivalent in effect.

[3] The remaining three MONASH agricultural commodities (dairy cattle, pigs, poultry) are dealt with in Steps 10 and 11.

[4] Tobacco products, government administration, defence, education, health services, community services, and other services.

[5] There is a small fall in the rental value weighted sum of capital inputs. In Step 7 information on capital stocks is fed in at the sectoral (not industrial) level. The detailed output information fed into the model in Step 11 causes a realignment of capital across industries within sectors. This has tended to favour industries with lower rental rates.

[6] From the f.o.c for profit max.: $MP_K = (W_K/P_I) \times (P_I/P) \times (1/A) = ROR \times g(TOT) \times (1/A)$.

[7] $GNP = GDP - i \times NFL$. Hence $\Delta GNP = \Delta GDP - i \times \Delta NFL$.

[8] For the case of one endogenous variable Z, Harrison, Horridge and Pearson (1999: 4-5) summarise their decomposition as follows. Assume Z can be expressed as a function of *n* exogenous variables $X_1, X_2, \ldots X_n$:
$Z = f(X_1, X_2, \ldots X_n)$

Next, assume that the vector of exogenous variables $X = (X_1, X_2, \ldots X_n)$ moves along some path which begins at $X_{INITIAL}$ and ends at X_{FINAL}:

$$X_{INITIAL} = (X_{10}, X_{20}, \ldots X_{n0})$$
$$X_{FINAL} = (X_{11}, X_{21}, \ldots X_{n1}) = (X_{10}+\Delta X_1, X_{20}+\Delta X_2, \ldots X_{n0}+\Delta X_n)$$

Assume that the shocks are divided in *h* equal instalments. Provided *h* is sufficiently large, the effect of applying the first 1/*h* th instalment of the total shock can be accurately approximated by:

$$dZ = f_1\, dX_1 + f_2\, dX_2 + \ldots\ f_n\, dX_n \quad \text{where } f_i = \delta f / \delta X_i \text{ and } dX_i = \Delta X_i/h$$

If h is sufficiently large (ie the dX_i are sufficiently small) then the approximation will be exact and the right hand side terms provide a decomposition of the total change dZ for this first instalment of the total shock. We would then go on to apply the remaining h-1 instalments of the shocks. The f_i will depend on the value of Z and X at each step, and so will change with each step. This provides no additional computational burden for GEMPACK, since values for the f_i are required anyway for the standard GEMPACK solution algorithm. Finally, we can calculate the contribution made by each shock ΔX_i to the total change in Z (ΔZ) by adding up the results for $f_i\, dX_i$ over each of the h steps. Note that some path for the exogenous variables must be chosen in order to implement such a decomposition. In the above example, and in the algorithm implemented in GEMPACK by Harrison et al., a straight line path for the movements of the exogenous variables from their pre- to their post-shock values is chosen. Harrison et al. argue that, among the possible choices for the path of the exogenous variables, a straight-line path will typically be among the more natural of the possible paths.

[9] The difference between the movements in real consumption and the movements in real GNP in Table 4 reflect movements in the government price deflator relative to the CPI. In MONASH, nominal consumption (private plus public) is equal to nominal GNP multiplied by the APC: $X_C\, P_C$ = GNP . APC. Assuming no change in the APC, the percentage change expression for this relationship is: $x_C + p_C = gnp$. The definition of real GNP in Table 4 is nominal GNP deflated by the CPI, hence: $x_C + p_C - p_{CPI} = gnp_{REAL}$. Note that p_C includes both the government and consumer price deflators. The percentage change in real consumption (x_C) will be less than gnp_{REAL} whenever the percentage change in the government price deflator exceeds the percentage change in the CPI.

[10] The linearised CES input nest can be expressed as:

(1) $x_D - a_D = z - \sigma\,(p_D + a_D - p_{AVE})$

(2) $x_M - a_M = z - \sigma\,(p_M + a_M - p_{AVE})$

(3) $z = S_D(x_D - a_D) + S_M(x_M - a_M)$

(4) $p_{AVE} = S_D(p_D + a_D) + S_M(p_M + a_M)$

Substituting (3) into (1) provides:

(5) $(x_D - x_M) = (1 - \sigma)\,(a_D - a_M) - \sigma\,(p_D - p_M)$

Horridge (2003) defines a twist as a combination of small technical changes which, taken together, are locally cost neutral while securing a given percentage change (equal to "twist") in input ratios. Horridge expresses the problem of finding such a combination as one of finding a_D and a_M such that $p_{AVE} = 0$ and $(x_D - x_M)$ = twist. Assuming no changes in prices, we have:

(6) $p_{AVE} = S_D\, a_D + S_M\, a_M = 0$

(7) $(x_D - x_M) = (1 - \sigma)\,(a_D - a_M) = \text{twist}$

Hence: $a_M = [- S_D / (1 - \sigma)]\,\text{twist}$ (8)

$a_D = [\,S_M / (1 - \sigma)]\,\text{twist}$ (9)

Substituting (8) and (9) into (5):

$(x_D - x_M) = -\sigma\,(p_D - p_M) + \text{twist}$

[11] Ignoring net interest on net foreign liabilities, GNP = $Y_R\, P_{GDP}$. The percentage change expression for this relationship is: $gnp = y_R + p_{GDP}$. Real GNP in Table 4 is nominal GNP deflated by the CPI, hence: $gnp_R = y_R + (p_{GDP} - p_{CPI})$.

[12] Starting with the tax-inclusive f.o.c for profit maximisation:

(1) $(P_0 / T)\, MP_K = W_K$

where T is the power of the indirect tax and P_0 is the purchaser's price of the good. Rearranging (1), we have:

(2) $MP_K = T\,(W_K/P_I)\,(P_I/P_0) = T \times ROR \times f(TOT)$

An increase in T requires MP_K to rise. With L fixed, this requires K to fall.