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Forecasting and Policy Analysis with a Dynamic CGE Model of Australia

by

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Abstract

The main ideas in this paper are:

- that CGE models can be used in forecasting; and
- that forecasts matter for policy analysis.

We demonstrate these ideas by describing an application of MONASH, a dynamic CGE model of Australia, to the Australian motor vehicle industry over the period 1987 to 2016.

The key to generating believable forecasts is to use detailed information available from expert groups specializing in the analysis of different aspects of the economy. In MONASH we incorporate forecasts by specialists: on the domestic macro economy; on Australian economic policy; on world commodity markets; on international tourism; on production technologies; and on consumer preferences. We have found that CGE forecasts incorporating such specialist information are readily saleable to public and private organizations concerned with investment, employment, training and education issues. This is partly because the economy-wide consistency guaranteed by the CGE approach enables users of economic intelligence to see the disparate forecasts dealing with different parts and aspects of the economy within an integrated perspective.

Over the last thirty five years, CGE models have been used almost exclusively as aids to "what if" (usually policy) analysis. In almost all cases it has been assumed that the effects of the shock under consideration are independent of the future path of the economy. Thus, for "what if" analysis, a common implicit view is that realistic basecase forecasts are unnecessary. Contrary to this view, we find that "what if" answers depend significantly on the basecase forecasts. This is not surprising when we are concerned with unemployment and other adjustment costs. However, we find that basecase forecasts are critical even when our concern is the long-run welfare implications of a policy change. For example, we find that the simulated long-run effects of a tariff cut on imported cars are strongly influenced by the basecase forecast of the rate of technical progress in the car industry relative to that in other industries.

Key words: CGE model, forecasting, policy analysis, MONASH model, automobile industry, adjustment costs.

J.E.L. Classification numbers: C53, C68, D58, F47.

Contents

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1. Introduction

The main ideas in this paper are: (a) CGE models can be used in forecasting; and (b) forecasts matter for policy analysis. We demonstrate these ideas by describing an application of MONASH, a dynamic CGE model of Australia.

The key to generating believable CGE forecasts is to use in the model detailed information available from expert groups specializing in the analysis of different aspects of the economy. In MONASH we incorporate forecasts by specialists: on the domestic macro economy; on Australian economic policy; on world commodity markets; on international tourism; on production technologies; and on consumer preferences.

We have found that our CGE forecasts are readily saleable to public and private organizations concerned with investment, employment, training and education issues. These organizations must base their decisions on views of the future. In forming these views, they struggle to interpret the array of partial forecasts available from specialist groups. By incorporating specialist forecasts into a CGE model, we are able to assist by tracing out the implications of specialist forecasts for variables of interest, e.g. sales of different products, employment in different occupational categories and population in different regions.

Over the last thirty five years, CGE models have been used almost exclusively as aids to "what if" (usually policy) analysis. In almost all cases it has been assumed that the effects of the shock under consideration are independent of the future path of the economy. Thus, for "what if" analysis, a common implicit view is that realistic basecase forecasts are unnecessary. Contrary to this view, we find that "what if" answers depend significantly on the basecase forecasts. This is not surprising when we are concerned with unemployment and other adjustment costs. However, we find that basecase forecasts are critical even when our concern is the long-run welfare implications of a policy change. For example, we find that the simulated long-run effects of a tariff cut on imported cars, are strongly influenced by the basecase forecast of the rate of technical progress in the car industry relative to that in other industries.

The paper is organised as follows. Sections 2 and 3 are a brief description of MONASH. Section 2 describes four closures and section 3 concentrates on the

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* We thank Brian Parmenter for valuable suggestions made during the preparation of this paper.

treatment of investment. The four closures are used: (1) in estimating historical changes in industry technologies and consumer preferences; (2) in decomposing past movements in economic variables into parts attributable to changes in policies, technologies, preferences and other variables usually considered in CGE modelling to be exogenous; (3) in generating forecasts; and (4) in calculating "what if" effects as deviations around explicit forecasts. All four closures are illustrated in sections 4 to 6 which contain an analysis of the Australian motor vehicle industry over the period 1987 to 2016. Concluding remarks are in section 7.

2. Closures of the MONASH model

MONASH is a 113 industry CGE model of Australia[1] with extensions allowing results to be generated for 56 sub-national regions, 282 occupations and numerous types of households. For each year, it takes the form

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

where F is an m-vector of differentiable functions of n variables X, and $n>m$. The variables X include prices and quantities applying for a given year and the m equations in (2.1) impose the usual CGE conditions such as: demands equal supplies; demands and supplies reflect utility and profit maximising behaviour; prices equal unit costs; and end-year capital stocks equal depreciated opening capital stocks plus investment.

In using MONASH we always have available a solution ($X_{initial}$) of (2.1) derived mainly from input-output data for a particular year. In simulations we compute the movements in m variables (the endogenous variables) away from their values in the initial solution caused by movements in the remaining $n - m$ variables (the exogenous variables) away from their values in the initial solution. In most simulations the movements in the exogenous variables are from one year to the next. If the initial solution is for year t then our first computation creates a solution for year t+1. This solution can in turn become an initial solution for a computation which creates a solution for year t+2. In such a sequence of annual computations, links between one year and the next are recognised by ensuring, for example, that the quantities of opening capital stocks in the year t computation are the quantities of closing stocks in the year t-1 computation. In some simulations the movements in the exogenous variables refer to changes over several years rather than one year. For example, in simulations to be discussed in section 4, the initial solution is for 1987 and the movements in the exogenous variables are for the entire period 1987 to 1994. In these simulations we create a solution for 1994 in a single computation.

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[1] MONASH is a development of the ORANI model (Dixon et al, 1982). For details of MONASH see Adams et al. (1994).

We identify four basic choices for the *n-m* exogenous variables, i.e. four classes of closures:

historical closures;

decomposition closures;

forecasting closures; and

policy or deviation closures.

All four types of closures are used in our analysis of the motor vehicle industry in sections 4 to 6. Historical and decomposition closures are used in single-computation analyses of the period 1987 to 1994 and forecasting and policy closures are used to create year-to-year projections for the period 1998 to 2016.

The historical and decomposition closures

Closures of these types are used in section 4 to provide a description of developments in the Australian economy, particularly the motor vehicle industry, over the period 1987 to 1994.

In a decomposition closure, we include in the exogenous set all naturally exogenous variables, that is variables not normally explained in a CGE model. These may be observable variables such as tax rates or unobservables such as technology and preference variables.

Historical closures include in their exogenous set two types of variables: observables and assignables. Observables are those for which movements can be readily observed from statistical sources for the period of interest (1987 to 1994 in the application in section 4). Historical closures vary between applications depending on data availability. For example, in our 1987-1994 application, the observables included a wide array of macro and industry variables but not intermediate input flows of commodity i to industry j. Input-output tables were published for 1987 but not for later years such as 1994. If input-output data had been available for 1994, then flows of i to j could have been included in the observable variables and treated as exogenous in our historical closure. The initial motivation for our historical simulation was the updating of input-output tables from 1987 to 1994. The updated tables are part of the 1994 solution of (2.1). The creation of updated input-output tables is an important payoff from historical simulations. However as we will see in section 4, these simulations have other uses.

Assignable variables are naturally exogenous (and are therefore exogenous in decomposition closures as well as historical closures). The key feature of an assignable variable in an historical simulation is that its movement can be assigned a value without contradicting anything that we have observed about the historical period or wish to assume about that period. We clarify this concept later in this section in the discussion of (2.2).

With reference to the two closures we can partition the MONASH variables into four parts:

$X(HD), X(H\overline{D}), X(\overline{H}D), X(\overline{H}\overline{D})$

where

H denotes exogenous in the historical closure,

$\overline{H}$ denotes not exogenous (that is endogenous) in the historical closure, and

D and $\overline{D}$ denote exogenous and endogenous in the decomposition closure.

Thus, for example, X(HD) consists of those MONASH variables that are exogenous in both the historical and decomposition closures, and $X(H\overline{D})$ consists of those MONASH variables that are exogenous in the historical closure but endogenous in the decomposition closure.

Table 2.1 gives some examples of the partitioning of variables used in the MONASH simulation reported in section 4. As indicated, variables in X(HD) include population size, foreign currency prices of imports and policy variables such as tax rates, tariff rates and public consumption. Values of these variables are readily observable and are not normally explained in CGE models.

Examples of variables in $X(\overline{H}\overline{D})$ are demands for intermediate inputs and demands for margins services (e.g. road transport) to facilitate commodity flows from producers to users. In the absence of end-of-period input-output tables, movements in these variables are not readily observable or assignable and are normally explained in CGE models.

Variables in $X(H\overline{D})$ include, at the industry or commodity level, outputs, employment, capital input, investment, exports, imports, private consumption and numerous price deflators. Also included in $X(H\overline{D})$ are several macro variables e.g. the exchange rate and the average wage rate. CGE models normally aim to explain the effects on these variables of policy changes, changes in technology and other changes in the economic environment. Hence, these variables are naturally endogenous, i.e. they belong to the $\overline{D}$ set, and because changes in their values can be readily observed they belong to the H set.

$X(\overline{H}D)$ contains the same number of variables as $X(H\overline{D})$ with each variable in $X(H\overline{D})$ having a corresponding variable in $X(\overline{H}D)$. These corresponding variables are predominantly unobservable technological and preference variables. Such variables are not normally explained by CGE models and are therefore exogenous in the decomposition closure. However in the historical closure they are endogenous with the role of giving MONASH enough flexibility to explain the observed movements in the variables in $X(H\overline{D})$. Table 2.1 show examples of corresponding pairs from $X(\overline{H}D)$ and $X(H\overline{D})$. As indicated in the table, in our historical simulation we use shifts in consumer preferences to accommodate observations on consumption by commodity, shifts in commodity-specific

intermediate input-saving technical change to accommodate observations on total intermediate usage by commodity, etc.

The principles underlying the four-way partitioning of the MONASH variables in the historical and decomposition closures can be clarified by an example. A stylized version of the MONASH equation for total intermediate usage of commodity i (X_i) is

$$X_i = \sum_j \frac{Z_j}{B_{ij} B_i} \tag{2.2}$$

where

Z_j is the activity level (overall level of output) in industry j; and

B_{ij} and B_i are technological variables which can be used in simulating the effects of changes in the input of i per unit of activity in j and the input of i per unit of activity in all industries.

In decomposition mode, B_{ij} and B_i are exogenous and Z_j and X_i are endogenous. Suppose that movements in the Z_js are not observed but that we have observed the movements over an historical period in X_i (possibly from information on commodity outputs, imports and final usage). Suppose that we wish to assume uniform input-i-saving technical change. Then in historical mode we can use movements in B_i to explain the observed movement in X_i and we can assign a uniform value (possibly zero) to the percentage movements in B_{ij} for all j. In this example, Z_j is a member of $X(\overline{HD})$ and the assignable variable B_{ij} is a member of $X(HD)$. X_i is a member of $X(H\overline{D})$ and B_i is the corresponding member of $X(\overline{H}D)$.

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

$$X(\overline{H}) = G^H(X(H)) \tag{2.3}$$

where $X(H)$ and $X(\overline{H})$ are the exogenous and endogenous variables in the historical closure, i.e.

$$X(H) = X(HD) \cup X(H\overline{D})$$

and

$$X(\overline{H}) = X(\overline{H}D) \cup X(\overline{HD}) \quad ,$$

and G^H is an m-vector of differentiable functions. By observing and assigning X(H) for two years, s and t, we can use (2.3) to estimate percentage changes, $x_{st}(\overline{H})$, in the variables in $X(\overline{H})$. Thus we combine a large amount of disaggregated information on the economy (the movements in the variables in X(H)) with a CGE model to estimate movements in a wide variety of technological and preference variables ($X(\overline{HD})$), together with movements in more standard endogenous variables ($X(\overline{HD})$).

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

$$X(\overline{D}) = G^D(X(D)) \quad . \tag{2.4}$$

Following the method pioneered by Johansen (1960), we can express (2.4) in log-differential or percentage change form as

$$x(\overline{D}) = A\ x(D) \tag{2.5}$$

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

$$A_{ij} = \frac{\partial\ G_i^D(X(D))}{\partial\ X_j(D)} \frac{X_j(D)}{X_i(\overline{D})} \quad . \tag{2.6}$$

With the completion of the historical simulation, the percentage changes in all variables are known. In particular the vector $x(D)$ is known. Thus we can use (2.5) to compute values for $x(\overline{D})$ over the period s to t[2].

The advantage of working with (2.5) rather than (2.4) is that (2.5) gives us a decomposition of the percentage changes in the variables in $X(\overline{D})$ over the period s to t into the parts attributable to movements in the variables in X(D). This is a legitimate decomposition to the extent that the variables in X(D) are genuinely exogenous, that is can be thought of as varying independently of each other. In setting up the decomposition closure, the exogenous variables are chosen with

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[2] To reduce linearization errors we use a mid-point value of A, i.e., we evaluate the elasticities defined in (2.5) with X(D) set at $0.5*(X_s(D) + X_t(D))$. With this mid-point value denoted by A_{st}, we compute $x_{st}(\overline{D}) = A_{st}\ x_{st}(D)$ where $x_{st}(D)$ is a vector of mid-point percentage changes (100 times the change divided by the mid-point level). In applications of MONASH, including that described in section 4, we have found that $x_{st}(\overline{D})$ computed as above is not substantially different from the true mid-point percentage movements which can be computed via (2.4).

exactly this property in mind. Thus, in the decomposition closure we find policy variables, technology variables, taste variables and international variables (e.g. foreign currency prices) all of which can be considered as independently determined, and all of which can be thought of as having their own effects on endogenous variables such as incomes, consumption, exports, imports, outputs, employment and investment.

In section 4.2 we use the historical closure to estimate changes in technology and tastes paying particular attention to technology and taste variables for motor vehicles. Then we use the decomposition closure and (2.5) to compute the effects on the economy of changes in the variables in X(D). Again we pay particular attention to the motor vehicle industry. Our decomposition analysis gives us a basis for assessing the relative importance to the industry of changes in policy variables, technology variables, taste variables and international variables. The relationship between our historical and decomposition simulations is illustrated in Figure 2.1.

The forecasting and policy closures

These two closures are used in sections 5 and 6. In section 5 we use a forecasting closure in generating basecase forecasts for the motor vehicle industry and the rest of the Australian economy for the period 1998 to 2016. In making these forecasts we assume no change in motor vehicle tariffs beyond 2001. In section 6 we use a policy closure in generating the deviations from the basecase forecasts that would be caused by cuts in motor vehicle tariffs.

Forecasting closures are close in philosophy to historical closures. Instead of exogenizing everything that we know about the past, in forecasting closures we exogenize everything that we think we know about the future. Thus in MONASH forecasts, we exogenize numerous naturally endogenous variables, including:

- volumes and prices for agricultural and mineral exports. This enables us to take advantage of forecasts prepared by the Australian Bureau of Agricultural and Resource Economics.
- numbers of international tourists. This enables us to take advantage of forecasts prepared by the Bureau of Tourism Research.
- most macro variables. This enables us to take advantage of forecasts prepared by macro specialists such as Access Economics and the Australian Treasury.

To allow these variables to be exogenous we need to endogenize numerous naturally exogenous variables, for example, the positions of foreign demand curves, the positions of domestic export supply curves and macro coefficients such as the average propensity to consume.

Because we know less about the future than the past, MONASH forecasting closures are more conventional than historical closures. In forecasting closures, tastes and technology are exogenous. As will be seen in section 5, our settings for these variables in forecasting simulations are made by reference to their estimated values from historical simulations.

In common with historical closures, in forecasting closures policy variables are exogenous. In forecasting values for these variables we draw on departments of the Australian government such as the Industry Commission and the Treasury.

Policy closures are similar to the decomposition closures. In policy closures naturally endogenous variables, such as exports of agricultural and mineral products, tourism exports and macro variables, are endogenous. They must be allowed to respond to the policy change under consideration. Correspondingly, in policy closures naturally exogenous variables, such as the positions of foreign demand curves, the positions of domestic export supply curves and macro coefficients, are exogenous. They are set at the values revealed in the forecasts.

The relationship between forecasting and policy simulations is similar to that between historical and decomposition simulations. Historical simulations provide values for exogenous variables in corresponding decomposition simulations. Similarly, forecasting simulations provide values for exogenous variables in corresponding policy simulations. However there is one key difference between the relationships. An historical simulation and the corresponding decomposition simulation produce the same solution. This is because all the exogenous variables in the decomposition simulation have the values they had (either endogenously or exogenously) in the historical solution. In a policy simulation, most, but not all, of the exogenous variables have the values they had in the associated forecast solution. The policy variables of interest are set at values that are different from those they had in the forecasts. Thus policy simulations generate deviations from forecasts. The relationship between the forecast and policy simulations reported in sections 5 and 6 is illustrated in Figure 2.2.

Because decomposition and policy closures are conventional (i.e., naturally exogenous variables are exogenous and naturally endogenous variables are endogenous), readers may wonder how they differ. The main difference concerns timing. As indicated earlier, decomposition closures are used in medium-term analyses, for example, the study of the effects of changes in technology over a period such as 1987 to 1994. Over such a period, it is reasonable to suppose that changes in technology cause adjustments in real wages but do not affect aggregate employment. Thus, in the decomposition closure used in section 4, aggregate employment is exogenous. In the policy analysis in section 6, we are concerned with year-to-year effects. For each year in the period 1998 to 2016, we generate the effects of tariff cuts in motor vehicles. In year-to-year analyses we need to recognize wage stickiness and consequent employment effects. Thus, in the policy closure used in section 6, we allow short-run employment responses to policy shocks and other changes in the economic environment.

Table 2.1: Categories of Variables in the Historical and Decomposition Closures.

Selected components of $X(H\bar{D})$	**Corresponding components of** $X(\bar{H}D)$
Consumption by commodity	Shifts in household preferences
Total intermediate usage by commodity (deduced from information on outputs, imports and final usage)	Intermediate input saving technical change
Employment and capital stocks by industry	Primary factor saving technical change and capital/labour bias in technical change
Imports by commodity	Shifts in import/domestic preferences
Producer prices by industry	Rates of return on capital or markups on costs
Export volumes and f.o.b. prices	Shifts in foreign demand and domestic supply functions
Macro variables, eg. aggregate consumption	Shifts in macro functions, eg. the average propensity to consume
Selected components X(HD)	
Policy variables, eg. tax and tariff rates, and public expenditure	
C.i.f. import prices in foreign currency	
Population	
Selected components $X(\bar{H}\bar{D})$	
Demands for intermediate inputs and margin services	

Figure 2.1. Historical and Decomposition Simulations

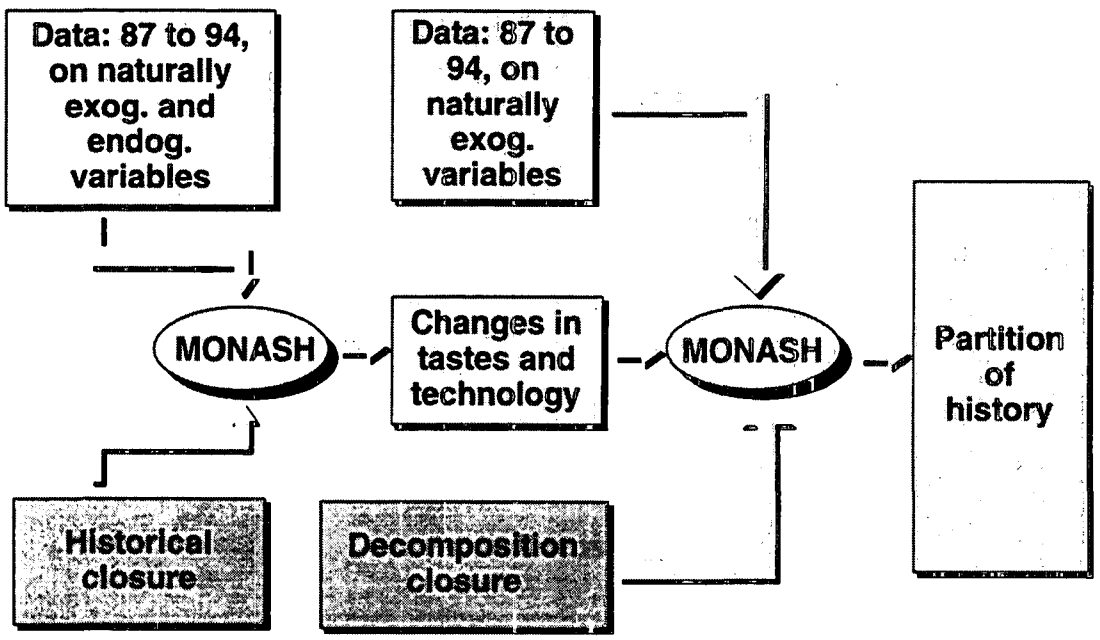
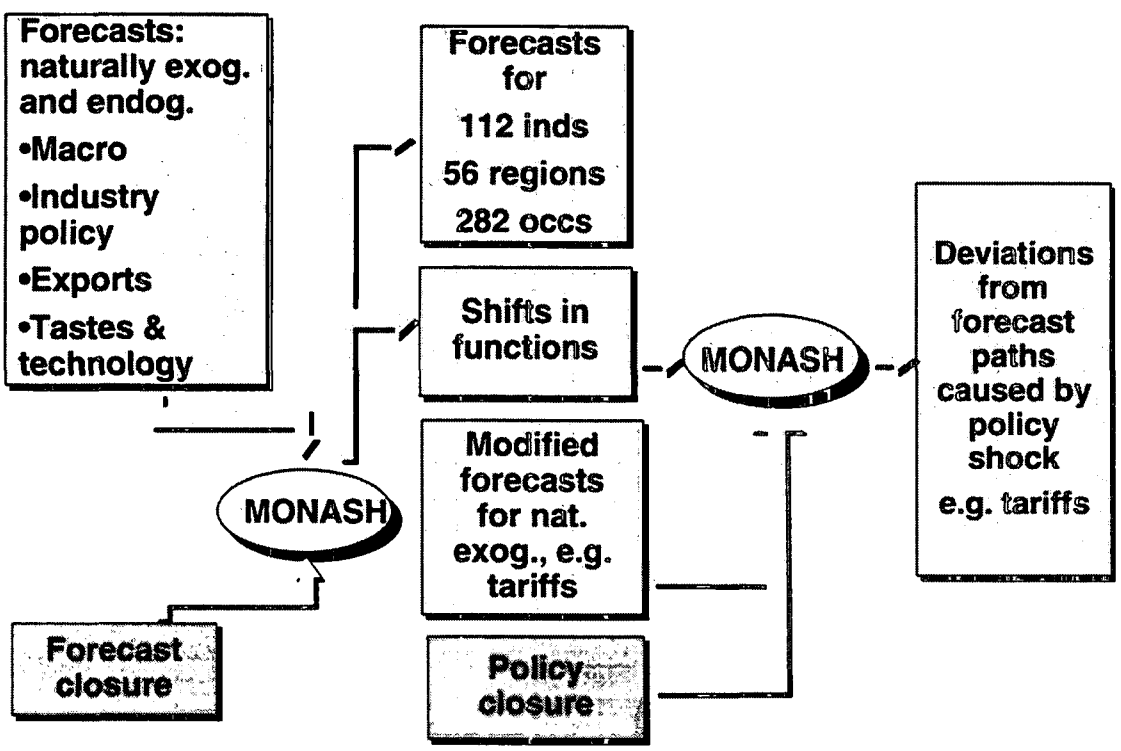


Figure 2.2. Forecast and Policy Simulations



3. Investment and capital accumulation in the MONASH model

The first question for readers wanting to know about the theoretical structure of a dynamic CGE model is likely to be: what is the treatment of investment and capital accumulation? Consequently in this section we describe the MONASH treatment of these variables. Other aspects of the MONASH theory are less distinctive and represent relatively minor developments of the theory underlying the ORANI model (Dixon et. al., 1982)[3].

In each year of year-to-year simulations, we assume that industries' capital growth rates (and thus investment levels) are determined according to functions which specify that investors are willing to supply increased funds to industry j in response to increases in j's expected rate of return. However, investors are cautious. In any year, the capital supply functions in MONASH limit the growth in industry j's capital stock so that disturbances in j's rate of return are eliminated only gradually.

The MONASH treatment of capital and investment in year-to-year simulations can be compared with that in models recognizing costs of adjustment (see, for example, Bovenberg and Goulder, 1991). In costs-of-adjustment models, industry j's capital growth (and investment) in any year is limited by the assumption that the costs per unit of installing capital for industry j in year t are positively related to the j's level of investment in year t. In the MONASH treatment, we assume (realistically) that the level of j's investment in year t has only a negligible effect (via its effects on unit costs in the construction and other capital supplying industries) on the costs per unit of j's capital. Instead of assuming increasing installation costs, we assume that j's capital growth in year t is limited by investor perceptions of risk. In the MONASH theory, investors are willing to allow the rate of capital growth in industry j in year t to move above j's historically normal rate of capital growth only if they expect to be compensated by a rate of return above j's historically normal level.

The rest of this section is organized in two subsections. Subsection 3.1 describes the relationships in MONASH between capital and investment, and between rates of capital growth and expected rates of return. Subsection 3.2 is concerned with actual and expected rates of return. Two treatments of expected rates of return are possible in MONASH: static and forward-looking. In year-to-year analysis with forward-looking expectations, MONASH must be solved iteratively, i.e., we need to conduct several sets of solutions for years t, t+1, t+2, etc.

3.1. Capital stocks, investment and the inverse-logistic relationship

The MONASH treatment of capital and investment in year-to-year simulations starts with the familiar equation:

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[3] All aspects of the MONASH model are described in Dixon and Rimmer (1997).

$$K_{j,t+1} = (1 - D_j)*K_{j,t} + I_{j,t} \qquad (3.1)$$

where

$K_{j,t}$ is the capital stock at the beginning of year t in industry j;

$K_{j,t+1}$ is the capital stock at the end of year t in industry j;

$I_{j,t}$ is investment during year t in industry j; and

D_j is a parameter giving the rate of depreciation in industry j.

In computations for year t, $K_{j,t}$ is set exogenously to reflect j's end-of-year capital stock in year t-1.

Next, dropping time subscripts to simplify the notation, we write

$$EROR_j = EEQROR_j + DISEQ_j \qquad (3.2)$$

where

$EROR_j$ is the expected rate of return (defined precisely in the next subsection) in year t to owners of capital in industry j;

$EEQROR_j$ is the expected equilibrium rate of return, i.e., the expected rate of return required to sustain indefinitely the current rate of capital growth in industry j; and

$DISEQ_j$ is a measure of the disequilibrium in j's current expected rate of return.

As illustrated by the AA′ curve in Figure 3.1, we specify the expected equilibrium rate of return as an inverse-logistic function[4]:

$$\begin{aligned} EEQROR_j = {} & RORN_j \\ & + (1/C_j)*[\ln(K\_GR_j - K\_GR\_MIN_j) - \ln(K\_GR\_MAX_j - K\_GR_j) \\ & - \ln(TREND_j - K\_GR\_MIN_j) + \ln(K\_GR\_MAX_j - TREND_j)] \ . \end{aligned} \qquad (3.3)$$

In this equation,

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[4] The MONASH code includes some additional variables on the RHS of (3.3). These allow for vertical shifts in the capital supply curves, the AA′ curves in Figure 3.1. Being able to move the AA′ curves is useful in forecasting and historical simulations. In these simulations we often have information from outside the model on either investment by industry or aggregate investment.

K_GR_j is the rate of growth of capital in industry j through year t, that is $(K_{j,t+1}/K_{j,t} - 1)$.

$K\_GR\_MIN_j$ is the minimum possible rate of growth of capital and is set at the negative of the rate of depreciation in industry j.

$TREND_j$ is the industry's historically normal capital growth rate. This is an observed growth rate in capital over an historical period.

$K\_GR\_MAX_j$ is the maximum feasible rate of capital growth in industry j. It is calculated by adding DIFF to $TREND_j$. In recent MONASH simulations, DIFF has been set at 0.06. Thus, for example, if the historically normal rate of capital growth in an industry is 3 per cent, then we impose an upper limit on its simulated capital growth in any year t of 9 per cent.

C_j is a positive parameter the setting of which is discussed below.

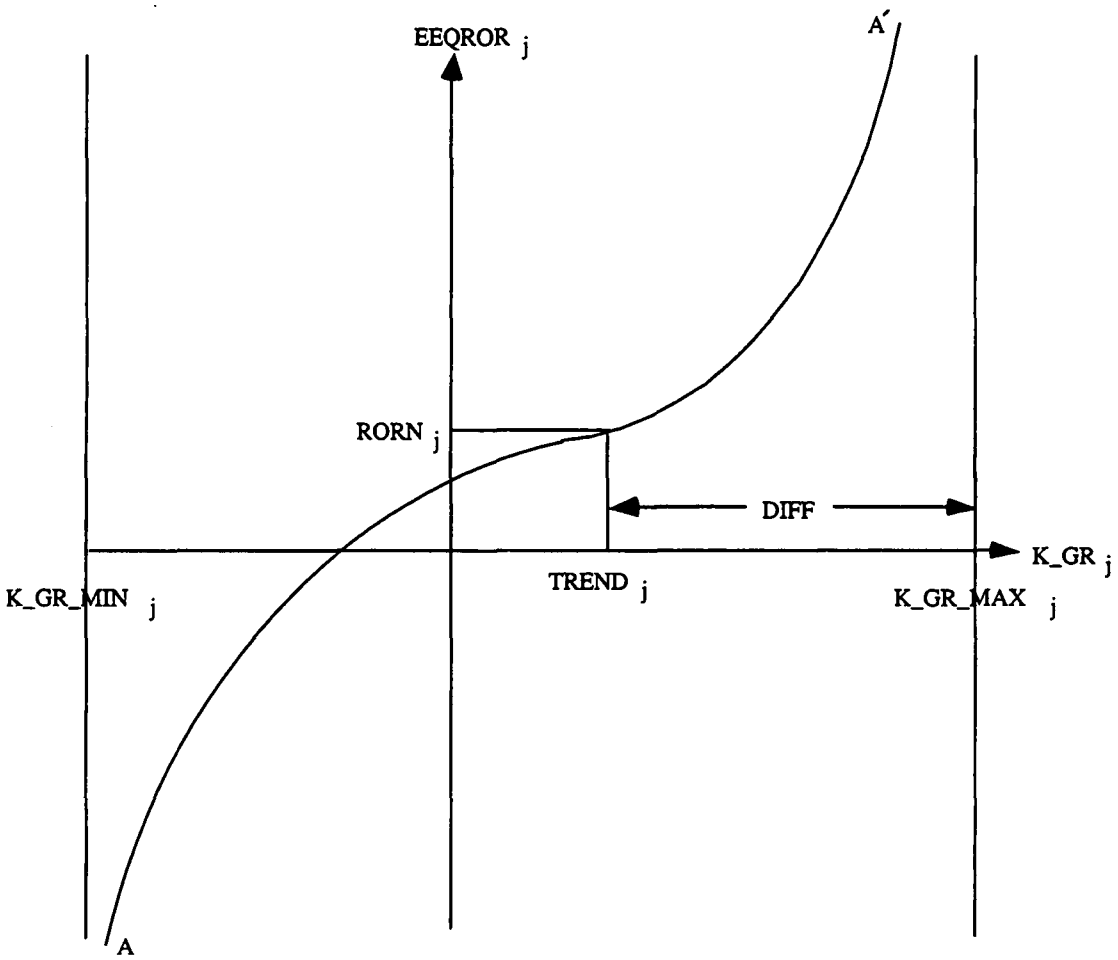
$RORN_j$ is the industry's historically normal rate of return. For each industry j, $RORN_j$ is an estimate of the average rate of return that applied over the historical period in which the industry's average annual rate of capital growth was $TREND_j$.

In understanding (3.3) it is helpful to start by assuming $DISEQ_j$ is zero. Then (3.2) and (3.3) mean that for industry j to attract sufficient investment in year t to achieve a capital growth rate of $TREND_j$, it must have an expected rate of return of $RORN_j$. For the industry to attract sufficient investment in year t for its capital growth to exceed $TREND_j$, its expected rate of return must be greater then $RORN_j$. Similarly, if the expected rate of return in the industry is less than that observed in the historical period, then provided that there is no disequilibrium, (3.2) and (3.3) imply that investors will restrict their supply of capital to the industry to below the level required to generate capital growth at the historically observed rate.

The sensitivity of j's equilibrium expected rate of return to variations in its capital growth (and consequently the sensitivity of j's capital growth to variations in its equilibrium expected rate of return) is controlled by the parameter C_j. Our first step in choosing the value for C_j was to note that

$$C_j = \left[\frac{\partial \, EEQROR_j}{\partial \, K\_GR} \Bigg|_{K\_GR_j = TREND_j} \right]^{-1} * \frac{K\_GR\_MAX_j - K\_GR\_MIN_j}{(K\_GR\_MAX_j - TREND_j)(TREND_j - K\_GR\_MIN_j)} \qquad (3.4)$$

Figure 3.1 The equilibrium expected rate of return schedule for industry j



Formula (3.4) allows us to evaluate C_j if we can assign a value to the slope of the AA′ curve in Figure 3.1 in the region of $K\_GR_j = TREND_j$.

We have no data for individual industries to give us a basis for such an assignment. However, by looking at the investment functions in Australian macro models[5], we obtained an idea of the overall sensitivity of capital growth to variations in expected rates of return, i.e., we obtained an estimate (denoted by SMURF) of the average value over all industries of the sensitivity of capital growth to variations in expected rates of return.

Then we computed the value of C_j via (3.4) with

$$\left(\frac{\partial \text{ EEQROR}_j}{\partial \text{ K\_GR}_j} \Big|_{\text{K\_GR}_j=\text{TREND}_j} \right)^{-1} = \text{SMURF} \quad . \tag{3.5}$$

Consider, now, the second term on the RHS of (3.2), $DISEQ_j$. Our data for year t-1 (either observed or the final simulated solution for t-1) for expected rates of return and for capital growth in industry j will not usually give a point on j's AA′ curve. Consequently, in our data for year t-1, $DISEQ_j$ will normally be non-zero.

We assume that this disequilibrium disappears over time according to the schedule:

$$DISEQ_j = (1 - \Phi_j)*DISEQ\_B_j \ , \tag{3.6}$$

where $DISEQ_j$ and $DISEQ\_B_j$ are the gaps between industry j's expected rate of return and the industry's expected equilibrium rate of return in the current year and in the data year (t-1), and Φ_j is a parameter with a value between 0 and 1. In most MONASH simulations, Φ_j has been set at 0.5.

3.2. Actual and expected rates of return under static and forward-looking expectations

The present value (PV) of purchasing in year t a unit of physical capital for use in industry j is given by:

$$PV_{j,t} = - \Pi_{j,t} + [Q_{j,t+1}*(1-T_{t+1}) + \Pi_{j,t+1}*(1-D_j) + T_{t+1}*\Pi_{j,t+1}*D_j]/[1 + INT_t*(1-T_{t+1})] \tag{3.7}$$

where

Π_{jt} is the cost of buying or constructing in year t a unit of capital for use in industry j;

D_j is the rate of depreciation;

$Q_{j,t}$ is the rental rate on j's capital in year t, i.e., the cost of using a unit of capital in year t;

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5 For example, the Murphy model (Powell and Murphy, 1997) and TRYM (Jilek et al.,1993).

T_t is the income-tax rate in year t; and

INT_t is the nominal rate of interest in year t.

In (3.7), we assume that units of capital bought or constructed in year t yield to their owners three benefits in year t+1. First, they generate rentals with a post-tax value of $Q_{j,t+1}*(1-T_{t+1})$. Second, they can be sold at the depreciated value of $\Pi_{j,t+1}*(1-D_j)$. Third, they give a tax deduction. We assume that this is calculated by applying the tax rate (T_{t+1}) to the value of depreciation ($\Pi_{j,t+1}*D_j$). To obtain the present value (value in year t) of these three benefits, we discount by one plus the tax-adjusted interest rate [$INT_t*(1-T_{t+1})$].

Equation (3.7) is converted to a rate of return formula by dividing both sides by $\Pi_{j,t}$, i.e., we define the actual[6] rate of return, $ROR\_ACT_{j,t}$, in year t on physical capital in industry j as the present value of an investment of one dollar. This gives

$$ROR\_ACT_{j,t} =$$

$$- 1 + [(1-T_{t+1})*Q_{j,t+1}/\Pi_{j,t} + (1-D_j)*\Pi_{j,t+1}/\Pi_{j,t} + T_{t+1}*D_j*\Pi_{j,t+1}/\Pi_{j,t}]/ [1 + INT_t*(1-T_{t+1})] \quad (3.8)$$

As we saw in the previous subsection, the determination of capital growth and investment in MONASH depends on expected (rather than actual) rates of return. In most simulations, we assume that capital growth and investment in year t depend on expectations held in year t concerning $ROR\_ACT_{j,t}$.

MONASH allows two possibilities for the specification of expected rates of return: static and forward-looking. Under static expectations, we assume that investors expect no change in the tax rate (i.e., they expect T_{t+1} will be the same as T_t) and that rental rates (Q_j) and asset prices (Π_j) will increase by the current rate of inflation (INF). Under these assumptions, their expectation of $ROR\_ACT_{j,t}$ is

$$ROR\_SE_{j,t} = -1 + [(1-T_t)*Q_{j,t}/\Pi_{j,t} + (1-D_j) + T_t*D_j]/(1+R\_INT\_PT\_SE_t) , \quad (3.9)$$

where $ROR\text{-}SE_{j,t}$ is the expected rate of return on capital in industry j in year t under static expectations, and $R\_INT\_PT\_SE_t$ is the static expectation of the real post-tax interest rate, defined by

$$1 + R\_INT\_PT\_SE_t = [1 + INT_t*(1-T_t)]/[1+INF_t] . \quad (3.10)$$

Under forward-looking or rational expectations, we assume that investors correctly anticipate actual rates of returns, i.e., their expectation of $ROR\_ACT_{j,t}$ is $ROR\_ACT_{j,t}$.

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[6] We use the adjective *actual* to emphasis that here we are defining the outcome for the rate of return, not a prior expectation held about that outcome.

In a year-t simulation under forward-looking expectations, we need to set j's expected rate of return equal to j's actual rate of return. The difficulty is that j's actual rate of return in year t depends on future rentals ($Q_{j,t+1}$), future tax rates (T_{t+1}) and future asset prices ($\Pi_{j,t+1}$), see (3.8). In the sequential approach to computing MONASH solutions, the values of variables in year t+1 cannot normally be known in the computation for year t. We are forced to adopt an algorithmic approach.

In the first iteration of the algorithm used for solving MONASH, we compute solutions for years 1 to T under the assumption of static expectations. Thus, if are happy to assume static expectations, we require only one iteration. However, if we wish to assume forward-looking expectations, then we will usually need further iterations (i.e., further calculations of solutions for years 1 to T). This is because the expected rates of return assumed for year t [$ROR\_SE_{j,t}$] are unlikely to equal the actual rates of return [$ROR\_ACT_{j,t}^{1}$] implied in the first iteration by the solutions for years t and t+1. For the final year (T), we do not generate information on future values of variables. We assume that industry j's actual rate of return in year T [$ROR\_ACT_{j,T}^{1}$] is the same as that in year T-1 [$ROR\_ACT_{j,T-1}^{1}$].

In the second iteration, we assume that the expected rates of return in years 0 to T are the actual rates of return calculated from the first iteration, i.e.,

$$EROR_{j,t}^{2} = ROR\_ACT_{j,t}^{1} \quad , \quad t = 0, \ldots T. \tag{3.11}$$

From the resulting solutions for years 1 to T and the data for year 0, we compute the implied actual rates of return, $ROR\_ACT_{j,t}^{2}$, t=0, ...T-1. As in the first iteration, we assume that the actual rates of return in the final year are equal to the actual rates of return in the second last year, i.e.,

$$ROR\_ACT_{j,T}^{2} = ROR\_ACT_{j,T-1}^{2} \ .$$

For the third and subsequent iterations, we adjust the expected rates of return according to

$$EROR_{j,t}^{n} = EROR_{j,t}^{n-1} + ADJ\_RE_{j} * (ROR\_ACT_{j,t}^{n-1} - EROR_{j,t}^{n-1}),$$

$$\text{for } n>2,\ t=0,\ldots,T,^{7} \text{ and } j \in IND, \tag{3.12}$$

where

ADJ_RE_j is a parameter set between 0 and 1.

Convergence is achieved when

$$EROR_{j,t}^{n} = ROR\_ACT_{j,t}^{n} \qquad \text{for all j and t.} \tag{3.13}$$

If ADJ_RE_j is set at 1, then (3.12) implies that the expected rates of return in iteration n are the actual rates of return in iteration n-1. We have found, however,

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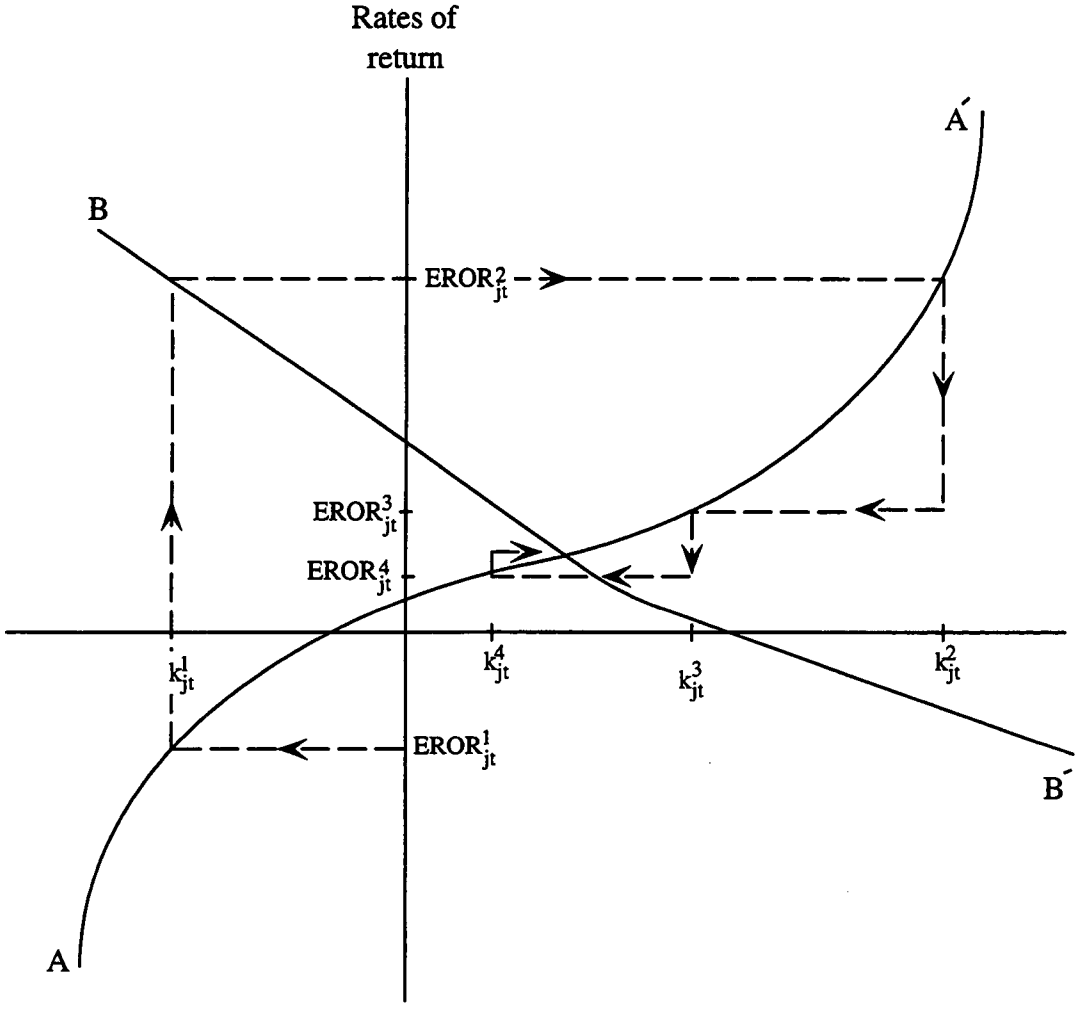
[7] We continue to assume that actual rates of return in the final year are the same as those in the second last year.

that convergence is more reliable when ADJ_RE_j is set at 0.5. Thus, as soon as we have some estimates of actual rates of return, we use them [see (3.11)], but in subsequent iterations, we adjust our assumed values for expected rates of return more cautiously. This reduces the likelihood of cycling (where low assumed values for expected rates of return in industry j in iteration n cause capital scarcity and high actual rates of return which then cause high expected rates of return in iteration n+1 resulting in capital abundance and low actual rates of return). With ADJ_RE_j set at 0.5, we find that satisfactory convergence is achieved in about 5 iterations (i.e., with n = 5). Figure 3.2 provides some intuition on the convergence properties of our algorithm.

Figure 3.2 Convergence of the algorithm for imposing forward-looking expectations*



*As in Figure 3.1, we assume that there is no disequilibrium in expected rates of return. Thus, we assume that the MONASH outcomes for expected rates of return and rates of capital growth in year t in industry j are on the AA′ schedule. We also assume that MONASH outcomes for actual rates of return and rates of capital growth are on the BB′ schedule. In drawing BB′ we have in mind the capital demand schedule for year t+1 which, other things being equal, implies a negative relationship between the availability of physical capital to industry j in year t+1 and its rental rate in year t+1, and thus a negative relationship between capital growth in year t and the actual rate of return in year t. In MONASH computations, BB′ moves between iterations and we do not necessarily operate on AA′. Nevertheless, we find Figure 3.2 a useful device for thinking about the convergence of our algorithm. For example, with the AA′ and BB′ curves in our diagram, convergence is very rapid when ADJ_REj is set at 0.5 (the illustrated case). If ADJ_REj is set at 1.0, then readers will find, after a little experimenting with the diagram, that the algorithm may become stuck in a non-converging cycle, or converge very slowly.

4. The Australian motor vehicle industry: 1987 to 1994

In this section we use MONASH historical and decomposition simulations in a description of developments in the Australian economy over the period 1987 to 1994 with special reference to the motor vehicle industry. Subsection 4.1 contains the motor vehicle input data to the MONASH simulations. Results and conclusions are in subsections 4.2 and 4.3.

4.1. Information for the period 1987 to 1994

Information of direct relevance to the motor vehicle industry for the period 1987 to 1994 is listed in Table 4.1. Some of these data refer to the motor vehicle industry (MONASH industry 68 and MONASH commodity 70) in isolation and some refer to a broader industry of which motor vehicles is a part. Our data on investment, for example, refer to transport equipment (industries 68-71), i.e. motor vehicles, ships, trains and planes.

Investment growth in this sector was -26.24 per cent for the period 1987 to 1994. In our MONASH historical simulation, we impose this sectoral investment growth, i.e., we assume that

$$\sum_{i=68}^{71} S(i)\, y(i) = -26.24$$

where

S(i) is the share of industry i in the investment of the transport-equipment sector; and

y(i) is the growth in investment in industry i from 1987 to 1994.

Then we determine the individual y(i)s by assuming a common movement in the investment/capital ratios of all industries in a sector. The result for motor vehicles is a decline in investment of 37.8 per cent, i.e y(68) = -37.8.

4.2. The historical and decomposition simulations: results

In the historical simulation, we exogenize all of the observed variables. Thus the results are consistent with all our statistical information. For example, we set investment growth in the transport sector exogenously at -26.24 per cent; growth in motor vehicle output at 14.50 per cent; growth in motor vehicle exports at 50.97 per cent, etc. To allow MONASH to hit these targets, we endogenized variables concerned with: primary-factor-saving technical change; intermediate-input-saving technical change; preferences for imported goods relative to domestic goods; household tastes (the form of the utility function); and rates of return on industrial capital. In the case of motor vehicles, we find for the period 1987 to 1994:

- that total-factor productivity growth was slightly positive. The numbers in Table 4.1 imply strong primary-factor-saving technical change in the motor vehicle

industry. Using the cost information in Table 4.3, we see that the primary factor input (the share weighted average of the percentage changes in capital and labour input) to the industry declined over the period 1987 to 1994 by about 15 per cent. With an output increase of 14.5 per cent this gives primary-factor productivity growth of 35 per cent. On the other hand, the industry suffered a considerable reduction in intermediate-input productivity. Our calculations imply that intermediate inputs to the industry increased by 23.26 per cent giving a decline in intermediate-input productivity of 7 per cent (= 100x(1.145/1.2326 - 1)). Taking account of the shares of primary factors and intermediate inputs in motor vehicle costs (about 25 and 75 per cent, see Table 4.3), a back-of-the-envelope estimate is that multi-factor productivity growth in the industry was about 0.7 per cent (=100x{1.145/[0.25x(1-0.15) + 0.75x(1.2326)]) - 1}. This was borne out in our historical simulation which gave - 0.55 as the result for the MONASH variable a(68), implying that the industry in 1994 could produce any given level of output with 0.55 per cent less of all inputs (primary and intermediate) than were required in 1987.

- that there was a strong twist in the industry's technology towards the use of capital. The result for the MONASH variable twistlk(68) was about -23 per cent. This means that the industry's technology changed so that at any given ratio of the wage rate to the rental rate on capital it would choose a capital/labour ratio 23 per cent higher in 1994 than in 1987.
- that there was a shift in consumer preferences towards the purchase of motor vehicles. The result for the MONASH variable a3com(70) was 21.39 per cent. This means that at any given set of prices and per capita income, consumption per household of motor vehicles would be about 21.39 per cent[8] higher in 1994 than in 1987.
- that there was a shift across industries towards the use of motor vehicles as an intermediate input and as a capital good. The result for the MONASH variable ac12mar_tot(70) was 18.2 per cent. This means that motor vehicle input per unit of output and per unit of capital creation in all industries was 18.2 per cent higher in 1994 than in 1987.
- that there was a shift in the preferences of users of motor vehicles towards the imported product. The result for the MONASH variable ftwist_src(70) was 45.70 per cent. If ftwist_src(70) is x per cent, then at any given ratio of import/domestic purchasers' prices, users of motor vehicles increase the import/domestic ratio in their demands for motor vehicles by x per cent.

Having completed the historical simulation, we then adopted the decomposition closure in which technology and taste changes (a(j), twistlk(j), etc) are exogenous. By setting these technology and taste changes at their values estimated

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[8] More precisely the consumption per household of motor vehicles in 1994 would be 21.39*(1 - S70) per cent higher than in 1987 where S70 is the share of motor vehicles in household expenditure.

from the historical simulation, we obtain results in the decomposition simulation for output, employment and other endogenous variables identical to those in the historical simulation.

Table 4.1. Growth in Motor Vehicle related variables from 1987 to 1994:Shocks used in the Historical Simulations*

Variable	Shock used in MONASH	Source	Note
Output of motor vehicles	14.50	Estimate supplied by the Industry Commission taking account not only the increase in the quantity of output but also its quality.	
Tariff on motor vehicles	-30.28	Unpublished data from the Industry Commission.	The impact effect is a reduction in landed duty paid price of motor vehicle imports of 6.49 per cent.
Exports of motor vehicles (volume)	50.97	Published ABS data (Cat 5215.0) and unpublished ABS data at the 5-digit SITC level mapped to input-output commodities using an unpublished ABS concordance.	This is less growth than for total exports (62 per cent).
Imports of motor vehicles (volume)	64.01	As above.	Total import growth was 58 per cent.
Foreign currency export price of motor vehicles	29.21	Unpublished ABS data on merchandise export price deflators by 4-digit IOIC group.	Exchange rate fell by 4.29 per cent. Therefore in domestic currency the f.o.b. export price rose by 33.50 per cent. The GDP deflator increased by 32.32 per cent.
Foreign currency import price of motor vehicles	24.62	Unpublished ABS data on merchandise import price deflators by 4-digit IOIC group.	In domestic currency the c.i.f. import price rose by 28.98 per cent.

Table 4.1 continued

Table 4.1 continued

Variable	Shock used in MONASH	Source	Note
Investment by the transport equipment sector (includes Motor vehicles, Ships, Trains and Aircraft)	-26.24	ABS published data in Cats 5221.0 and 5626.0 on private gross fixed capital expenditure.	Investment growth is allocated to industries in this sector according to their relative rates of growth of capital. This gives the percentage change in investment by motor vehicles as -37.81.
Capital stock of the motor vehicles industry	0.00	Estimate supplied by the Industry Commission.	
Labour input to the motor vehicles industry	-17.50	Estimate supplied by the Industry Commission.	
Household consumption in National Accounts (NA) categories. The bulk of motor vehicle expenditures are in categories 22 (Purchases of motor vehicles) and 24 (Operation of motor vehicles nec.)	NA(22) = 36.05 NA(24) = 36.05	Unpublished National Accounts consumption data for 38 commodities supplemented by unpublished concordance matrix between these 38 commodities and 115 MONASH commodities.	Most of motor vehicle consumption is in NA commodity 22 and NA(22) is almost entirely motor vehicles. Despite this, MONASH implies Motor vehicle consumption growth of 55.88 per cent. This reflects a collapse of mechanical repair consumption in NA(24).

* Our data and simulation results refer to financial years, that is years ending on June 30.

With technology and tastes exogenous in the decomposition closure, we can answer questions about the effects of changes in these variables. More generally, we can decompose history into the parts attributable to changes in variables such as those identified in the column headings of Tables 4.4 to 4.7. The first column of Tables 4.4 and 4.5 shows the effects of shifts in foreign demand and supply curves holding constant the variables identified in the headings of the other columns, i.e. holding

constant protection, technology, preferences, employment, etc . The second column shows the effects of changes in protection holding constant the positions of foreign demand and supply curves, technology, etc. In each column we treat the balance of trade and the macro composition of GNE as exogenous. Thus, for example, the second column gives the effects of the changes in protection that took place from

Table 4.2. Sales Structure of the Australian Motor Vehicle Industry

	1987	1994
Industry		
Motor vehicles	0.22	0.14
Mechanical repairs	0.05	0.06
Defence	0.03	0.03
Other	0.04	0.06
Investment	0.37	0.31
Households	0.22	0.28
Exports	0.07	0.12
Total	1.00	1.00
Import share in domestic market	0.38	0.50

Table 4.3. Cost Structure of the Australian Motor Vehicle Industry

	1987	1994
Commodity inputs		
Motor vehicles	0.42	0.42
Rubber	0.06	0.04
Iron and steel	0.04	0.04
Other	0.25	0.22
Labour	0.20	0.20
Returns to capital	0.02	0.08
Other costs	0.01	0.00
Total	1.00	1.00

1987 to 1994 under the assumption that these changes had no effect on the balance of trade and no effect on the shares of private consumption, public consumption and

investment in GNE.[9] The effects of the changes in the balance of trade and the composition of GNE are given in column 8.

Tables 4.4 and 4.5 divide history into 10 parts:

(1) *the effects of shifts in foreign demands and supplies, i.e., the effects of movements in foreign demand curves for Australian products and of movements in the foreign-currency prices of imports.*

Over the period 1987 to 1994, the c.i.f. price of imported cars increased by about 14 per cent relative to overall c.i.f. prices of Australia's imports and f.o.b. prices of Australia's exports. The price of imported cars to Australia rose sharply due to an appreciation of the Yen. Because, from Australia's point of view, imported cars became relatively expensive on world markets, we find a positive entry in the motor vehicle row (8a) of the first column in Table 4.5.

General equilibrium factors had mixed effects on the domestic motor vehicle industry in column 1. As can be seen in column 1 of Table 4.4, shifts in foreign demands and supplies resulted in a strong improvement in Australia's terms of trade (13.14 per cent in row 17, Table 4.4) with associated real appreciation (15.59 per cent, row 2, Table 4.4), wage growth (4.31 per cent, row 3) and GNE growth (2.97 per cent, row 10). Real appreciation is a negative influence on the domestic motor vehicle industry but GNE growth is a positive influence. Another positive influence in column 1 arises from the structure of the demand shifts for Australian exports. These shifts strongly favoured manufacturing (including motor vehicles) relative to traditional exports (agriculture and mining).

(2) *the effects of changes in protection.*

For most industries, protection fell. This reduced the real exchange rate (-0.79 per cent, row 2, column 2, Table 4.4) and increased real pre-tax wage rates (2.10 per cent, row 3, column 2, Table 4.4).[10] For motor vehicles, the effect of all reductions in protection was a 5.01 per cent decrease in output (row 8a, column 2,

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[9] Readers would expect to see in all columns except 8 of Table 4.4 identical percentage changes for real consumption, real investment and other absorption (rows 7 to 9). The sum of the decomposition results for any variable from the decomposition simulation does not precisely equal the value for the variable obtained in the historical simulation. In each of the tables we use scaling factors (different in each row) to force the decomposition results to add to the historical results given in the final column. This causes the small discrepancies observed in the results in rows 7 to 9.

[10] Reductions in tariff rates reduce government revenue. In the decomposition simulation, we avoid modelling the revenue replacement tax by assuming (a) that revenue replacement is via a non-distorting poll tax and (b) that consumption is determined in each column of the decomposition table independently of disposable income as an exogenously given share of GNE. If the replacement tax were modelled, we might find that the real post-tax incomes of wage earners are reduced by tariff cuts despite increased real pre-tax wage rates.

Table 4.5). The effect on motor vehicle output of the reduction in the motor vehicles tariff alone was a contraction of 6.04 per cent (row 8a, column 1, Table 4.7). Motor vehicle output was stimulated by 1.03 per cent by the reductions in non-motor vehicle tariffs (row 8a, column 2, Table 4.7).

(3) and (4) *the effects of primary-factor-saving and intermediate-input-saving technical change.*

In combination, columns 3 and 4 of decomposition Tables 4.4 and 4.5 show the effects of technical changes, that is, shifts in production functions. Over the period 1987 to 1994, technical changes were the main source of total-factor productivity growth. As can be seen in column 11 of Table 4.4, GDP increased by 20.43 per cent, while capital and labour inputs increased by 28.65 and 10.51. There was no increase in land input. With weights of 0.300 for capital, 0.685 for labour and 0.015 for land, these figures imply an overall improvement in total-factor productivity of 4.64 per cent [=20.43 - (0.3x28.65 + 0.685x10.51 + 0.015x0.00)]. In columns 3 and 4 of Table 4.4, total-factor productivity growth is 4.57 [= (3.47+4.88) - 0.3x(5.55+7.04)]. Apart from technical change, other sources of total-factor productivity growth were improvements in resource allocation. For example, in column 2 of Table 4.4 we find that reductions in protection generated total-factor productivity growth of 0.10 per cent (0.49 - 0.3x1.29).

Total-factor productivity growth in columns 3 and 4 of Table 4.4 is the main source of real wage growth (5.69 per cent out of a total increase in real wage rates of 7.52 per cent). It also accounts for about 40 per cent of GDP growth (8.35 per cent out of a total increase in GDP of 20.43 per cent). The only other significant contributing factor to GDP growth in Table 4.4 is employment growth (column 7).

Separately, columns 3 and 4 are concerned with the effects of primary-factor-saving and intermediate-input-saving technical changes. In explaining the results in the two columns it is convenient to start with column 4.

Over the period 1987 to 1994 there were strong shifts in industry technologies favouring the use of motor vehicles, that is, there were sharp increases in motor vehicle inputs per unit of output across all industries. This is reflected in row 8a, column 4 of Tables 4.5 where the entry for motor vehicle output is 17.27 per cent. Motor-vehicle-favouring shifts in technology are consistent with the increasing use by public and private enterprises of business cars as part of employee remuneration. Other products for which there were strong increases in industry usage per unit of output include finance and insurance, electronic equipment and communications. This explains the large positive entries in rows 16, 9 and 15 of column 4, Tables 4.5.

In making the column 4 computation, we assumed that intermediate-input-saving technical changes are cost neutral. For example, if industry j is observed to use 50 per cent more computers per unit of output and computers account for 5 per cent of the industry's costs, then, in our computation in column 4 we assume that j's extra computer use is accompanied by a uniform 2.5 per cent reduction in j's use of all inputs (intermediate and primary). Despite our cost neutrality assumption, intermediate-input-saving technical change in column 4 of Table 4.4 generates a 2.8

per cent increase in total-factor productivity (= 4.88 - 0.3x7.04). There are two explanations of approximately equal importance. The first involves efficiencies in margin usage e.g. reductions in the use of transport and retail trade per unit of sales. In column 4 we took these efficiencies into account but did not assume that they were cost-neutralized. The second explanation for the total-factor productivity gain in column 4 of Table 4.4 concerns the taxation implications of the shocks. Intermediate-input-saving technical change in column 4 favours the use of inputs which happen to be heavily imported and heavily taxed at the point of sale (for example electronic equipment). (Notice that import volumes in column 4 of Table 4.4 increase by 19.86 per cent.) Because sales taxes (including tariffs) put a wedge between resource costs and market value, stimulation of taxed activities increases total-factor productivity growth.

Apart from its implications for total-factor productivity growth, another implication of the strong import growth in column 4 of Table 4.4 is strong export growth. This follows from our assumption in column 4 of an unchanged balance of trade. The increase in exports in column 4 requires a real devaluation, explaining the positive results in column 4 of Table 4.5 for the traditional export industries (agriculture and mining).

Column 3 of decomposition Tables 4.4 and 4.5 gives the effects of primary-factor-saving technical changes apart from those generated by our cost-neutralizing assumption described above. From 1987 to 1994, the motor vehicle industry achieved a 35 per cent reduction in its use of primary factors per unit of output. Despite this strong improvement in primary-factor productivity, the entry in row 8a, column 3 of Table 4.5 is negative. The explanation has two parts. First, primary factors are only a small share (about 25 per cent) of motor vehicle costs, limiting the cost advantage to the industry from primary-factor-saving technical change. Second, primary-factor-saving technical changes in other industries have a negative impact on the motor vehicle industry. This is because they increase real wage rates. Notice in row 3, column 3 of Table 4.4 that the real wage rate increases by 2.36 per cent. In row 8a of Table 4.7 we can see the favourable effect of primary-factor-saving technical change on motor vehicle output (2.24 per cent, column 3) being more than offset by the unfavourable effects of primary-factor-saving technical changes in other industries (- 4.08 per cent, column 4).

A surprising feature of the results in column 3 of Table 4.4 is that real exchange rate appreciation (6.46 per cent) is associated with strong growth in exports (6.08 per cent) relative to GDP (3.47 per cent). The explanation is that primary-factor-saving technical changes over the period 1987 to 1994 strongly favoured export-oriented industries especially agriculture and mining.

(5) *the effects of changes in import/domestic preferences.*

These favoured imports, generating an increase in import volumes of 10.75 per cent in column 5, row 11 of Table 4.4. Because we assume no change in the balance of trade, the twists in import/domestic preferences generate real devaluation and export growth (column 5, rows 2 and 12, Table 4.4).

The effect on the Australian motor vehicle industry of the motor-vehicle import/domestic twist is strongly negative (-12.68 per cent in row 8a, column 5, Table 4.7). This is offset to a small extent (2.42 per cent in row 8a, column 6, Table 4.7) by the general equilibrium effects (e.g. real devaluation) of the import/domestic twists for other products.

The twist in import/domestic preferences against Australian motor vehicles is consistent with the increase in variety of imported cars available since the abolition of import quotas in the mid-1980s. An effect of these quotas (which operated on the number of imported car not their value) was to limit imports to a narrow range of large expensive cars.

(6) *the effects of changes in consumer preferences, i.e., changes in the parameters of the household utility function.*

Over the period 1987 to 1994, household purchases of motor vehicles increased by more than can be explained by changes in: the number of households; household income; and consumer prices. Thus MONASH in historical mode indicates that there was a shift in consumer preferences in favour of motor vehicles. The effects of this shift together with the effects of other shifts in consumer preferences are given in column 6 of Tables 4.4 and 4.5. Reflecting the shift towards motor vehicles we find positive entries in row 8a, column 6 of Table 4.5 (3.43 per cent) and in row 8a, column 7 of Table 4.7 (4.15 per cent). At the macro level, the effects of shifts in consumer preferences were minor (column 6, Table 4.4).

(7) *the effects of employment growth and growth in the number of households.*

Both employment and the number of households grew by about 10 per cent between 1987 and 1994. This generated an approximately balanced 10 per cent expansion in the economy (column 7 of Tables 4.4 and 4.5). Motor vehicles is slightly favoured (12.23 per cent in Table 4.5) because of real devaluation associated with terms-of-trade decline. The terms-of-trade decline arises from export expansion in a model with downward-sloping foreign demand curves and flat import-supply curves. The below-average expansion for agricultural output (7.32 per cent in row 1, column 7, Table 4.5) is explained by the fixity of agricultural land.

(8) *the effects of changes in the macro composition of GDP.*

In all the columns of Tables 4.4 and 4.5 apart from column 8, we assume no change in the balance of trade and no change in the ratios of private consumption to investment and of public consumption to investment. In column 8 we show the effects of the change in the balance of trade (a movement towards surplus, row 1, column 8, Table 4.4) and of the changes in the expenditure ratios (compare rows 7, 8 and 9 of column 8 in Table 4.4). While investment is only about 20 per cent GNE, it accounts for over 30 per cent of motor vehicles sales (see Table 4.2). Thus, the change in the composition of GNE, which was strongly against investment, has a negative effect on motor vehicle output (-2.48 per cent, row 8a, column 8 in Table 4.5).

(9) *the effects of apparent changes in required rates of return.*

In the historical simulation, we assume that there is a tendency for low rates of return to increase and high rates of return to fall, that is, if industry j's rate of return is high (low) in 1987 relative to the economy-wide average rate of return then we introduce a negative (positive) shift to j's rate of return over the period 1987 to 1994. The main shocks in column 9 are these rate-of-return shifts. A negative shift in industry j's rate of return allows relatively rapid capital growth whereas a positive shift retards j's capital growth.

Because in 1987 the mining sector had high rates of return, strong expansion of the sector is generated by our assumed rate-of-return shifts. Thus the largest positive entry in column 9 of Table 4.5 is for mining (19.11 per cent growth). For motor vehicles, the entry in column 9 is negative (-5.18 per cent, row 8a) reflecting mainly a low initial rate of return in the industry. Another negative influence on motor vehicles in column 9 is real appreciation (3.19 per cent) associated with the growth in mining and the assumption of no change in the balance of trade.

(10) *the effects of shifts in export supply curves.*

As part of the explanation in the historical simulation of changes in export prices and volumes (both observed) we endogenize the positions of the export demand curves and the levels of supply-shifting export taxes and subsidies (phantoms)[11]. In the decomposition simulation the demand and supply shift variables are exogenous. The effects of the demand shift variables have already been discussed in relation to column 1 of Tables 4.4 and 4.5. The effects of the supply-shift variables (phantom export taxes and subsidies) are given in column 10 of Tables 4.4 and 4.5. For motor vehicles, the unexplained export-supply shifts make small positive contributions to output growth. This may reflect the operation of the export facilitation scheme which is not explicitly modelled in our historical simulations. This scheme subsidized motor vehicle exports.

4.3. Decomposition simulation: conclusions for the motor vehicle industry

Conclusions that can be drawn from our tables regarding the Australian motor vehicle industry over the period 1987 to 1994 include the following.

- A major negative for the industry was a shift in user preferences towards imported motor vehicles (-12.68 per cent, row 8a, column 5 in Table 4.7).
- Another major negative influence was a cut in motor-vehicle protection. This reduced the industry's output by 6.04 per cent (row 8a, column 1, Table 4.7). Cuts in the protection of other industries had a small favourable impact on motor vehicle output (1.03 per cent, row 8a, column 2, Table 4.7).

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[11] The supply-shift variables are modelled as export taxes and subsidies. We refer to them as phantoms. They are not genuine taxes and subsidies and do not appear in the MONASH specification of the government accounts. Their role is to allow MONASH in historical mode to "explain" observed export behaviour. Details are in Dixon and Rimmer (1997, section 31).

- The motor vehicle industry achieved rapid primary-factor productivity growth. Nevertheless, the favourable effects of this growth on the industry's output were more than offset by the unfavourable effects of wage-enhancing primary-factor productivity growth in the rest of the economy.
- Two final negative influences on the motor vehicles industry were (a) the shift in the composition of GNE away from investment and (b) the industry's initial low rate of return which restricted its investment.
- A major positive influence on motor vehicle output was changes in the composition of the intermediate inputs used by industries. These changes included a strong increase in the input of motor vehicles per unit of output. In row 8a, column 4 of Table 4.5 we find that intermediate-input-affecting technical changes contributed 17.27 per cent to the growth in motor vehicle output.
- Another positive influence on the industry's growth was shifts in foreign demand and supply curves (4.57 per cent growth, row 8a, column 1, Table 4.5). The industry benefited from a relatively large increase in c.i.f. prices of imported cars associated with appreciation of the Yen and strong growth in motor vehicle exports.
- Changes in consumer preferences favoured the use of motor vehicles, contributing 3.43 per cent to the growth in the industry's output (row 8a, column 6, Table 4.5).
- General employment growth in the economy (column 7, Table 4.5) was an important favourable influence.

Perhaps the main implication of the results in our decomposition tables is that output growth of Australian motor vehicles was influenced strongly by several factors apart from government policy towards the industry. Positive influences on the industry included shifts in industry technologies and consumer preferences towards motor vehicles, increases in world prices of cars and general growth in the Australian economy. Although the effects of cuts in motor vehicle tariffs were significant, their influence on the industry was probably less than that of reductions in the attractiveness of the local product relative to imported substitutes.

Table 4.4. Macroeconomic and Trade Variables: Decomposition of Changes from 1987 to 1994

Column	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
	Changes attributable to:										
	shifts in foreign demands and supplies	changes in protection	primary factor saving technical change	intermediate input saving	changes in import/ domestic preferences	changes in consumer preferences	growth in employment	changes in macro composition of GDP	apparent changes in required rates of return	shifts in export supply curves	Total
1. Change in balance of trade, % of GDP	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.31	0.00	0.00	1.31
Percentage changes											
2. Real exchange rate	15.59	-0.79	6.47	-2.86	-1.98	-0.03	-2.02	0.44	3.19	-0.78	17.23
3. Real wage rate	4.31	2.10	2.36	3.33	-0.51	-0.04	-0.78	-0.04	-1.68	-1.53	7.52
4. Capital stock	1.78	1.29	5.55	7.04	0.47	0.40	11.25	5.55	-4.19	-0.50	28.65
5. Employment	0.00	0.00	0.00	0.00	0.00	0.00	10.51	0.00	0.00	0.00	10.51
6. Real GDP	0.79	0.49	3.47	4.88	0.33	-0.26	10.79	1.37	-0.92	-0.50	20.43
7. Real consumption	3.02	0.43	3.59	4.54	0.07	-0.27	10.73	3.34	-0.81	-0.95	23.69
8. Real investment	2.79	0.40	3.30	4.18	0.07	-0.25	9.89	-13.44	-0.75	-0.88	5.31
9. Other absorption (public consumption and stocks)	3.04	0.43	3.60	4.56	0.07	-0.27	10.78	4.67	-0.82	-0.96	25.12
10. Real GNE	2.97	0.43	3.53	4.46	0.07	-0.27	10.55	-0.16	-0.80	-0.93	19.85
11. Imports, volume	10.84	2.89	6.43	19.86	10.75	0.06	11.59	-3.60	0.12	-0.70	58.22
12. Exports, volume	-4.06	3.32	6.08	22.67	12.43	0.09	13.32	6.86	-0.75	2.25	62.20
13. Traditional exports, volume	-47.92	2.94	26.80	22.61	11.99	-0.26	13.44	7.84	0.15	-1.75	35.85
14. Non-traditional exports, volume	67.83	5.04	-36.06	24.00	14.76	0.28	12.90	6.42	1.25	15.23	111.66
15. Price index for imports/ consumer prices	-17.76	1.06	-7.83	4.02	2.25	0.02	2.23	-2.54	-5.22	-0.26	-24.05
16. Price index for exports/ consumer prices	-3.94	0.62	-7.47	1.24	0.58	-0.02	0.52	-3.16	-4.37	-2.99	-18.97
17. Terms of trade	13.14	-0.41	0.27	-2.64	-1.58	-0.03	-1.62	-0.62	0.77	-2.63	4.66
18. Capital goods prices/ consumer prices	-1.58	-0.71	3.72	1.46	0.13	-0.09	0.09	-7.23	-3.70	-2.01	-9.92
19. GDP deflator/consumer prices	2.74	0.02	0.66	0.30	-0.36	-0.03	-0.42	-2.07	-1.11	-1.35	-1.62
20. Total trade	3.36	3.10	6.25	21.27	11.59	0.07	12.46	1.65	-0.32	0.78	60.22

Table 4.5. Sectoral Outputs: Decomposition of Changes from 1987 to 1994

Column	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
	Changes attributable to:										
	shifts in foreign demands and supplies	changes in protection	primary factor saving technical change	intermediate input saving	changes in import/ domestic preferences	changes in consumer preferences	growth in employment	changes in macro com-position of GDP	apparent changes in required rates of return	shifts in export supply curves	Total
*Secoral output**											
1. Agriculture, forestry, fishing	-4.11	0.24	8.94	5.27	1.74	1.15	7.32	-0.02	-7.60	0.07	12.99
2. Mining	-36.84	2.99	6.09	12.09	6.12	-0.03	15.38	9.89	19.11	3.51	38.31
3. Food processing	3.35	0.29	2.16	7.30	1.22	-2.35	10.29	2.41	-4.98	-3.80	15.91
4. Textiles, clothing, footwear	-4.47	-5.03	-3.40	1.58	-8.45	-5.07	9.70	3.17	-1.33	-1.56	-14.88
5. Paper, printing	0.95	-0.09	1.39	1.31	-1.56	0.30	10.70	2.37	-0.59	-0.34	14.43
6. Chemicals, petroleum, coal products	-1.05	-0.31	-2.41	13.71	-2.52	0.76	11.50	3.69	-0.72	0.86	23.52
7. Basic metal products	-24.28	1.13	15.30	18.92	-6.90	0.26	13.21	1.96	-10.56	15.57	24.60
8. Transport equipment	3.94	-2.62	0.43	5.18	-8.01	1.48	11.54	-1.65	-2.64	0.82	8.47
8a *motor vehicles*	**4.57**	**-5.01**	**-1.85**	**17.27**	**-10.26**	**3.43**	**12.23**	**-2.48**	**-5.18**	**1.79**	**14.50**
9. Electronic equipment	4.64	-0.63	-0.19	12.54	-4.81	-0.47	11.08	-4.14	-0.62	0.46	17.87
10. Other manufacturing	2.97	-0.87	-1.85	0.43	-5.90	-0.72	10.43	1.89	-1.26	-0.55	4.57
11. Electricity, gas, water	-2.29	0.45	3.99	8.07	0.04	0.15	11.17	2.63	-1.83	0.88	23.25
12. Construction	2.81	0.36	3.45	7.42	0.07	-0.24	10.20	-11.52	-0.58	-0.76	11.21
13. Wholesale trade	2.92	0.56	2.45	1.43	0.40	-1.07	10.36	-0.69	-1.48	0.54	15.43
14. Retail trade, repairs	2.70	0.60	2.24	-0.78	-0.13	-1.43	10.24	0.93	0.06	-0.07	14.37
15. Transport, storage, communication	0.21	0.83	7.90	17.76	2.02	-1.00	12.03	2.37	-0.27	-0.82	41.04
16. Finance, insurance	1.35	0.32	12.03	57.53	2.58	3.41	14.08	0.78	-3.10	-0.48	88.51
17. Other business services	2.84	0.46	2.53	8.31	0.04	-0.20	11.08	1.22	0.04	-0.65	25.66
18. Education, libraries	4.70	0.31	3.11	4.69	-0.29	6.34	10.92	-2.20	-0.64	-0.54	26.38
19. Health, welfare	2.21	0.11	5.08	4.36	0.21	-0.31	11.28	9.47	-0.12	-0.71	31.60
20. Entertainment	6.44	0.56	1.06	8.54	0.03	6.87	10.96	-0.24	0.54	-7.44	27.33
21. Personal services	4.18	0.00	-4.46	3.69	0.34	-5.68	10.70	4.19	0.12	2.48	15.58
22. Reataurants, hotels	13.85	0.31	-3.90	2.52	1.58	-8.47	10.83	4.95	-0.49	0.61	21.78
23. Ownership of dwellings	2.50	0.73	-1.07	9.28	0.37	1.08	10.97	7.40	-6.37	-0.67	24.22
24. Public administration	2.68	0.40	3.66	3.82	0.12	-0.66	10.86	6.59	-0.78	-0.78	25.90
25. Non-competing imports	2.94	0.41	3.13	4.14	0.11	-0.48	9.69	-18.03	-0.71	-0.80	0.41
26. Defence	3.25	0.45	2.94	4.44	0.22	-0.25	10.05	-10.91	-0.74	-0.72	8.74

Table 4.6. Macroeconomic Variables: Decomposition of Changes from 1987 to 1994, Motor Vehicles and the Rest

Column	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Changes attributable to:									
	changes in protection		primary factor saving technical change		changes in import/ domestic preferences		changes in consumer preferences		other changes	Total
	Motor vehicles	*the rest*	*Motor vehicles*	*the rest*	*Motor vehicles*	*the rest*	*Motor vehicles*	*the rest*		
1. Change in balance of trade, % of GDP	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.31	1.31
*Percentage changes**										
2. Real exchange rate	-0.22	-0.57	0.02	6.46	-0.21	-1.77	-0.16	0.12	13.56	17.23
3. Real wage rate	0.32	1.78	0.09	2.27	-0.05	-0.46	-0.05	0.01	3.60	7.52
4. Capital stock	0.26	1.03	0.03	5.52	0.12	0.36	-0.29	0.69	20.93	28.65
5. Employment	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.51	10.51
6. Real GDP	0.11	0.38	0.03	3.44	0.08	0.25	0.02	-0.28	16.40	20.43
7. Real consumption	0.09	0.34	0.03	3.56	0.06	0.01	0.00	-0.27	19.87	23.69
8. Real investment	0.09	0.31	0.03	3.28	0.05	0.01	0.00	-0.25	1.79	5.31
9. Other absorption (public consumption and stocks)	0.09	0.34	0.03	3.57	0.06	0.01	0.00	-0.28	21.28	25.12
10. Real GNE	0.09	0.33	0.03	3.50	0.06	0.01	0.00	-0.27	16.09	19.85
11. Imports, volume	0.70	2.18	-0.10	6.53	1.04	9.71	0.63	-0.57	38.11	58.22
12. Exports, volume	0.82	2.49	-0.11	6.19	1.21	11.22	0.74	-0.65	40.29	62.20
13. Traditional exports, volume	0.63	2.31	-0.22	27.03	1.12	10.87	0.69	-0.95	-5.62	35.85
14. Non-traditional exports, volume	1.45	3.59	0.19	-36.25	1.48	13.29	0.89	-0.61	127.63	111.66
15. Price index for imports/ consumer prices	0.25	0.80	-0.02	-7.81	0.24	2.01	0.20	-0.19	-19.54	-24.05
16. Price index for exports/ consumer prices	0.13	0.49	-0.01	-7.46	0.07	0.51	0.10	-0.12	-12.69	-18.97
17. Terms of trade	-0.11	-0.29	0.01	0.26	-0.16	-1.42	-0.10	0.07	6.40	4.66
18. Capital goods prices/ consumer prices	-0.25	-0.46	-0.06	3.78	0.01	0.13	0.07	-0.17	-12.97	-9.92
19. GDP deflator/ consumer prices	-0.04	0.06	0.00	0.66	-0.04	-0.32	0.00	-0.03	-1.91	-1.62
20. Total trade	0.76	2.34	-0.11	6.36	1.12	10.47	0.68	-0.61	39.20	60.22

Table 4.7. Sectoral Outputs: Decomposition of Changes from 1987 to 1994
Motor Vehicles and the Rest

Column	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Changes attributable to:									
	changes in protection		primary factor saving technical change		changes in import/ domestic preferences		changes in consumer preferences		other changes	Total
	Motor vehicles	*the rest*	*Motor vehicles*	*the rest*	*Motor vehicles*	*the rest*	*Motor vehicles*	*the rest*		
*Secoral output**										
1. Agriculture, forestry, fishing	0.19	0.05	-0.04	8.97	0.30	1.44	0.01	1.14	0.92	12.99
2. Mining	0.52	2.48	-0.09	6.18	0.78	5.34	0.34	-0.37	23.14	38.31
3. Food processing	0.20	0.09	-0.04	2.20	0.32	0.90	-0.20	-2.16	14.58	15.91
4. Textiles, clothing, footwear	0.07	-5.10	0.00	-3.41	0.10	-8.55	-0.24	-4.83	7.09	-14.88
5. Paper, printing	0.09	-0.18	0.03	1.36	0.05	-1.62	-0.06	0.36	14.40	14.43
6. Chemicals, petroleum, coal products	0.18	-0.49	0.02	-2.43	0.19	-2.71	-0.05	0.82	27.99	23.52
7. Basic metal products	0.22	0.91	0.01	15.29	0.19	-7.09	0.36	-0.10	14.82	24.60
8. Transport equipment	-3.53	0.91	1.34	-0.91	-7.48	-0.53	2.53	-1.06	17.19	8.47
8a *motor vehicles*	**-6.04**	**1.03**	**2.24**	**-4.08**	**-12.68**	**2.42**	**4.15**	**-0.72**	**28.19**	**14.50**
9. Electronic equipment	0.12	-0.76	0.03	-0.22	0.06	-4.87	0.08	-0.55	23.96	17.87
10. Other manufacturing	0.05	-0.92	0.06	-1.91	0.00	-5.90	-0.05	-0.67	13.91	4.57
11. Electricity, gas, water	0.09	0.36	0.02	3.97	0.07	-0.03	-0.23	0.38	18.63	23.25
12. Construction	0.07	0.29	0.04	3.41	0.07	0.00	-0.06	-0.17	7.57	11.21
13. Wholesale trade	0.13	0.43	0.02	2.42	0.10	0.30	0.03	-1.10	13.09	15.43
14. Retail trade, repairs	0.13	0.47	0.05	2.20	0.01	-0.14	0.18	-1.60	13.08	14.37
15. Transport, storage, communication	0.16	0.67	0.00	7.91	0.22	1.80	-0.05	-0.94	31.28	41.04
16. Finance, insurance	0.05	0.28	0.05	11.98	0.01	2.57	-0.27	3.69	70.16	88.51
17. Other business services	0.09	0.37	0.04	2.49	0.04	-0.01	-0.01	-0.19	22.83	25.66
18. Education, libraries	0.09	0.23	0.02	3.08	0.09	-0.38	-0.12	6.45	16.92	26.38
19. Health, welfare	0.04	0.07	0.02	5.07	0.08	0.13	-0.30	-0.01	26.51	31.60
20. Entertainment	0.05	0.50	0.02	1.04	0.07	-0.04	-0.42	7.30	18.80	27.33
21. Personal services	0.02	-0.02	0.01	-4.46	0.09	0.25	-0.56	-5.11	25.38	15.58
22. Reataurants, hotels	0.07	0.24	-0.03	-3.87	0.22	1.36	-0.40	-8.07	32.26	21.78
23. Ownership of dwellings	0.13	0.60	0.02	-1.09	0.10	0.27	-0.57	1.65	23.10	24.22
24. Public administration	0.08	0.32	0.03	3.63	0.04	0.08	-0.02	-0.64	22.38	25.90
25. Non-competing imports	0.09	0.32	0.03	3.10	0.06	0.06	0.00	-0.48	-2.76	0.41
26. Defence	0.10	0.35	0.03	2.91	0.07	0.15	0.01	-0.26	5.38	8.74

5. MONASH forecasts for the Australian motor vehicle industry

Table 5.1 provides estimates for 1987 to 1994 and forecasts for 1998 to 2016 for macro and motor vehicle variables. The purpose of this section is to explain the motor vehicle forecasts. Our strategy is as follows. In subsection 5.1 we explain the forecast movement in imports of motor vehicles relative to domestic sales of domestically produced motor vehicles, that is we explain the ratio M/D. Then in subsection 5.2 we explain the forecast growth in domestic sales of motor vehicles, that is we explain S where S = M + D. At this stage we have a complete explanation of S, M and D. In subsection 5.3 we introduce our forecast for exports (E) of motor vehicles. This then gives us a forecast for output (Z), where Z= D+E. A summary of the forecasts is in subsection 5.4.

Table 5.1. Growth rates in macro and motor vehicle variables: 1987 to 2016

Percentage annual growth in:		Estimates for 1987 to 1994	Basecase* forecasts for 1998 to 2016
Macro variables			
Real GDP		2.7	3.2
Real investment		0.7	3.7
Real consumption		3.1	3.2
C.i.f. price of imports		1.4	3.2
Motor vehicles:			
Sales on domestic market (domestic and imported)	(S)	4.0	3.2
Domestic sales on domestic market	(D)	1.6	1.4
Imports	(M)	7.3	4.8
Domestic output	(Z)	2.0	1.8
Exports	(E)	6.1	4.6
Basic price of domestic product		3.1	3.1
Basic price of imports (includes tariff)		2.9	2.7
C.i.f. price of imports (excludes tariff)		3.8	3.0

* In the basecase forecasts, the scenario for the tariff on motor vehicles (MONASH commodity 70) is that shown in the first column of Table 6.1.

5.1. Forecast growth in imports relative to growth in domestic sales of domestically produced motor vehicles (M/D)

As can be seen in Table 5.1, between 1987 and 1994 domestic sales of domestically produced motor vehicles grew by 1.6 per cent a year and imports grew by 7.3 per cent a year implying an annual 5.6 per cent (= 100*(1.073/1.016 - 1)) increase in the import/domestic ratio (M/D) in domestic sales. This is explained in part by a decrease in the basic price[12] of imported motor vehicles (P_{MB}) relative to that of the domestic product (P_{DB}). Reductions in tariffs had a significant negative influence on the ratio of these prices. If c.i.f. prices of imported motor vehicles had increased in line with c.i.f. prices of other imported products then the decline in P_{MB}/P_{DB} would have been very large. However, the decrease in P_{MB}/P_{DB} ratio was limited to 0.2 per cent a year (= 100*(1.029/1.031 - 1)). This was because the c.i.f. price of imported motor vehicles increased sharply relative to the c.i.f. price of other imported products (3.8 per cent a year compared with 1.4 per cent a year). The Armington elasticity in MONASH for motor vehicles is 5.2, and margins represent about 15 per cent of purchasers' prices. Assuming that margin costs are independent of basic prices, we find that the change in the import/domestic basic price ratio generated an annual increase in the M/D ratio of about 0.9 per cent (= 5.2*0.85*0.2).

The remaining 4.7 per cent a year increase in the import/domestic ratio is explained by a twist in user preferences towards imports. With imports occupying about 50 per cent of the domestic market (Table 4.2), the twist in user preferences increased the growth in imports by about 2.35 percentage points a year and reduced the growth of domestic sales of the domestic product by a similar amount. The twist in user preferences towards imports reflected increased variety in imports relative to the domestic product. Government policy toward the motor vehicle industry (the Button Plan) led to a reduction in the number of domestic product lines, and the elimination of import quotas in the mid 1980's led to increased variety among imports.

Because the variety of foreign cars relative to that of domestic cars on the Australian market is likely to continue increasing, but at a slower rate, we assume a continuing twist in preferences towards imports, but at a slower rate. Instead of the twist contributing 4.7 percentage points a year to the increase in the M/D ratio for motor vehicles, we assume that its contribution will be 2.7 percentage points a year. On the other hand, our forecasts imply that relative price changes will make a larger contribution to M/D growth than they did in history (1987 to 1994). Tariff cuts in the basecase forecasts are less significant than in history but we assume that there will be no further increase in the c.i.f. price of imported motor vehicles relative to the c.i.f. prices of all imports. Our assumptions for tariffs and c.i.f. import prices, together with the other assumptions underlying our forecasts, generate an annual

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[12] The basic price of an import is the landed-duty-paid price and for domestic products it is the factory-door price. Basic prices are separated from purchasers' prices by sales taxes and margin costs (e.g. wholesale, retail and transport costs).

decrease in P_{MB}/P_{DB} for motor vehicles of 0.4 per cent a year (= 100*(1.027/1.031 - 1))). This is reduced to about 0.3 per cent a year for purchasers' prices. By multiplying by the Armington elasticity of 5.2, we find that the effect of relative price changes is to increase M/D for motor vehicles in our forecasts by about 1.6 (=5.2x0.3) per cent a year. Together, the twist and relative price contributions explain an annual increase in M/D of 4.3 per cent a year. Our actual forecast of 3.4 per cent (= 4.8 - 1.4) reflects not only twist and relative price effects, but also changes in the forecast composition of activity throughout the economy. This favours domestically produced motor vehicles relative to imports. Notice in Table 5.1 that investment growth is forecast to be 3.7 per cent, considerably above consumption and GDP growth. Investment usage of motor vehicles is relatively domestic-intensive.

5.2. Forecast growth in sales of motor vehicles (S)

In history, sales of motor vehicles on the domestic market (S) increased by 4.0 per cent a year. This is a combination of the 7.3 per cent annual growth in imports (M) and the 1.6 per cent annual growth in domestic sales of domestic output (D) discussed in the previous subsection. Growth in GDP in the historical period was 2.7 per cent a year, growth in real consumption was 3.1 per cent a year and growth in investment was 0.7 per cent a year. These macro growth rates suggest sales growth for motor vehicles in the Australian market of about 2.0 per cent a year[13]. To explain 4.0 per cent a year in sales growth, our historical simulation implied a small shift in consumer preferences and a strong shift in industry technologies (input-output coefficients) towards the use of motor vehicles. These shifts contributed about 2 per cent a year to growth in motor vehicle sales. The strong shift in industry technologies towards motor vehicles is consistent with their increasing use as part of remuneration packages.

In our forecasts for 1998 to 2016, annual real growth rates in GDP, consumption and investment are 3.2 per cent, 3.2 per cent and 3.7 per cent, suggesting an increase in the rate of growth of motor vehicle sales of 1.2 percentage points, that is an increase in the annual growth in sales from 4.0 per cent a year to 5.2 per cent[14]. However, growth in motor vehicle sales in our forecasts is only 3.2 per

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[13] In our data for 1987, the shares of investment, consumption and intermediate usage in the sales of motor vehicles were 0.39, 0.22 and 0.40. Using these shares and assuming that intermediate usage grows in line with GDP we calculate the expected growth in motor vehicle sales as:

expected sales growth = 0.39x0.7 + 0.22x3.1 + 0.40x2.7 = 2.0.

[14] In our data for 1994, the shares of investment, consumption and intermediate usage in the sales of motor vehicles were 0.30, 0.26 and 0.45. Using these shares and continuing to assume that intermediate usage grows in line with GDP we calculate the expected extra sales growth in our forecasts compared with history from extra growth in investment, consumption and GDP as:

cent. In our forecasts we have assumed no further shifts in industry and consumer preferences towards the use of motor vehicles. Thus, rather than contributing two per cent a year to the growth in motor vehicle sales, as they did in history, in the forecasts these shifts contribute nothing.

5.3. Forecast growth in output of motor vehicles (Z)

We forecast that exports of motor vehicles (E) will grow at 4.6 per cent a year. The rate achieved in the historical period was 6.1 per cent. The slowdown reflects our forecast that the rate of growth of manufactured exports will be below the very high rates of growth since the mid-1980s. Together with our forecast of 1.4 per cent annual growth in domestic sales of the domestic product (D), our export forecast implies annual output growth for motor vehicles (Z) of 1.8 per cent.

5.4. Summary of forecasts for motor vehicles

Our forecast growth rates for key variables in the Australian motor vehicle industry (S, D, M, M/D, Z and E) are all a little lower than the growth rates in recent history (1987 to 1994). This is the result of negative influences slightly outweighing positive influences.

Relative to recent history, in our forecasts we expect stronger growth in investment. This will be a positive influence on motor vehicle sales (S, D and M). On the other hand, we expect a slowdown in the rate of shift of consumer preferences and industry technologies towards motor vehicles. This will be a negative influence on S, D and M.

With regard to the ratio of M to D, negative influences in our basecase forecasts are a reduced effect of tariff cuts and a reduction in the rate of twist in user preferences towards imported vehicles. The main positive influence is that in our forecasts we assume that c.i.f. prices of imported vehicles will not increase relative to c.i.f. prices of other imports. In the historical period, growth in M/D was inhibited by a sharp increase in the c.i.f. prices of imported vehicles relative to other c.i.f. prices.

Our export forecasts (E) for motor vehicles follow from our forecasts for manufacturing exports as a whole. Because we are assuming a slower rate of growth for manufacturing exports to that of recent history, our forecast growth for motor vehicle exports is also slower than that in recent history. With our forecast growth rates for D and E being slower than their historical growth rates, we are forecasting a slight slowdown in the growth rate of output in the vehicle industry (Z).

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extra sales growth = 0.30x(3.7 - 0.7) + 0.26x(3.2 - 3.1) + 0.45x(3.2 - 2.7) = 1.2

6. The effects of reductions in the tariff on motor vehicles

This section reports results from a MONASH policy simulation concerned with the effects of reductions in tariffs on motor vehicles (MONASH commodity 70).

Different tariff rates apply to the sub-commodities within commodity 70. As explained in Dixon, Malakellis and Rimmer (1997) the average tariff rate applying to commodity 70 in 1997 is 19.13 per cent. Current government plans imply that the average tariff rate will follow the path shown in column (1) of Table 6.1, that is it will fall from its 1997 level to 11.69 per cent in 2001 and then stabilize. In 1997 the Industry Commission advised the Australian government to continue the reductions in motor vehicle tariffs beyond 2001 according to the path shown in column (2) of Table 6.1. In the basecase forecasts described in section 5 we adopted the tariff path from column (1). In the policy simulation to be described in this section we calculate deviations from the basecase forecasts caused by adopting the tariff path in column (2), that is we calculate the effects of adopting the Industry Commissions' advice.

The remainder of this section is organized as follows. In subsection 6.1 we describe the key assumptions underlying the policy simulation. Subsection 6.2 presents the results and explains them by the use of back-of-the-envelope algebra. Subsection 6.3 contains some policy conclusions.

Table 6.1. Tariff rates applying to c.i.f. imports of motor vehicles (MONASH commodity 70)

	(1)	(2)
Year	Basecase forecasts	Policy simulation
1997	19.13	19.13
1998	17.27	17.27
1999	15.41	15.41
2000	13.55	13.55
2001	11.69	11.69
2002	11.69	9.83
2003	11.69	7.97
2004	11.69	6.11
2005	11.69	4.25
*	*	*
*	*	*
*	*	*
*	*	*
2016	11.69	4.25

6.1. Key assumptions

(a) Labour market

We assume that the deviation in the post-tax real wage rate from its basecase forecast level increases in proportion to the deviation in employment from its basecase forecast level. The coefficient of proportionality is chosen so that the employment effects of a shock to the economy are largely eliminated after 5 years. In other words, after about 5 years, the benefits or costs of a shock, such as a reduction in the tariff on commodity 70, are realised almost entirely as an increase or decrease in real wage rates. This labour market assumption is consistent with conventional macro-economic modelling in which the NAIRU is exogenous. Further explanation of our labour market assumption is given in appendix 6.1.

(b) Public expenditure and taxes

We assume that reductions in tariffs make no difference to the path of real public consumption. We also impose an additional tax of x per cent on all consumer expenditures. The value of x is computed endogenously so that there is no deviation in the path of the ratio of net tax collections[15] to GDP. Thus in effect we replace the lost revenue associated with reductions in the tariff on commodity 70 by a broad-based consumption tax. Alternatively we could have used additional income tax to replace the lost tariff revenue. However replacement by an indirect tax seems the more policy-relevant assumption because the current thrust of taxation policy in Australia is towards indirect taxes and away from direct taxes.

(c) Consumption, investment, ownership of capital and measurement of welfare

In each year of the policy simulation, aggregate real consumption diverges from its basecase forecast level by an amount reflecting the divergence in real income available to Australians. In other words, we assume that the benefit or cost in year t from the additional cuts in tariffs specified in the policy simulation is absorbed in that year entirely as a change in real household consumption. With no change in the path of real public consumption and with revenue neutrality, our consumption assumption is consistent with a zero marginal rate of household saving. Marginal rates of saving in the Australian economy are low but not zero. Consequently, our consumption assumption leads to a small over-estimation of the immediate consumption effects of income changes. Against this, our assumption has two important simplifying advantages. First, it means in our model that it is easy to keep track of foreign/domestic ownership of units of capital. Extra units created as a result of additional tariff cuts are entirely foreign owned. Similarly if the tariff cuts

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[15] Net tax collections are defined in MONASH as income taxes plus indirect taxes minus subsidies minus unemployment benefits. In MONASH the motor vehicle industry is treated as if it pays the full tariff rate on all its imports of automotive products. However via a by-law scheme much of these imports enter Australia duty free. We capture the effects of the by-law allowances via a subsidy on motor vehicle production in year t. Details are in Dixon, Malakellis and Rimmer (1997).

lead to a reduction in the capital stock then there is a corresponding reduction in the quantity of foreign-owned capital. Consequently, in our policy simulation, all of the variation in post-tax capital income associated with variations in the capital stock is excluded in the calculation of the change in income available to Australians. The second simplifying advantage is that compensating variation calculations based on the divergences in the paths of the volumes of consumption of each commodity provide a valid indicator of the welfare effects of the tariff cuts under consideration. This is because in our policy simulations the domestic population undertakes no extra investment, owns no extra capital and incurs no extra debt.

(d) Rates of return on capital

In policy simulations, MONASH allows for short-run divergences in post-tax rates of return on industry capital stocks from their levels in the basecase forecasts. Short-run increases/decreases in rates of return cause increases/decreases in investment and capital stocks, thereby gradually eroding the initial divergence in post-tax rates of return.

(e) Production technologies

MONASH contains many types of technical change including: primary-factor and intermediate-input-saving technical change in current production; input-saving technical change in capital creation; and input-saving technical change in the provision of margin services. In our policy simulations we assumed that all technology variables have the same values as in the basecase forecast simulation, that is, we assume that the cut in motor vehicle tariffs has no effect on technology.

6.2. Results

Charts 6.1 to 6.8 show the macro-economic effects of the assumed additional tariff cuts. Charts 6.9 to 6.11 show the effects on the motor vehicle industry and Charts 6.12 and 6.13 give effects on other industries.

(a) Macro effects: back-of-the-envelope model

We begin with a back-of-the-envelope (bote) model. This will be useful for explaining the macro results. In the bote model we assume that the economy produces one good (grain) and imports one good (vehicles). Grain production is via a constant-returns-to-scale production function of capital and labour inputs. Grain and vehicles are both consumption and investment goods. Units of consumption and investment are formed as Cobb-Douglas functions of grain and vehicles leading to Cobb-Douglas unit-cost functions. Finally, we assume that the costs per unit of employing capital and labour equal the values to the employer of their marginal products. Under these assumptions we have:

$$P_c = (P_g T_{gc})^{\alpha_{gc}} (P_v T_{vc})^{\alpha_{vc}} \quad , \qquad (6.1)$$

$$P_i = (P_g T_{gi})^{\alpha_{gi}} (P_v T_{vi})^{\alpha_{vi}} \quad , \tag{6.2}$$

$$W = P_g M_l \quad , \tag{6.3}$$

$$Q = P_g M_k \quad , \tag{6.4}$$

$$W_{real} = W / P_c \quad , \tag{6.5}$$

and

$$R = Q / P_i \tag{6.6}$$

where:

P_g and P_v are the basic price of grain and the c.i.f. price of vehicles;

P_c and P_i are the purchasers' prices of a unit of consumption and a unit of investment;

T_{gc}, T_{vc}, T_{gi} and T_{vi} are the powers (one plus rates) of the taxes (including tariffs) applying to consumption purchases of grains and vehicles and investment purchases of grains and vehicles;

Q and W are the factor payments, the rental rate and the wage rate;

M_l and M_k are the marginal products of labour and capital;

W_{real} is the real wage rate;

R is the rate of return on capital calculated as the rental or user price of capital divided by the cost or asset price of a unit of capital; and

the α's are positive parameters reflecting the shares of grains and vehicles in consumption and investment, such that $\alpha_{gc} + \alpha_{vc} = 1$ and $\alpha_{gi} + \alpha_{vi} = 1$.

From these equations we find that

$$M_l(\frac{K}{L}) = W_{real} * \left(\frac{P_v}{P_g}\right)^{\alpha_{vc}} * T_c \tag{6.7}$$

and

$$M_k(\frac{K}{L}) = R * \left(\frac{P_v}{P_g}\right)^{\alpha_{vi}} * T_i \tag{6.8}$$

where T_c and T_i are the average powers of the taxes on consumption and investment defined by

$$T_c = T_{gc}^{\alpha_{gc}} * T_{vc}^{\alpha_{vc}} \text{ and } T_i = T_{gi}^{\alpha_{gi}} * T_{vi}^{\alpha_{vi}} \quad . \tag{6.9}$$

In (6.7) and (6.8), we emphasise that the marginal products are both functions of K/L. M_l is a positive function of K/L and M_k is a negative function of K/L.

As explained in subsection 6.1(b), in our MONASH policy simulation we reduce the tariff on vehicles and replace the lost revenue with a broad-based consumption tax. In terms of the bote model, this has the effect of increasing the average power of the tax rate on consumer goods (T_c) and reducing the average power of the tax on investment goods (T_i).

In the short run, W_{real} is sticky (see subsection 6.1(a)). With a cut in tariffs there is an increase in both imports and exports leading to an increase in P_v relative to P_g, that is a decline in the terms of trade. Thus from (6.7) we see that M_l, and consequently K/L, will increase . Because K moves slowly, there must be a short-run decrease in L. This is confirmed in Chart 6.1 where we see employment moving below control (basecase forecast) in the years of additional tariff cuts (2002 to 2005).

Looking now at (6.8), we ask what is the short-run impact of the additional tariff cuts on the rate of return (R)? With an increase in K/L, M_k falls. As already mentioned, P_v / P_g rises. Both these effects tend to reduce R. However T_i falls and this tends to increase R. Thus the effect on R is uncertain. In our MONASH simulation R falls, and as can be seen in Chart 6.1, K begins to edge downwards.

The short-run decrease in employment leads to reduced wage demands and W_{real} moves down (Chart 6.5 and subsection 6.1(a)). Thus, after the initial increase, M_l moves back down towards control (see (6.7)). This means that after its initial rise, K/L must fall towards control. Because K edges down only slowly, the fall in K/L towards control is accomplished mainly by an upward movement in L towards control. This can be seen in Chart 6.1 where L rises steadily from its trough deviation in 2005.

Although L is rising from its trough deviation, W_{real} continues to fall. It will fall as long as employment is below control. In terms of (6.7), M_l continues to move back down towards control until L is increased to control. In our simulation this happens in 2016. The upward movement in L between 2005 and 2016 is facilitated by a gradual recovery in the terms of trade, that is a fall in P_v / P_g, (see Chart 6.6 and the explanation in the next paragraph). If we had continued our simulation beyond 2016, L would have risen slightly above control. With L at control in 2016, the path of W_{real} is momentarily flat (see Chart 6.5). However with the terms of trade continuing to improve, M_l continues to fall. By 2016, K is falling

only slowly and the continued fall in K/L is accomplished by a movement in L above control.

What explains the movements in the terms of trade in Chart 6.6? In MONASH, we treat Australia as a small country on the import side, that is we treat c.i.f. import prices in foreign currency as exogenous. On the other hand, we recognize that Australia has considerable shares of world markets for several relatively homogeneous agricultural and mineral products, and that Australia exports distinctive varieties of manufactured goods. Thus, we assume that expansions of Australia's exports reduce their world prices and generate a decline in Australia's terms of trade. Consequently the deviation path of the terms of trade is closely connected with the deviation path in aggregate exports. Looking at the charts, we see that they give results for aggregate exports and other trade variables consistent with those which would be expected in a model with a fixed balance of trade: the additional tariff cuts stimulate imports (Chart 6.3); reduce the real exchange rate (Chart 6.4); stimulate exports (Chart 6.3); and thereby reduce the terms of trade (Chart 6.6). However, in our policy simulation the balance of trade is not fixed. It moves towards surplus (requiring real devaluation with consequent export expansion and terms-of-trade deterioration) when investment is weak. It moves towards deficit (requiring real appreciation with consequent export contraction and terms-of-trade improvement) when investment is strong. Thus fluctuations in the path of the terms of trade are closely connected with fluctuations in the path of investment (Chart 6.2). The path of investment depends on the slope of the capital path (Chart 6.1). During the period of additional tariff cuts, the capital stock declines at an increasing rate, causing investment to move further and further below control and the terms of trade to decline rapidly. Beyond the period of additional tariff cuts, the rate of decline of the capital stock eases. Thus investment, and consequently the terms of trade, moves back towards control.

In the absence of terms-of-trade effects, (6.8) suggests that the additional tariff cuts would cause a long run increase in K/L. If P_v / P_g were unaffected, then in the long run M_k would be below control. This is because T_i is below control and R eventually returns to control (subsection 6.1(d))[16]. However, it is clear from Chart 6.1 that the terms-of-trade effects are sufficiently strong, at least for ten years beyond the period of additional tariff cuts, to leave K/L below control. Thus our model predicts a decease in K/L over any period that is likely to be of policy relevance.

The final two macro results requiring explanation are those for real GDP and consumption. At first glance, the GDP path in Chart 6.1 is perplexing. In the initial years of the simulation it is high in relation to the paths for capital and labour. For

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[16] In a separate policy simulation of the effects of additional cuts in motor vehicle tariffs we eliminated terms-of-trade effects by assuming (unrealistically) that all of the foreign export demand elasticities for Australian products are close to infinity. As predicted by the bote model, MONASH produced a long run increase in the K/L ratio.

example, with labour contributing about 70 per cent and capital about 30 per cent to GDP[17], the employment and capital deviations in Chart 6.1 for 2005 contribute about -0.015 per cent (= -0.021x0.7 - 0.002x0.3) to the GDP deviation. But the actual GDP deviation is -0.002 per cent. That is, other factors including improvements in resource allocation (welfare rectangles and triangles) associated with the additional tariff cuts made a positive contribution of 0.013 per cent. In contrast, the employment and capital deviations for 2016 contribute about -0.005 per cent to GDP (= 0.0x0.7 - 0.018x0.3) but the actual GDP deviation is -0.014 per cent. That is other factors make a negative contribution of 0.009 per cent. Why does the contribution of these other factors change sign as we move through the simulation period?

(b) Decomposition of GDP deviations

To help us understand the GDP results, we decompose the path of the GDP deviations into six parts. This is shown in Chart 6.7. The decomposition starts with the equation[18]:

gdpreal =

Sum[(o,j), *LABOCCIND*, [LAB(o,j)/ GDP]*employment(o,j)]
+ Sum[j, *IND*, [CAP(j)/ GDP]*capital(j)]
+ [TARIFF(70)/ GDP]*impvol(70)
+ Sum[j, *ALLFLOWS*, [FLOW(j)/ GDP]*tc(j)]
+ Sum[j, *ALLFLOWS*, [TAX(j)/ GDP]*realflow(j)] .

(6.10)

In (6.10) the variables denoted by lowercase symbols are percentage changes between years t-1 and t:

gdpreal is the percentage change in real GDP from year t-1 to t;

employment(o,j) is the percentage change in employment in occupation o in industry j;

capital(j) is the percentage change in the quantity of capital in industry j;

impvol(70) is the percentage change in the volume of imports of commodity 70 (motor vehicles);

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[17] These are approximate shares in GDP at factor cost. In back-of-the-envelope calculations it is reasonable to assume that GDP moves in line with GDP at factor cost and to use shares in GDP at factor cost in calculations of factor contributions to GDP growth.

[18] Sum[j, *SET*, X(j)] is the sum of all X(j) for j in *SET*.

tc(j) is the percentage change in the technology coefficient associated with flow j;[19] and

realflow(j) is the percentage change in the quantity of flow j.[20]

The uppercase symbols are levels of variables:

GDP is the level of nominal GDP;

LAB(o,j) is the level of payments to labour by occupation and industry;

CAP(j) is the level of payments (rentals) to capital by industry;

TARIFF(70) is the level of tariff collection on imports of commodity 70;

FLOW(j) is the value of flow j; and

TAX(j) is the collection of indirect taxes on flow j including tariffs apart from those on commodity 70.

The italic symbols refer to sets:

COM is the set of all commodities;

LABOCCIND is the set of all occupation/industry categories of employment;

IND is the set of all industries; and

ALLFLOWS is the set of all commodity and primary-factor flows.

To reduce linearization error in (6.10), we use mid-point percentage changes. For example, gdpreal is $g_t/(1+g_t/200)$ where g_t is the percentage growth in real GDP between years t-1 and t with real GDP in year t-1 as the base. Similarly, the coefficients (GDP, LAB, etc.) are averages[21] of values in years t-1 and t.

With the paths of GDP defined by (6.10), we demonstrate in appendix 6.2 that the percentage gap (Dev_T) in year T between GDP in a policy (or deviation) simulation and GDP in a forecast simulation is given by:

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[19] tc(j) refers to intermediate- or primary-factor-saving technical change in any industry; input-saving technical change in the creation of units of industry capital; and changes in the use of margins services per unit of sales.

[20] Flow j refers to intermediate-input and primary-factor flows to industries; and commodity flows to investment, exports, households, inventories and government.

[21] In multi-step solutions of the MONASH model, the average values for coefficients reflect their values at each point along the solution path as we move the exogenous variables from their year t-1 values to their year t values.

$$Dev_T = \sum_{i=1}^{F} QCONT_{iT} + \sum_{i=1}^{F} SHCONT_{iT} \tag{6.11}$$

where

$$QCONT_{iT} = \sum_{t=1}^{T} S_{Tti}(v^d_{ti} - v^f_{ti}) \quad , \tag{6.12}$$

$$SHCONT_{iT} = \sum_{t=1}^{T} v_{ti}(S^{d*}_{Tti} - S^{f*}_{Tti}) \quad , \tag{6.13}$$

$$S_{Tti} = (S^{d*}_{Tti} + S^{f*}_{Tti})/2 \quad , \tag{6.14}$$

and

$$v_{ti} = (v^d_{ti} + v^f_{ti})/2 \quad . \tag{6.15}$$

v^d_{ti} and v^f_{ti} refer to percentage changes between years t-1 and t in the policy and forecast simulations in the quantity variables on the RHS of (6.10). For example, v^d_{ti} for i = employment(o,j) is the mid-point percentage change in employment(o,j) between t-1 and t in the policy simulation.

S^{d*}_{Tti} and S^{f*}_{Tti} are modified ratios (as defined in appendix 6.2) between years t-1 and t of the value of i to GDP in the policy and forecast simulations. For example, S^{d*}_{Tti} for i = employment(o,j) refers to a modified share in GDP of occupation o in industry j (LAB(o,j)/GDP) between years t-1 and t in the policy simulation.

We interpret $QCONT_{iT}$ as the contribution to Dev_T of the differences between the policy and forecast simulations in the growth rates of the *quantity* of factor i, and we interpret $SHCONT_{iT}$ as the contribution of the differences between the two simulations in the GDP *shares* of factor i. Thus, we see that Dev_T will be positive if

- growth in quantity variables is rapid in the policy simulation compared with the forecast simulation (that is, the v^d_{ti}s are large relative to the v^f_{ti}s, giving positive quantity effects); and
- the modified GDP shares of fast growing quantity variables are greater in the policy simulation than in the forecast simulation (that is, as we vary i, positive values for $S^{d*}_{Tti} - S^{f*}_{Tti}$ correspond to large values for v_{ti}, giving positive share effects).

In the context of the MONASH model, (6.11) decomposes real GDP deviations into many thousands of components. In Chart 6.7 we have aggregated

these components into six parts. The first four are quantity effects for labour, capital, the tariff on commodity 70 and for other taxes. For example, the labour line in Chart 6.7 shows aggregations for each year T of the $QCONT_{iT}$s over all i where i is a category of labour. The fifth part is technical change. The technical change line in Chart 6.7 shows share contributions for technical change, that is it shows an aggregation of the $SHCONT_{iT}$s over all technical change variables. As explained in subsection 6.1(e), we assume that the reductions in motor vehicle tariffs do not affect the paths of the technical change variables. Thus the quantity effects for technical change are zero. All remaining share effects are aggregated and form the sixth part of our decomposition of the GDP deviations. These share effects are shown in Chart 6.7 by the share line. The six parts add to the GDP deviations represented by shaded columns.

The labour line in Chart 6.7, especially in the early years, has approximately the same shape as the aggregate employment line in Chart 6.1. In the early years the contribution of employment to the GDP deviation is approximately 0.63 times[22] the percentage deviation in employment. In the later years this relationship breaks down. For example, in 2016 the employment deviation is zero (Chart 6.1) but the labour contribution to the GDP deviation is -0.01 per cent. In the early years, employment growth in the policy simulation is low relative to employment growth in the forecasts ($v_{ti}^d - v_{ti}^f < 0$ for i = employment). The opposite is true in the later years ($v_{ti}^d - v_{ti}^f > 0$). During the early years the labour share in GDP is higher than in the later years. This is a feature of the forecasts which involve a gradual decline in the labour share of GDP from 63.4 per cent in 1998 to 57.8 per cent in 2016. In the calculation of the labour contributions to the GDP deviations, the negative growth deviations occurring in the early years receive higher weights than the positive growth deviations in the later years. Thus the labour contribution to the GDP deviation in 2016 is negative even though the deviation in employment is zero. More generally, real GDP is a divisia (continuously varying weight) index of movements in factor, technology and tax variables. Even if each of these variables ends up at the same point in a policy simulation as in the forecasts, real GDP need not end up at the same point. The deviation in real GDP depends on the paths of the deviations in the constituent variables not just their endpoints.

The contribution line for capital in Chart 6.7 tracks the capital deviation line in Chart 6.1 quite closely. Compared with labour, for capital there is little variation through the simulation period in the growth deviations $v_{ti}^d - v_{ti}^f$: as is apparent from Chart 6.1, for capital $v_{ti}^d - v_{ti}^f$ is less than zero throughout the simulation period. Consequently in each year of the simulation period, the capital contribution to GDP deviations is approximately the capital share times the deviation in the capital stock. This relationship is not upset despite a steady increase in our forecasts in the capital share of GDP.

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[22] The share of labour in GDP (at market prices) is approximately 0.63.

The tariff(70) contribution in Chart 6.7 covers the familiar triangles and rectangles from partial equilibrium welfare economics. In each year T, the tariff(70) contribution is given approximately by

$$QCONT_{tariff(70),T} = (TAR70_{f,T} + 0.5 * DIFTAR70_T) * SM70_T * m70_T \qquad (6.16)$$

where

$TAR70_{f,T}$ is the forecast tariff rate for motor vehicles in year T;

$DIFTAR70_T$ is the difference between the tariff rate for motor vehicles in the policy simulation and the basecase forecasts;

$SM70_T$ is the share of imported motor vehicles in GDP (an average between the forecast and policy simulations); and

$m70_T$ is the percentage increase in imports of motor vehicles caused by the additional tariff reductions.

From our forecasts for 2005, we find that $SM70_T$ is about 0.023 and from our results for the motor vehicle industry (to be discussed below) we find that $m70_T$ is 4.91 per cent. Table 6.1 indicates that $TAR70_{f,T}$ is 0.1169 and $DIFTAR70_T$ is -0.0744. Thus (6.16) gives a tariff contribution in 2005 of about 0.009. This is consistent with the tariff contribution for 2005 shown in Chart 6.7. $SM70_T$ rises slightly through the simulation period but $m70_T$ falls. The net result in Chart 6.7 is a gradual decline in the tariff(70) contributions to the GDP deviations.

Chart 6.7 includes a line showing the quantity contributions to the GDP deviations of indirect taxes and tariffs other than the tariff on commodity 70. Most of these taxes are on consumption. As will be discussed in subsection 6.2(c) and as can be seen from Chart 6.2, the deviation in aggregate real consumption declines (becomes more negative) during the period of additional tariff cuts and then approximately stabilizes. Our initial expectation was that the other-tax contribution line in Chart 6.7 would have a similar shape. In working out why the other-tax contribution follows the up and down path shown in Chart 6.7 we found it helpful to disaggregate this contribution into two parts: the contribution from sales taxes on motor vehicles and the contributions from all other indirect taxes. This reveals (Chart 6.7a) that the second part follows the expected shape and that the up and down path for the other-tax contributions in Chart 6.7 is explained by the sales taxes on motor vehicles. Sales of both imported and domestic motor vehicles, especially to households, are heavily taxed. During the period of tariff cuts there is a net stimulation of motor vehicle sales to households, causing the up movement in Chart 6.7a in the motor vehicle part of the other-tax contributions. In later years, the deviations in the household consumption paths of both domestic and imported motor vehicles decline, Chart 6.9a. As explained in subsection 6.2(d), this behaviour is caused by continuing twists in the basecase forecasts towards imported motor vehicles. It is the declining motor vehicle consumption deviations that cause the

down movement in Chart 6.7a of the motor vehicle part of the other-tax contributions.

The share effects in Chart 6.7 make an increasingly negative contribution to the GDP deviations throughout the simulation period. Computations not presented here show that the share effects are dominated by tax terms, that is

$$\text{Share effect(T)} \approx \text{Sum[i = tax term, } \sum_{t=1}^{T} v_{ti}(S_{Tti}^{d*} - S_{Tti}^{f*})\text{]} \quad . \tag{6.17}$$

For the purpose of understanding the behaviour of the share effects in Chart 6.7 it is reasonable to assume that there are only two indirect taxes: the tariff on motor vehicles and a uniform tax on all consumption. Then ignoring the minor modifications discussed in appendix 6.2 in the definitions used in the decomposition formulas of shares (the S^*s), we simplify (6.17) to

$$\text{Share effect(T)} \approx \sum_{t=1}^{T}(S_{tc}^{d} - S_{tc}^{f}) * c_t + \sum_{t=1}^{T}(S_{tm}^{d} - S_{tm}^{f}) * m_t \tag{6.18}$$

where

S_{tc}^{d} and S_{tc}^{f} are the shares in the policy and forecast simulations of consumption taxes in GDP in year t,

S_{tm}^{d} and S_{tm}^{f} are the shares in the policy and forecast simulations of motor vehicle tariff revenue in GDP in year t,

c_t is the growth rate, averaged between the policy and forecast simulations, in real consumption from year t-1 to year t, and

m_t is the growth rate, averaged between the policy and forecast simulations, in the volume of motor vehicle imports from year t-1 to year t.

Revenue neutrality (see subsection 6.1(b)) requires that

$$S_{tc}^{d} + S_{tm}^{d} \approx S_{tc}^{f} + S_{tm}^{f} \quad . \tag{6.19}$$

Using (6.19) we can write (6.18) as

$$\text{Share effect(T)} \approx \sum_{t=1}^{T}(S_{tm}^{d} - S_{tm}^{f}) * (m_t - c_t) \quad . \tag{6.20}$$

With tariff cuts, S_{tm}^{d} is less than S_{tm}^{f} for all t in the simulation period. In our forecasts, motor vehicle imports grow rapidly relative to real consumption. This leaves m_t greater than c_t for all t. Thus, consistent with the share line in Chart 6.7, (6.20) implies that Share effect(T) becomes increasingly negative as T increases.

The final part of the decomposition of the GDP deviations is the technical change effect. As we will see in subsections 6.2(c) and (d), the additional cuts in motor vehicle tariffs cause a reduction in the share of the economy's resources (capital and labour) devoted to motor vehicle production and an increase in the share of resources devoted to export-oriented activities. In our forecasts, these latter activities have more rapid rates of technical progress than motor vehicle production. Thus, although we assume no difference between the forecast and deviation simulations in the rates of technical progress in each industry (subsection 6.1(e)), the overall rate of technical progress in the policy simulation is greater than that in the forecast simulation. This is because the share of relatively technologically progressive export-oriented activities in GDP is higher in the policy simulation than in the forecast simulation and the share of relatively technologically backward motor vehicle production is lower. Thus we find in Chart 6.7 an increasingly positive technical change contribution.

In comparative static models and models with basecase forecasts exhibiting balanced growth, GDP deviations induced by policy changes can be explained largely in terms of welfare triangles and rectangles and changes in employment and capital usage. As pointed out earlier, only a glance at Chart 6.1 is required to show that such an explanation is inadequate for MONASH policy simulations. Our analysis of Chart 6.7 reveals that GDP deviations in these simulations depend critically on the details of the realistic (unbalanced) basecase forecasts. In the present example, we found that the GDP deviations are affected by the following features of the basecase forecasts:

- a downward trend in the labour share of GDP;
- a continuing twist in user preferences towards imported motor vehicles and away from domestic motor vehicles;
- rapid growth in imports of motor vehicles relative to aggregate consumption; and
- slow technological progress in motor vehicle production relative to that in export-oriented industries.

(c) Consumption and welfare

As explained in subsection 6.1(c), we assume that variations in the capital stock caused by the additional reductions in motor vehicle tariffs are accommodated by variations in foreign-owned capital. Thus a back-of-the-envelope representation of the relationship between deviations in real GNP (income available to Australians) and deviations in real GDP is

$$dev_T(gnpr) = [\, dev_T(gdpr) - devcont_T(cap) \,] + T_k * devcont_T(cap) \qquad (6.21)$$

where

$dev_T(gnpr)$ is the percentage deviation in year T in real GNP;

$dev_T(gdpr)$ is the percentage deviation in year T in real GDP;

T_k is the tax rate on capital income; and

$devcont_T(cap)$ is the percentage deviation contribution of capital to real GDP.

In writing (6.21) we assume (realistically) that GNP is approximately the same size as GDP. The first term on the RHS of (6.21) is the deviation in real GDP net of the contribution of capital. In the absence of taxes, this would be the deviation in real income available to Australians. However, although we assume that all of the variations in capital reflect variations in foreign-owned capital, not all of the variations in capital income accrue to foreigners. Australians retain the tax component, represented by the second term on the RHS of (6.21). Using the values for $dev_T(gdpr)$ and $devcont_T(cap)$ from Chart 6.7 and noting that the tax rate T_k is 0.1935, we have plotted $dev_T(gnpr)$ in Chart 6.8. For comparative purposes the chart shows $dev_T(gdpr)$.

To convert percentage deviations in real GNP into percentage deviations in real expenditure by Australians, we use the back-of-the-envelope formula

$$dev_T(Aus\_expr) = dev_T(gnpr) + dev_T(PGDP/PGNE) \qquad (6.22)$$

where

PGDP is the price deflator for GDP which we assume is the same as that for GNP;

PGNE is the price deflator for GNE which we assume is the same as that for expenditure by Australians (consumption, public expenditure and domestically financed investment);

$dev_T(Aus\_expr)$ is the percentage deviation in year T in real expenditure by Australians; and

$dev_T(PGDP/PGNE)$ is the percentage deviation in year T in PGDP/PGNE.

In (6.22) we assume (realistically) that expenditure by Australians is approximately the same size as GNP.

Deviations in PGDP/PGNE reflect movements in the terms of trade: PGDP includes the price of exports but not imports whereas PGNE includes the price of imports but not exports. As already discussed with reference to Chart 6.6, additional cuts in tariffs reduce the terms of trade thereby reducing PGDP/PGNE. Thus, as illustrated in Chart 6.8, the deviations in real expenditure by Australians are more negative than the deviations in real GNP.

In subsection 6.1(c) we assumed that all deviations in real expenditure by Australians are reflected in deviations in real consumption. Thus our back-of-the-

envelope calculations suggest that the percentage deviations in real consumption are related to percentage deviations in real expenditure by Australians by[23]

$$dev_T(consr) = dev_T(Aus\_expr)/SH_T(CONS) \qquad (6.23)$$

where

$dev_T(consr)$ is the percentage deviation in year T in real household consumption; and

$SH_T(CONS)$ is the share in expenditure by Australians accounted for by consumption.

In Chart 6.8 we have plotted $dev_T(consr)$ derived from (6.23) using the path of $dev_T(Aus\_expr)$ and the values of $SH_T(CONS)$ from our forecasts (about 0.6). As can be seen from the chart, this back-of-the-envelope (bote) calculation of the path of real consumption closely reproduces the deviation path for real consumption (CR) from the MONASH policy simulation.

The MONASH variable (CR) for real consumption is a divisia index of percentage movements in the consumption of individual commodities. Thus the deviation in CR in year T from its forecast value caused by the additional tariff cuts could be non-zero in circumstances where there is no deviation in the consumption of any individual commodity[24]. This implies that deviations in CR may not accurately indicate deviations in household welfare, even under the assumptions in subsection 6.1(c). Consequently, we calculated the compensating variation (cv_T) for each year as a percentage of the household budget ($AGGCON_T$) according to

$$cv_T = \sum_i BSH^d_{Ti} * dev_T(consr_i) / AGGCON_T \qquad (6.24)$$

where

BSH^d_{Ti} is the share in year T of the household budget accounted for by good i in the policy simulation; and

---

[23] Notice that we do not include in (6.23) deviations in the ratio of the price of consumption to the price of all expenditure by Australians. Under the assumption (subsection 6.1(c)) that the domestic economy continues to finance the same real levels of investment and of public consumption that it did in the forecasts, variations in this ratio do not allow any deviation in real consumption beyond that shown in (6.23).

[24] Assume for example that the forecast share of good i in the household budget trends down from year 1 to year T. Assume also that the policy growth rate in the consumption of i is greater than the forecast growth rate in the early years of the policy simulation but less than this growth rate in the later years. Then the deviation in CR in year T could be positive even if the consumption of good i in year T in the deviation simulation had returned to its forecast level. A similar phenomenon was discussed in subsection 6.2(b) in connection with the labour contribution to the deviations in real GDP.

$dev_T(consr_i)$ is the percentage deviation in year T in real household consumption of good i.

Under the assumptions in subsection 6.1(c), the path of cv is a legitimate indicator of the overall welfare effect of the additional tariff cuts. As can be seen in Chart 6.8, the cv path is close to the deviation path for CR. Thus, in the current application of the MONASH model, CR is not misleading as a welfare indicator.

(d) Results for the motor vehicle industry

Chart 6.9 shows that in 2016, sales in Australia of domestically produced commodity 70 and imports of commodity 70 in the policy simulation are 7.18 per cent below and 4.59 per cent above their forecast levels. This is an 11.3 per cent reduction in the domestic to import sales ratio (=100*[(1-0.0718)/(1.0459) - 1]). It arises from a change in relative prices and from a change in the composition of demand for commodity 70.

The direct effect of the tariff cuts is to reduce the landed-duty-paid price (that is the basic price) of imports of commodity 70 by 6.66 per cent (=100*[1.0425/1.1169 - 1], see the tariff rates in the second column of Table 6.1). The MONASH results indicate that there is little effect on the exchange rate and that in 2016 the basic price of imported commodity 70 (PM70) in the policy simulation is 6.56 per cent below its basecase forecast value. With a lower import price, there is a reduction of 2.23 per cent in the basic price of domestic commodity 70 (PD70). The main reason is that the domestic industry benefits from a reduction in the cost of one of its principal inputs, namely imported automotive parts[25]. Bringing the results for PM70 and PD70 together, we find that by 2016 the tariff cuts have reduced PM70/PD70 by 4.4 per cent (=100*[(1-.0656)/(1-.0223) - 1]). However, for households, basic prices of domestic and imported cars are only about half of purchasers' prices. Sales taxes account for about 22 per cent and margins (e.g. retail, wholesale and transport costs) make up the rest. Because we assume that margin costs are determined independently of basic prices, the effect of tariff cuts on the import/domestic ratio of purchasers' prices to households is much less than their effect on the import/domestic ratio of basic prices. In the policy simulation, the reduction in the import/domestic ratio of purchasers' prices to households is only 3.2 per cent. The substitution elasticity between imported and domestic cars in MONASH is 5.2. Thus we find in our results for 2016 (Chart 6.9a), a reduction for households of 15.6 per cent in their ratio of purchases of domestic commodity 70 to imports of commodity 70 (=100*(1-(1-0.032)$^{5.2}$)). For other users of commodity 70, margins play a less important role and the changes in their import/domestic purchasers' price ratios are closer to 4.4 per cent. This gives reductions in their

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[25] Against this, the industry loses much of its by-law subsidy (discussed in the footnote to subsection 6.1(b)). Because the automotive imports by the industry exceed the level allowed under the by-law, the cost-reducing effects on the industry of reductions in automotive tariffs outweigh the cost-increasing effects of the erosion of the by-law subsidy.

domestic/import mixes of close to 21 per cent ($=100*(1-(1-0.044)^{5.2})$). Nevertheless, the reduction in the overall domestic/import sales ratio is limited to 11.3 per cent. This reflects an import-reducing change in the composition of demand for commodity 70. The motor vehicle industry (which suffers a negative output deviation and is a major user of commodity 70) is a much more intensive user of imported 70 than are other users of commodity 70 (e.g. households).

Having explained the deviation result for the domestic/import ratio in the sales of 70, we now turn to the deviation result for total domestic sales (domestically produced plus imported). In Chart 6.9, total domestic sales in 2016 are almost unaffected. Lower prices for commodity 70 increase the demands of households (Chart 6.9a) and most other users. However, as already mentioned, one of the main users of commodity 70 is the motor vehicle industry. Contraction of this industry is sufficient to cause the path of total domestic sales of 70 in the deviation simulation to lie slightly below the forecast path for much of the simulation period.

From the deviation results for total domestic sales and their domestic/import mix, we can explain the results for both domestic sales of the domestic commodity and import sales. We use the equations:

$$\%\text{dev(total domestic sales)} = Sh_m * \%\text{dev(imports)} + Sh_d * \%\text{dev(domestic)} \quad (6.25)$$

and

$$100*\left[\frac{1+\%\text{dev(domestic)}/100}{1+\%\text{dev(imports)}/100}-1\right] = -11.3 \quad , \quad (6.26)$$

where Sh_m and Sh_d are import and domestic shares of total domestic sales. In our forecasts for 2016 these two shares have the values 0.52 and 0.48. With the percentage deviation in total domestic sales being approximately zero, (6.25) and (6.26) imply that:

$$\%\text{dev(domestic)} = -6.2$$

and

$$\%\text{dev(imports)} = 5.7 \quad .$$

These are close to the values (-6.1 and 4.6) in Chart 6.9 for the deviations in 2016 for domestic sales of the domestic commodity and for import sales.

The output path for commodity 70 in Chart 6.9 lies above the path for domestic sales of the domestic commodity. This is because exports of 70 are not reduced by tariff cuts.

Chart 6.10 shows output paths for the motor vehicle industry in the basecase forecasts and in the policy simulation. During the period of the additional tariff cuts (2001 to 2005), motor vehicle output is projected to have very slight negative growth in the policy simulation. Beyond that period, the policy simulation shows moderate output growth, at about the same rate as in the forecast simulation.

Motor vehicle employment (Chart 6.11) declines slowly over the period 2001 to 2016 in the basecase forecasts. With tariff cuts, the loss in employment is more marked. By 2016, employment in the policy simulation is 5.8 per cent below its basecase forecast level. This is a slightly smaller negative deviation than for output (-6.1 per cent). In common with other industries (see the macro results in Chart 6.1), the motor vehicle industry adopts a lower capital/labour ratio in the policy simulation than in the basecase forecasts. A lower capital/labour ratio leads to a lower output/labour ratio.

One curious result, mentioned in subsection 6.2(b) in our discussion of tax contributions to the GDP deviations, is the decline after 2005 in the deviation paths of household consumption for both domestic and imported motor vehicles, see Chart 6.9a. Despite these declines, the deviation path for overall household consumption of motor vehicles has a positive slope.

In simplified notation the percentage growth rates ($c70^j(dom,t)$ and $c70^j(imp,t)$) in year t in household demands for domestic and imported cars in simulation j [j = policy (d) or forecast (f)] are given by

$$c70^j(dom,t) = a^j(t) - SH70^j(imp,t)*twist \qquad (6.27)$$

and

$$c70^j(imp,t) = a^j(t) + SH70^j(dom,t)*twist \qquad (6.28)$$

where

$SH70^j(dom,t)$ and $SH70^j(imp,t)$ are the shares of household expenditure on cars accounted for by the domestic and imported products in simulation j;

$a^j(t)$ is a variable summarizing income, population and price factors affecting the demand for cars in simulation j; and

twist is a preference variable affecting consumer choice between imported and domestic cars. It imposes a change in the import/domestic mix of motor vehicle purchases without affecting overall growth [$c70^j(t)$] in demand for motor vehicles where overall growth is given by

$$c70^j(,t) = SH70^j(dom,t)*c70^j(dom,t) + SH70^j(imp,t)*c70^j(imp,t)$$
$$= a^j(t) \qquad . \qquad (6.29)$$

In (6.27) and (6.28) we have assumed that the same summary variable $a^j(t)$ applies to the consumption of both domestic and imported cars. This is representative of the forecast and policy simulations beyond the period of tariff cuts. Broadly consistent with the MONASH simulations, the preference variable, twist, has no superscripts or subscripts. We assume that it is the same for all years and in both simulations.

From (6.27) to (6.29) we obtain the growth rates along the deviation paths for domestic, imported and overall household consumption of motor vehicles as

$$c70^d(dom,t) - c70^f(dom,t) = a^d(t) - a^f(t) - (SH70^d(imp,t) - SH70^f(imp,t))*twist, \quad (6.30)$$

$$c70^d(imp,t) - c70^f(imp,t) = a^d(t) - a^f(t) + (SH70^d(dom,t) - SH70^f(dom,t))*twist \quad (6.31)$$

and

$$c70^d(t) - c70^f(t) = a^d(t) - a^f(t) \quad . \quad (6.32)$$

Beyond the period of additional tariff cuts, $a^d(t)$ is very similar to $a^f(t)$ but slightly more positive. This explains the slight positive slope in Chart 6.9a of the deviation path for overall household consumption of motor vehicles. As mentioned in subsection 5.1, in our forecasts we assume a continuing preference twist in favour of imported cars. Hence twist is positive. Additional cuts in tariffs mean that

$$SH70^d(imp,t) - SH70^f(imp,t) > 0 \text{ and } (SH70^d(dom,t) - SH70^f(dom,t) < 0 \quad .$$

Therefore the twist terms make negative contributions on the RHSs of both (6.30) and (6.31). These negative contributions are sufficient to produce the negative slopes in the deviation paths in Chart 6.9a of household demands for domestic and imported cars.

(e) Results for other industries

Chart 6.12 shows the deviations in the output paths of the industries which are the main winners from the additional tariff cuts. These are industries for which the output deviation in 2016 is more than 0.5 per cent. They are traditional export industries and related industries. Output in these industries is stimulated by real devaluation (Chart 6.4).

Apart from motor vehicles, only six industries have output deviations in 2016 of less than -0.15 per cent (Chart 6.13). For rubber products, glass and carpets, the negative output deviations are explained mainly by the heavy dependence of these industries on sales to the motor vehicle industry. Insurance, residential building and ownership of dwellings suffer negative output deviations because of overall contraction in consumption and via substitution in the consumption bundle towards motor vehicles.

6.3. Policy implications

In this section, we have reported results from a MONASH policy simulation concerned with the effects of implementing a recommendation by the Industry Commission to lower the tariff on motor vehicles from about 12 per cent in 2001 to

about 4 per cent in 2005. We found negative macroeconomic effects. At the industry level, we found some winners and some losers, but the effects were generally minor.

After a vigorous public debate during 1997, the Australian government rejected the Commission's recommendation. Superficially the results in this section appear to support the government's decision. However, there is an alternative interpretation.

The policy simulation reported here was made under two pessimistic assumptions: (a) that further tariff cuts will not generate efficiency gains in the motor vehicle industry; and (b) that these cuts will not affect Australia's access to foreign markets.

In a separate policy simulation, reported elsewhere[26], we assumed that the motor vehicle industry would reduce its unit costs by an amount sufficient to match the reductions in the price of imported vehicles caused by additional tariff cuts. The industry in Australia is far from competitive. It is dominated by four vehicle assemblers producing slightly differentiated products with production runs that are short by world standards. It is reasonable to suppose that further tariff cuts could eliminate one of the assemblers leading to expanded production runs and lower unit costs for the remaining three. Under this assumption, the MONASH policy simulation showed that the proposed tariff cuts would generate significant macroeconomic benefits.

Australia had previously announced in APEC its intention to reduce tariffs on all manufactured imports to 5 per cent of their f.o.b. value (about 4 per cent in MONASH simulations which use c.i.f. prices) by 2005. It appears that Australia will meet this target for the bulk of its manufactured imports. The decision not to meet the target for motor vehicles, and a similar decision made subsequently for textiles, clothing and footwear (TCF), will reduce Australia's ability to argue effectively for tariff cuts by other countries both inside and outside APEC. Terms-of-trade effects were responsible for a large part of the negative macro results obtained in subsection 6.2. These effects would be eliminated or even reversed by a slightly faster rate of world trade liberalization. If by carrying out its original intentions Australia induced its trading partners to increase their rates of tariff reductions, then the proposed cuts in motor vehicle and TCF tariffs could improve Australia's terms of trade. In these circumstances, a MONASH policy simulation would show a favourable macroeconomic outcome from further tariff cuts.

We interpret the results in this section as being supportive of the proposed tariff cuts for motor vehicles. Under pessimistic assumptions, they indicate that the cuts would have had very minor macroeconomic costs and would have caused little if any microeconomic disruption. Even if the proposed tariff cuts were implemented, it is likely that the Australian motor vehicle industry would experience positive output

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[26] See Dixon, Malakellis and Rimmer (1997).

growth over the period 2001 to 2016. On the other hand, employment in the industry is likely to decline with or without tariff cuts. Without the cuts, the rate of decline in employment is likely to be about 1.5 per cent a year. With the cuts, the likely rate of decline is about 2 per cent a year. Such rates of employment decline can be handled by natural employment turnover in the industry. Thus we think that there was almost no chance of a significant negative outcome from implementing the proposed tariff cuts. On the other hand, there was a reasonable chance of a significant positive outcome. This could arise from efficiency gains in the motor vehicle industry and from more open policies by Australia's trading partners.

Chart 6.1. Real GDP and factor inputs (% deviation from basecase forecasts)

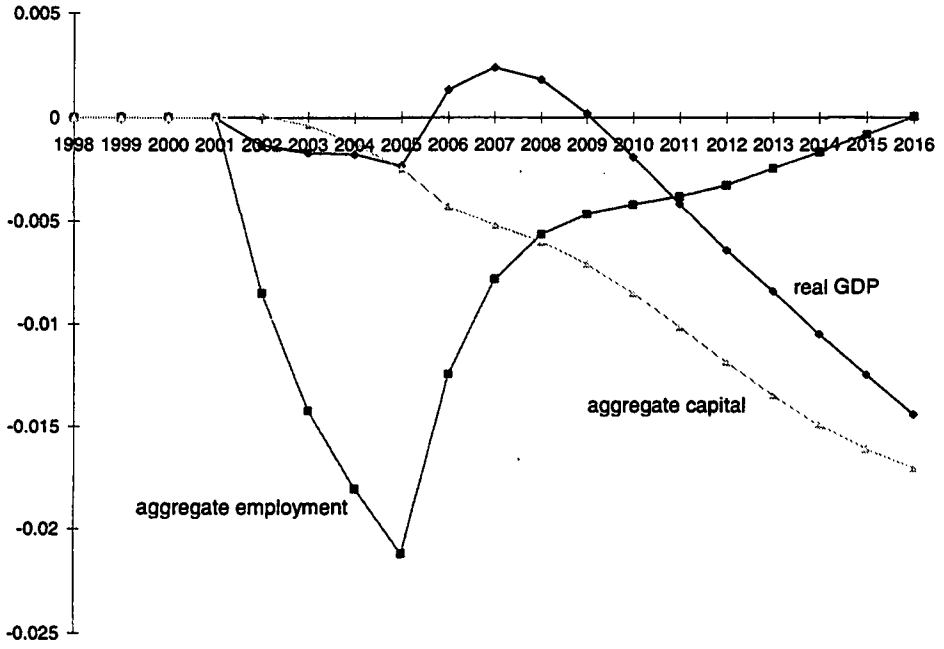


Chart 6.2. Real investment and consumption (% deviation from basecase forecasts)

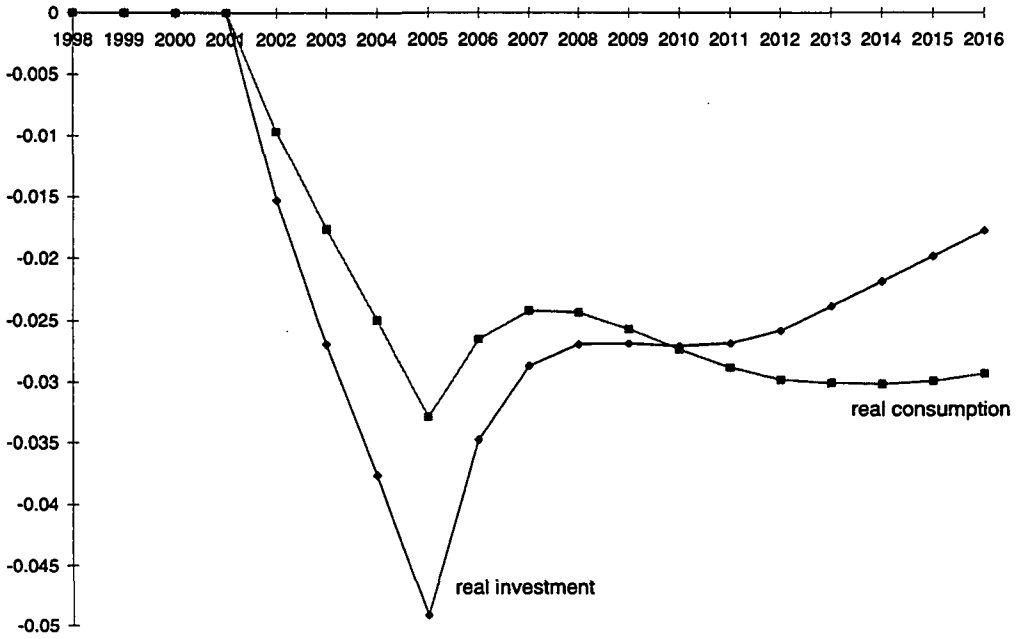


Chart 6.3. Aggregate export and import volumes (% deviation from basecase forecasts)

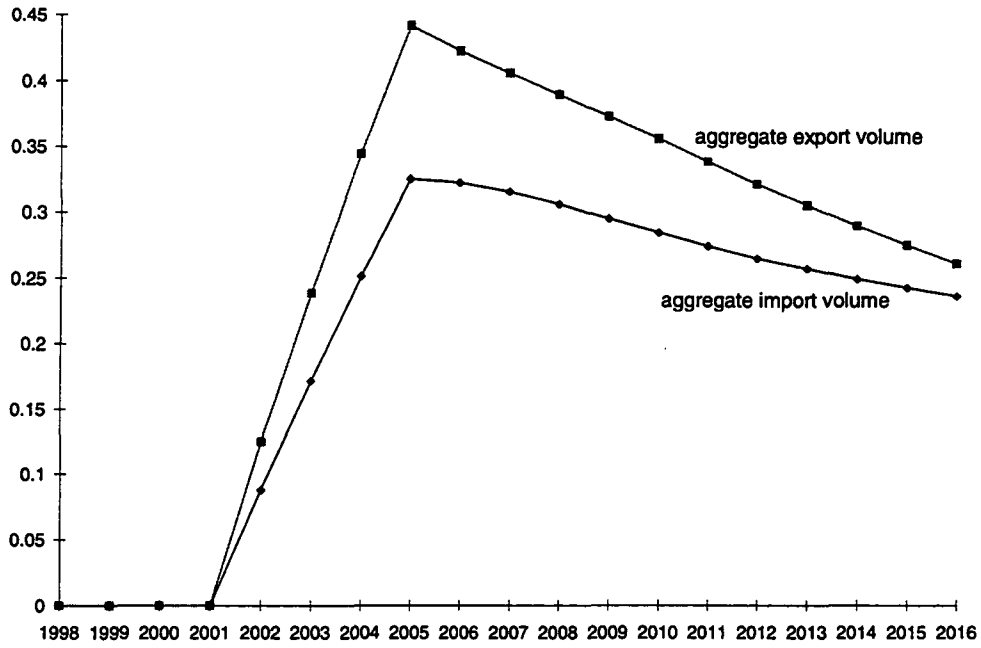


Chart 6.4. Real exchange rate (positive means appreciation) (% deviation from basecase forecasts)

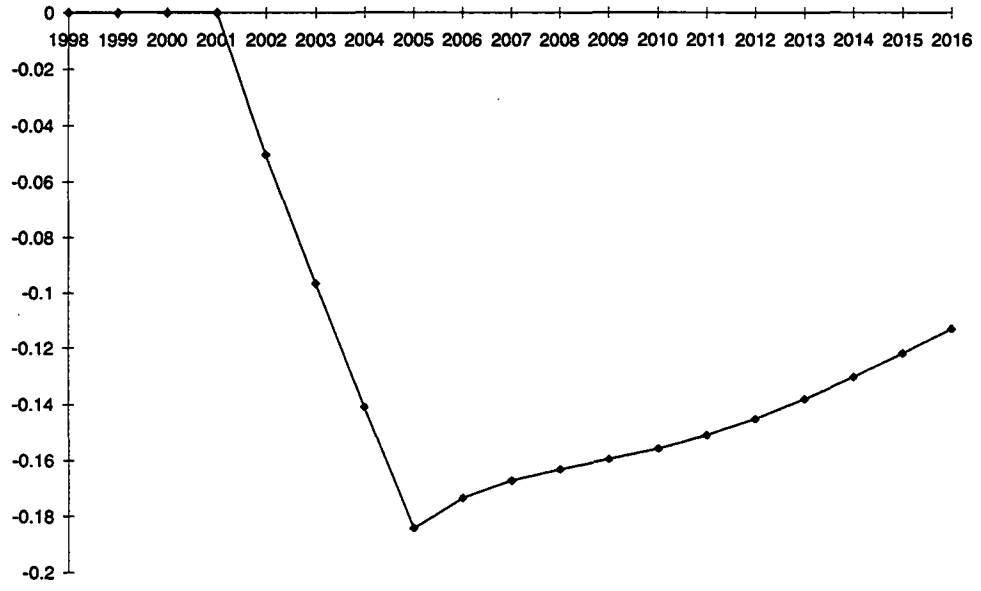


Chart 6.5. Real wage rates and aggregate employment (% deviation from basecase forecasts)

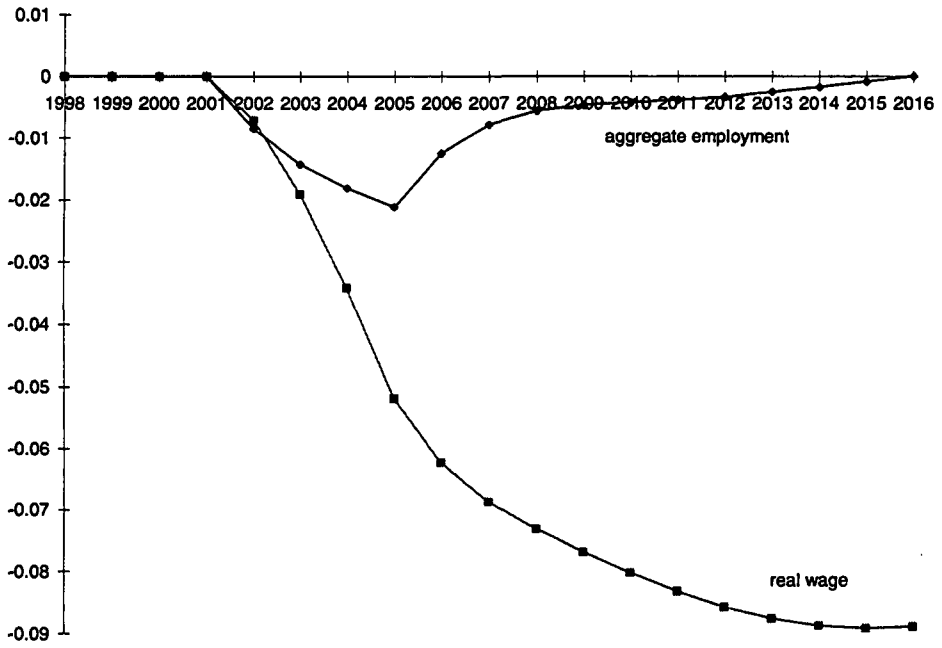


Chart 6.6. Terms of trade (% deviation from basecase forecasts)

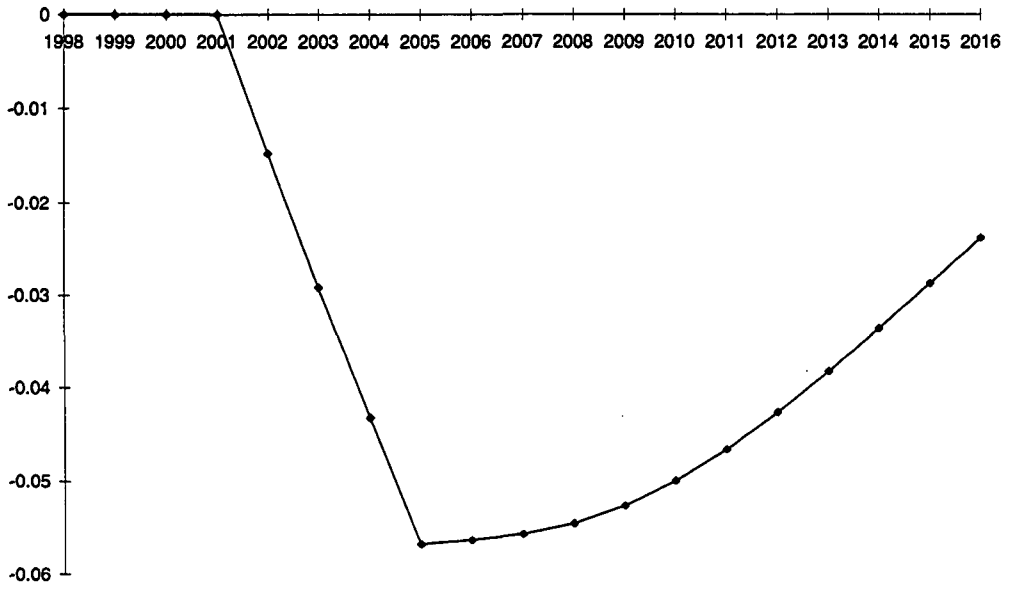


Chart 6.7. Percentage point contributions to the deviations in real GDP

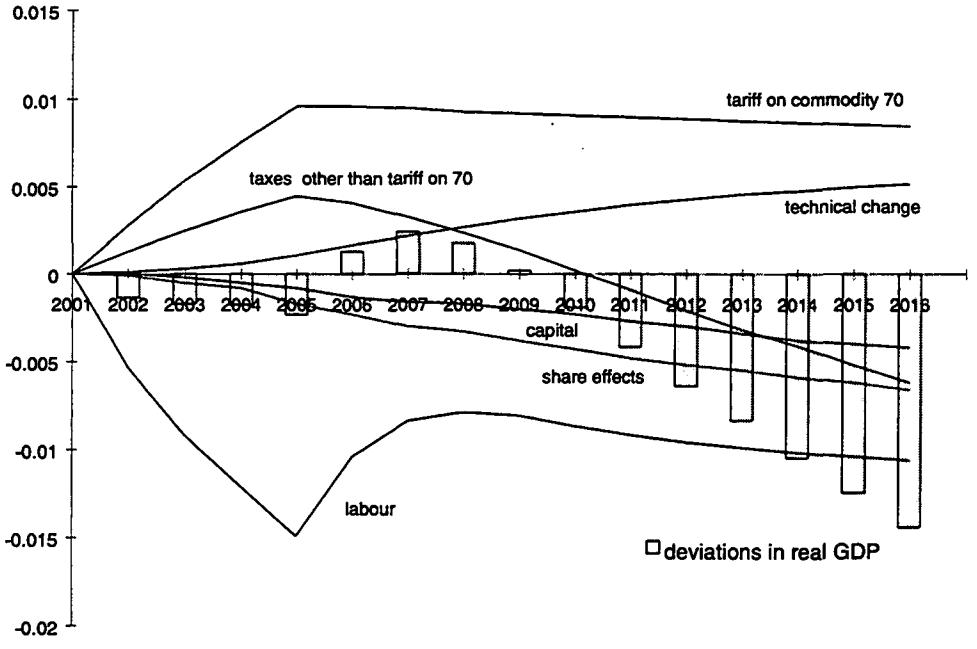


Chart 6.7a. Percentage point contributions to the deviations in real GDP: the other tax contribution disaggregated

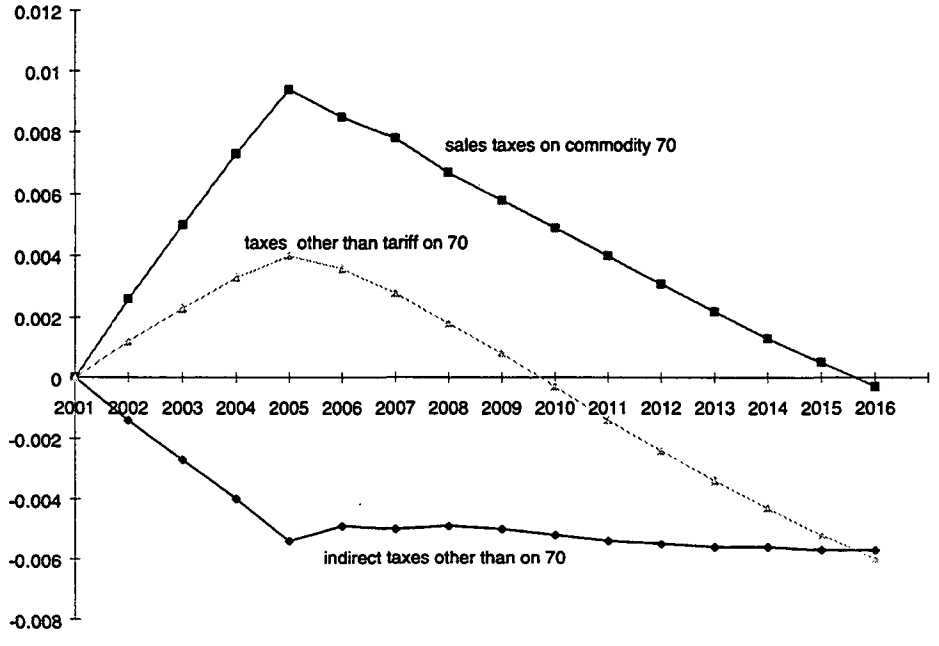


Chart 6.8. Real GDP, real GNP, real consumption and compensating variations

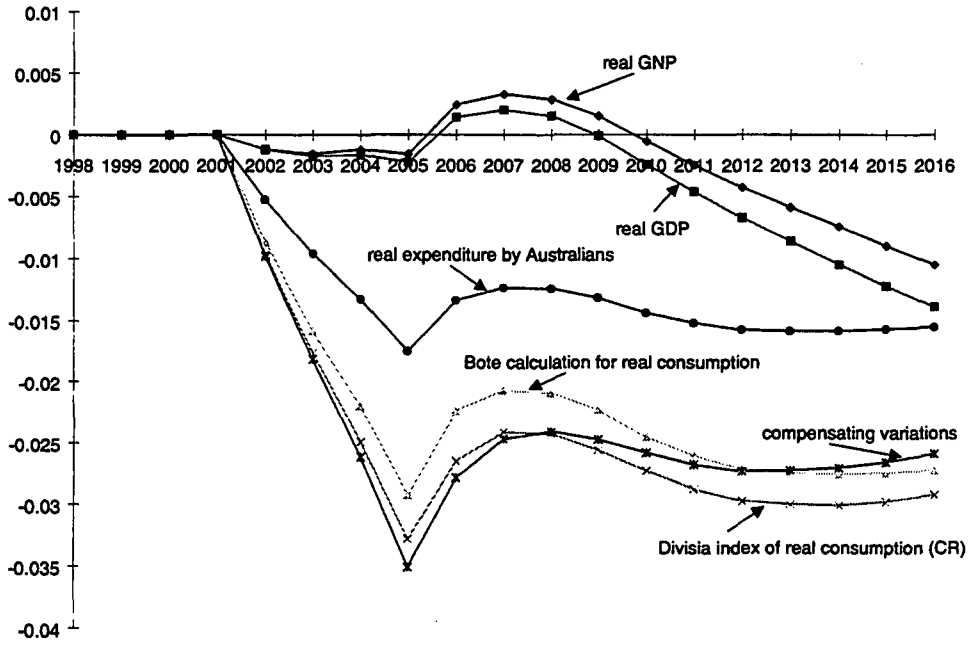


Chart 6.9. Output, imports and sales of motor vehicles (% deviation from basecase forecasts)

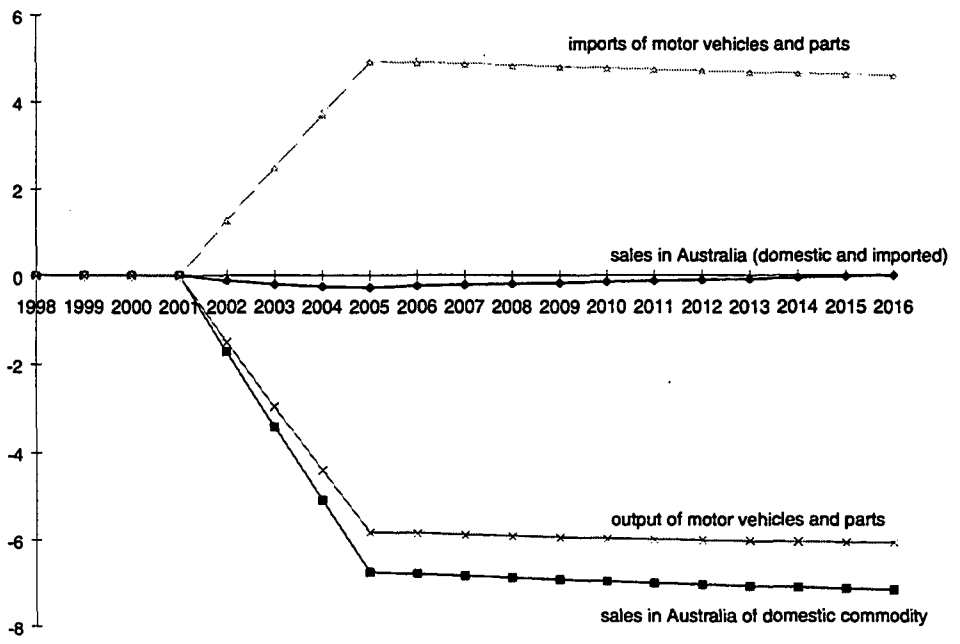


Chart 6.9a. Household consumption of motor vehicles (% deviation from basecase forecasts)

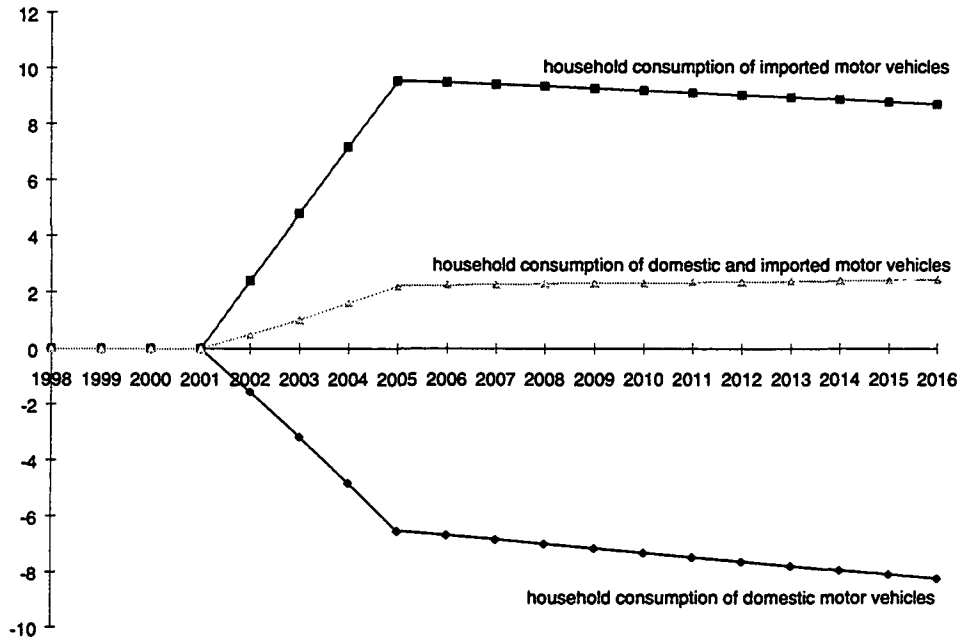


Chart 6.10. Index of output of motor vehicles (1998=1)

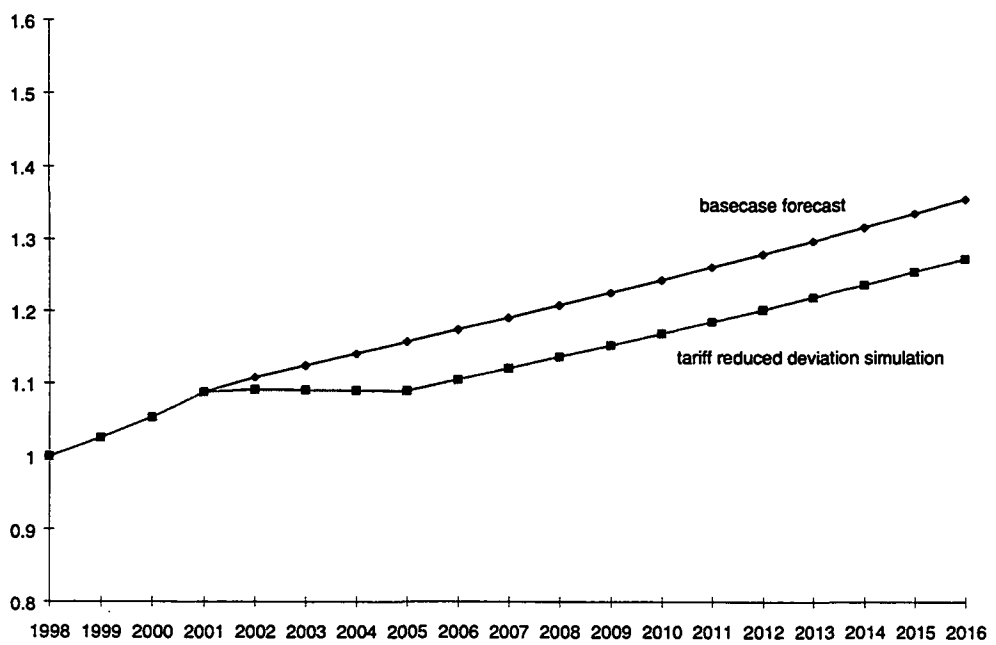


Chart 6.11. Index of employment in motor vehicles (1998=1)

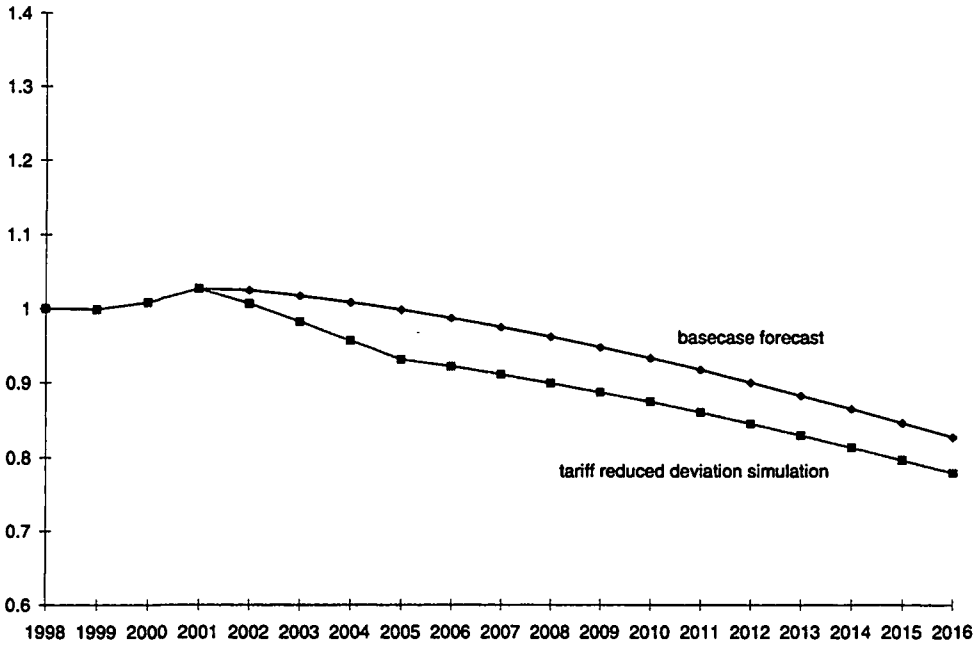


Chart 6.12. Output of main winners from additional cuts in tariff on motor vehicles (% deviation from basecase forecasts)

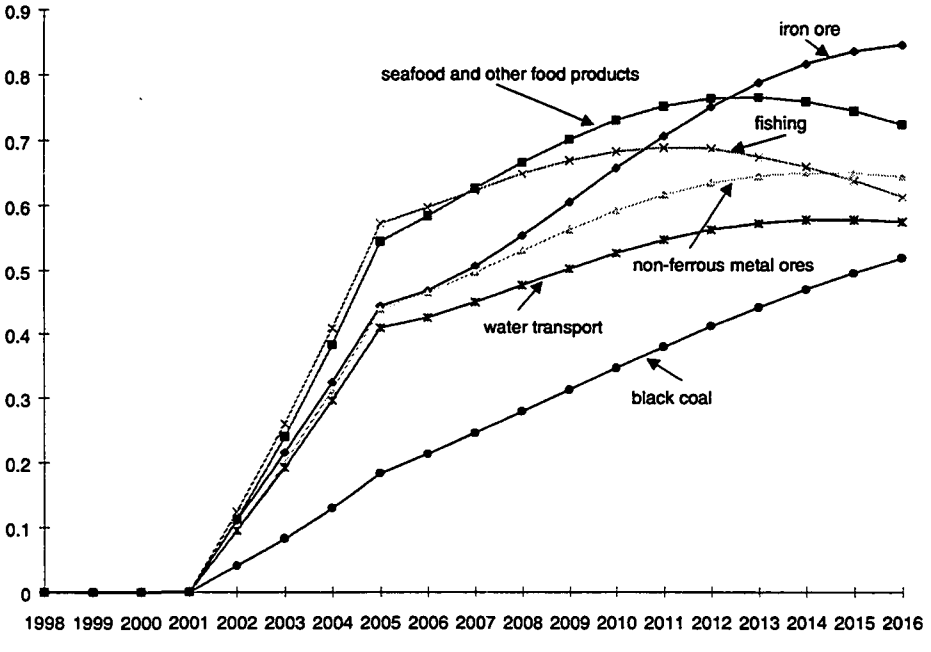
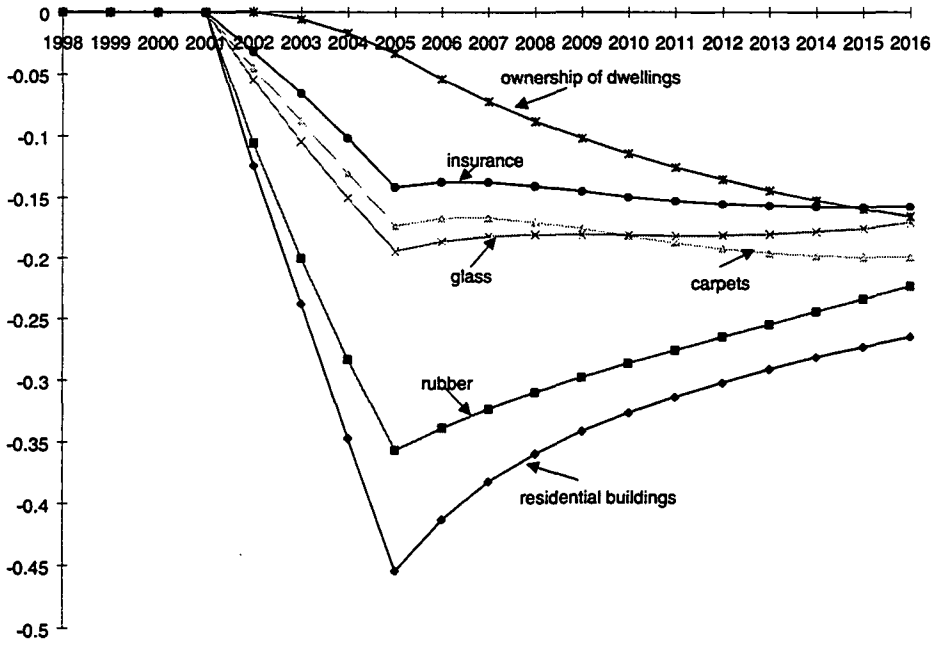


Chart 6.13. Output of main losers from additional cuts in tariff on motor vehicles (% deviation from basecase forecasts)



7. Concluding remarks

Our primary aim in developing the MONASH model is to produce results of use to economic-decision makers in the public and private sectors. At its current stage of development, MONASH is a framework for:

- estimating changes in tastes and technology and for generating up-to-date input-output tables (historical simulations);
- explaining periods of economic history in terms of driving factors such as policy changes, changes in world commodity prices and changes in tastes and technology (decomposition simulations);
- generating forecasts of growth rates in industrial, occupational and regional variables incorporating (a) detailed extrapolations of trends in tastes and technology and (b) a wide variety of projections from organization specializing in macro, export, tourism and policy forecasting (forecasting simulations); and
- calculating the deviations, from explicit forecast paths for macro and micro variables, which would be caused by the implementation of proposed policy changes (policy simulations).

All four aspects of the framework were illustrated in sections 4 to 6 where we analysed the Australian motor vehicle industry for the period 1987 to 2016. We used an historical simulation to estimate changes in tastes and technology for 1987 to 1994 with special emphasis on motor vehicles. We used a decomposition simulation for the same period to assess the significance of changes in tariffs relative to changes in other variables (e.g. tastes and technology) as determinants of the performance of the motor vehicle industry. We used a forecasting simulation to project output and employment for the motor vehicle industry to 2016 in the absence of further reductions in tariffs beyond those planned to 2001. Finally, we used a policy simulation to work out the deviations, from the forecast paths for macro and industry variables, which would be caused by proposed further reductions in motor vehicle tariffs.

Throughout the paper we have supported our results by detailed back-of-the-envelope (bote) calculations. Such calculations have been important in our development, understanding and application of MONASH and earlier models. There are five reasons for our emphasis on bote calculations.

- Bote calculations are a necessary check for data handling and other coding errors.
- Bote calculations reveal result-affecting theoretical shortcomings. For example, such calculations applied to earlier versions of the policy simulations reported in section 6 revealed that the results were heavily influenced by the treatment in the model of miscellaneous costs (e.g. the costs of holding inventories). In effect, these minor costs were treated (unrealistically) as production taxes. Because miscellaneous costs were relatively large for some export-oriented industries, this treatment led to an overestimation of the welfare gains from export-stimulating

tariff cuts. This problem was avoided in the results eventually reported in section 6 by recognizing in the model that miscellaneous costs involve resource usage.

- Bote calculations allow us to identify the principal mechanisms and data items underlying particular results. Such identification is a necessary part of explaining the results to business decision makers and policy advisers. We cannot expect these people to be familiar with the details of a large model such as MONASH, and we should not expect them to accept the results on a black-box basis.
- Bote calculations are an effective form of sensitivity analysis. Clients are often concerned about sensitivity issues. One approach to attempting to answer their questions is repeated simulations. We have found it more informative to use well-designed bote models. These allow us to help clients to assess the reasonableness of our results and how these results would be affected by alternative assumptions and parameter values.
- Bote calculations generate theoretical insights. The CGE models of the last thirty five years have provided numerical illustrations of well understood theoretical propositions. For example, they have illustrated the proposition that pollution problems are better tackled by tradable emission permits than by mandated targets. Illustration and quantification of existing propositions is a valuable role for CGE models. However CGE models can incorporate detailed structural and dynamic information well beyond that in purely theoretical analyses. Thus we would expect such models to reveal new theoretical insights. We have found that bote calculations are an effective way of deriving these insights. For example, in the present paper we have used bote calculations to explain how policy results depend on characteristics of our basecase forecasts.

There is considerable potential for using models like MONASH to extend CGE analysis into areas of policy which it has not so far informed. For example, we see adjustment costs as a key area for CGE research over the next few years. Adjustment costs are a major concern for policy makers in deciding at what rate to implement microeconomic reforms.

Calculation of adjustment costs requires forecasts. If the motor vehicle industry is forecast to have good prospects, then we would expect tariff cuts to be absorbed with low costs of adjustment. The reduced level of employment in the industry would be handled simply by a reduced rate of hiring. On the other hand, if the industry has poor prospects in the basecase forecasts, then we would expect tariff cuts to require an increased rate of retrenchment in the industry and high relocation and job-search costs for some motor vehicle workers. However, even in this case, we should not conclude that tariff cuts will necessarily increase overall costs of adjustment in the labour market. While the tariff cuts may impose adjustment costs on some motor vehicle workers, they may reduce adjustment costs experienced by workers in other industries. For example, cuts in motor vehicle tariffs may reduce retrenchment rates in agriculture, mining and export-oriented manufacturing.

Because MONASH is a dissaggregated, forecasting framework, it is potentially suitable for calculating adjustment costs associated with microeconomic

reforms. The model's regional dimension can provide information about the geographic location of job losses and gains, and the sectoral and occupational breakdown can provide information about the types of jobs being lost and gained. The forecasting dimension gives information required to work out the extent to which job losses and gains require changes in the rate of movement of workers between regions, industries and occupations. Changes in these rates of movement are the main input to a calculation of the rate of loss of productive labour associated with retraining, relocating and job search.

In future research, we plan to develop an index of the rate of productive labour loss[27]. This index will exploit the occupational, regional and industrial detail in MONASH. By comparing the path of the index in a forecasting simulation with that in a policy simulation we will be able to estimate an important component of the adjustment costs of proposed microeconomic reforms. In this way we hope to provide quantitative information to policy makers on the trade off between (a) adopting a slow rate of microeconomic reform with long-delayed benefits and (b) adopting a rapid rate of microeconomic reform with potentially high adjustment costs.

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[27] Preliminary work on this index is reported in Dixon, Parmenter and Rimmer (1997).

Appendix 6.1. Labour market specification

We assume that real wages are sticky in the short run and flexible in the long run. In this labour market specification, policy shocks generate short-run changes in aggregate employment and long-run changes in real wages. Algebraically, we assume that

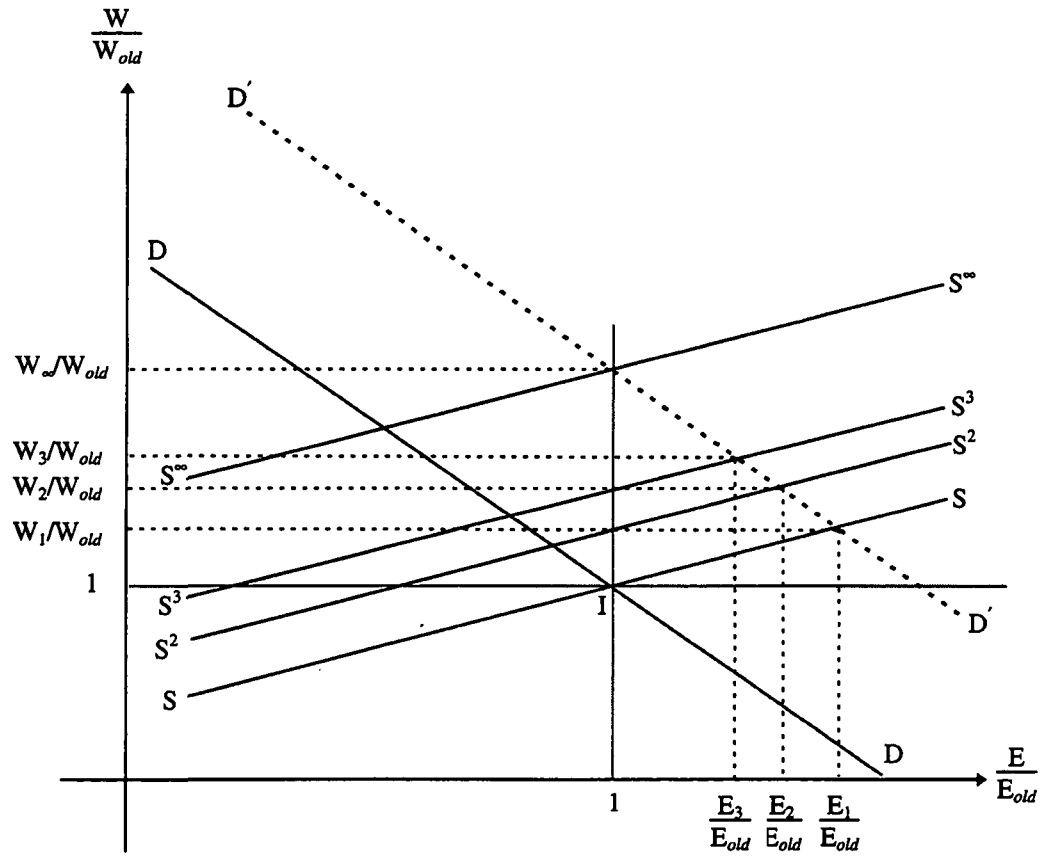
$$\left\{\frac{W_t}{W_{t,old}} - 1\right\} = \left\{\frac{W_{t-1}}{W_{t-1,old}} - 1\right\} + \alpha\left\{\frac{E_t}{E_{t,old}} - 1\right\}. \qquad \text{(A6.1.1)}$$

In this equation, *old* indicates a basecase forecast value. $W_{t,old}$ and $E_{t,old}$ are the real wage rate and the level of employment in year t in the basecase forecasts. W_t and E_t are the real wage rate and the level of employment in year t in the policy simulation, and α is a positive parameter. Under (A6.1.1) the real wage rate in the policy simulation will continue to move further above the real wage rate in the basecase forecasts whenever employment in the policy simulation is above that in the forecasts. We set the value of α so that the effect on aggregate employment of a policy change in year t will be largely eliminated by year t+5. That is, we assume that employment gains/losses from policy changes are a short-run phenomenon with the economy tending in the long run to an exogenously given natural rate of unemployment.

The operation of the employment-wage specification is illustrated in Figure A6.1.1 for a steady-state case in which technology, consumer tastes, foreign prices and capital availability are unchanged from year to year. In this steady state, the demand curve for labour in each year t is DD and the supply curve is SS. In each year employment is E_{old} and the real wage rate is W_{old}, that is, the employment-wage combination is at point I in Figure A6.1.1. Now assume that there is a policy change in year 1 which causes the demand curve for labour to shift up to $D'D'$, where it remains for all future years. The supply curve for year 1 is the initial supply curve SS. The policy-simulation levels for employment and the real wage rate in year 1 are E_1 and W_1. In year 2 there is a vertical upward shift in the supply curve reflecting the gap between W_1 and W_{old}. In our diagram employment and the real wage rate in year 2 are E_2 and W_2. Eventually the supply curve for labour stops moving when W reaches W_∞. At this stage employment has returned to E_{old}.

In implementing equation (A6.1.1) in the policy simulation reported in section 6 we used the post-tax wage rate deflated by consumer prices. I

Figure A6.1.1: Operation of employment-wage specification in steady-state



Appendix 6.2. Formulas for analysing the difference between the GDP paths in alternative simulations

Growth in real GDP in simulation j from year 0 to year T is

$$g_{0T}^{j} = \prod_{t=1}^{T}(1+g_t^j) - 1 \qquad \text{(A6.2.1)}$$

where g_t^j is the proportionate growth rate in real GDP for year t-1 to year t.

A second order approximation to g_{0T}^{j} is

$$g_{0T}^{j} = \sum_{t=1}^{T} g_t^j + \sum_{t=1}^{T} \sum_{\tau>t} g_t^j g_\tau^j \ . \qquad \text{(A6.2.2)}$$

From (A6.2.2) we obtain

$$g_{0T}^{d} - g_{0T}^{f} = \sum_{t=1}^{T}\left(g_t^d - g_t^f\right) + \sum_{t=1}^{T} \sum_{\tau>t}\left(g_t^d g_\tau^d - g_t^f g_\tau^f\right) \qquad \text{(A6.2.3)}$$

where the superscripts d and f denote the policy (or deviation) and forecast simulations.

Using the identity

$$g_v^d g_w^d - g_v^f g_w^f = \left(g_v^d - g_v^f\right)\left(g_w^d + g_w^f\right)/2 + \left(g_w^d - g_w^f\right)\left(g_v^d + g_v^f\right)/2 \qquad \text{(A6.2.4)}$$

we can rewrite (A6.2.3) as

$$g_{0T}^{d} - g_{0T}^{f} = \sum_{t=1}^{T}\left(g_t^d - g_t^f\right)\left(1+H_{tT}\right) \qquad \text{(A6.2.5)}$$

where

$$H_{tT} = \sum_{\substack{s=1 \\ s\neq t}}^{T}\left(g_s^d + g_s^f\right)/2 \ . \qquad \text{(A6.2.6)}$$

From (A6.2.5), we see that the proportionate difference between the policy and forecast results for real GDP in year T, i.e.,

$$Dev_T \equiv \left(g^d_{0T} - g^f_{0T}\right) / \left(1 + g^f_{0T}\right), \qquad \text{(A6.2.7)}$$

can be written as

$$Dev_T = \sum_{t=1}^{T} \left(g^d_t - g^f_t\right) h_{tT} \quad , \qquad \text{(A6.2.8)}$$

where

$$h_{tT} = \left(1 + H_{tT}\right) / \left(1 + g^f_{0T}\right) \quad . \qquad \text{(A6.2.9)}$$

Next we decompose the g^j_ts into component parts. We start with the formula

$$m^j_t = \sum_{i=1}^{F} S^j_{ti} v^j_{ti} \qquad \text{(A6.2.10)}$$

where

m^j_t is the proportionate increase in real GDP between year t-1 and t calculated from a mid-point base, i.e.,

$$m^j_t = g^j_t / \left(1 + \tfrac{1}{2} g^j_t\right); \qquad \text{(A6.2.11)}$$

v^j_{ti} is the proportionate increase in quantity variable i (e.g., employment and capital stock, see (6.10)) between year t-1 and t calculated from a mid-point base; and

S^j_{ti} is the mid-point share of quantity variable i in real GDP, i.e., S^j_{ti} is the average share of i in real GDP over years t-1 and t.

By using mid-point concepts, we ensure that (A6.2.10) is highly accurate, i.e., the omitted second order terms are negligible.

On rearranging (A6.2.11) as

$$g^j_t = m^j_t / \left(1 - \tfrac{1}{2} m^j_t\right) \quad , \qquad \text{(A6.2.12)}$$

and substituting from (A6.2.12) and (A6.2.10) into (A6.2.8) we find that

$$Dev_T = \sum_{t=1}^{T} \left(\sum_{i=1}^{F} S^{d*}_{Tti} v^d_{ti} - S^{f*}_{Tti} v^f_{ti} \right) \quad , \qquad \text{(A6.2.13)}$$

where

$$S^{j*}_{Tti} = h_{tT}\, S^{j}_{ti} \Big/ \left(1 - \tfrac{1}{2} m^{j}_{t}\right) \quad . \qquad \text{(A6.2.14)}$$

Finally we rewrite (A6.2.13) as

$$Dev_T = \sum_{i=1}^{F} QCONT_{iT} + \sum_{i=1}^{F} SHCONT_{iT}$$

where $QCONT_{iT}$, $SHCONT_{iT}$, S_{Tti} and v_{ti} are defined by (6.12) to (6.15).

References

Adams, P.D., P.B. Dixon, D. McDonald, G.A. Meagher, and B.R, Parmenter (1994), 'Forecasts for the Australian Economy using the MONASH model', *International Journal of Forecasting* 10, 557-71.

Bovenberg, A.L. and L.H. Goulder (1991), "Introducing intertemporal and open economy features in applied general equilibrium models", in H. Don, T. van de Klundert and J. van Sinderen, eds, *Applied general equilibrium modelling.* Dordrecht: Kluwer Academic Publishers, pp. 47–64.

Dixon, P.B. M. Malakellis and M.T. Rimmer (1997), *The Australian Automotive Industry from 1986-87 to 2009-10: Analysis using the MONASH Model,* a report to the Industry Commission by the Centre of Policy Studies and IMPACT Project, Monash University, May.

Dixon, P.B., B.R. Parmenter., J. Sutton and D.P. Vincent (1982), *ORANI: A Multisectoral Model of the Australian Economy,* North Holland.

Dixon, P.B., B.R. Parmenter and M.T. Rimmer (1997), "The Australian Textiles, Clothing and Footwear Sector from 1986-87 to 2009-10: Analysis using the MONASH Model", a paper presented to the 26th Conference of Economists, Hobart, September. Available from the Centre of Policy Studies and IMPACT Project, Monash University.

Dixon, P.B. and M.T. Rimmer (1997), *MONASH: A Disaggregated, Dynamic Model of the Australian Economy: Chapters 4 to 6.* A partial draft of a book, available from the Centre of Policy Studies and IMPACT Project, Monash University, November.

Jilek, Paddy, Andrew Johnson and Bruce Taplin (1993), " Exports, Imports and the Trade Balance", Australian Treasury, Canberra: paper presented to the June 1993 Treasury Conference on the TRYM Model of the Australian Economy; *TRYM Paper No. 4, pp. 48.*

Johansen, L. (1960), *A Multi-Sectoral Study of Economic Growth,* North Holland.

Powell, A.A. and C.W. Murphy (1997), *Inside a Modern Macroeconometric Model —A Guide to the Murphy Model,* Second Edition, Springer-Verlag.