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LONG-RUN CLOSURE OF ORANI : A PROPOSAL

by

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The views expressed in this paper do not necessarily reflect the opinions of the participating agencies, nor of the Commonwealth government

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LONG-RUN CLOSURE OF ORANI:

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1. INTRODUCTION

In recent times research on ORANI (Dixon, Parmenter, Sutton and Vincent (1982) — hereafter DPSV) at the IMPACT Project has focussed on questions of closure. ORANI's flexibility makes many closures of its existing equation system feasible (see DPSV Sections 1.7 and 48). Typically, these closures involve designating aggregate consumption and investment exogenous. Often we would prefer to endogenise absorption and instead exogenise new variables not explicitly defined in the standard version of ORANI — such as the average propensity to consume. Augmenting ORANI with equations defining new variables can make explicit what a standard ORANI solution implies about, for instance, foreign ownership of capital. The additional equations, of course, increase the range of closures technically possible. Indeed, recent work has tended to be concerned almost exclusively with closures which involve adding equations to ORANI's standard structural form as set out in DPSV. For example, Cooper and McLaren ((1980), (1982),

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* We are grateful to Peter B. Dixon and Brian R. Parmenter for comments on a draft.

(1983)), Cooper (1983), and Powell, Cooper and McLaren (1983), have investigated the augmentation of ORANI by the Reserve Bank's RBII model in order to provide ORANI with short term macroeconomic closure. Meagher (1983) adds an equation explicitly defining disposable income and thereby makes it possible to use ORANI to analyse the short-run effects of a change in the mix of direct and indirect taxation.

Another stream of research has been concerned with long-run closures of ORANI. Although long-run applications (e.g., Dixon, Harrower and Powell (1977); Vincent (1980)) are possible with the standard version of ORANI, these do not deal with the issue of foreign capital flows in a satisfactory way. The prototype for the necessary extension of ORANI has been developed by Dixon, Parmenter and Rimmer (forthcoming 1984) (hereafter, DPR), who implement their proposals on a miniature version of ORANI, MO81. The current contribution is situated in this latter stream. Specifically, the aims of this paper are:

(a) to investigate empirically the performance of MO81 in more detail than was possible for DPR;

(b) to suggest a minimal augmentation of MO81 necessary to improve its suitability for policy-analytic work;

and

(c) in the light of (a) and (b), to suggest a procedure for obtaining a satisfactory long-run closure of a minimally augmented ORANI 78 via a backsolution procedure which takes as starting point the solution of standard ORANI 78 in a standard closure.

The idea behind (c) is that a safe strategy for the development of computer code for the new long-run closure of ORANI is one which does not run the risk of corrupting existing systems of known high reliability.

The paper is structured as follows. In Section 2 is given a brief description of the MO81 miniature version of ORANI as developed by DPR. Some new insights and minor modifications to MO81, are also detailed in Section 2. A resumē of results obtained using MO81 is reported in Section 3. Section 4 contains our proposals for the computation of long-run ORANI simulations as backsolutions of standard ORANI 78.

2. BRIEF DESCRIPTION OF MO81[1]

MO81 was developed to explore long-run closures of ORANI. These are distinguished from neo-classical short-run closures in the following way. Whereas in the latter, industry-specific capital stocks in use are taken as exogenous, with endogenous adjustment of industries' rates of return, in long-run closures the roles of these variables are reversed. That is, a shock (a tariff change, say) is injected at t=0; the long run is then defined as the period between t=0 and $t=\tau$, where τ is some future year (the 'snapshot' year) which is sufficiently distant to allow any initial disturbance induced in industries' rates of return to have been eliminated by differential rates of growth of the capital stocks of different industries. Thus in the projected year τ, the industrial composition of the capital stock is endogenous, but the rates of return are exogenous. A possible interpretation is that Australia is a small part of the world capital market on which these rates are set.

1. This section draws freely upon Powell, Cooper and McLaren (1983).

2.1 Intertemporal Aspects of MO81

The basic method of analysis in MO81 is contemporaneous differential comparative statics (cdcs). The ideas are illustrated in Figure 1. Relative to its control values at any point of time, a permanent percentage change in the value of an exogenous variable (a tariff, say) is introduced at the beginning of the year t=0. After sufficient time has elapsed for the adjustment described in the previous paragraph to have occurred, an endogenous variable Y assumes the value Y_τ^1. In the absence of the shock at t=0, in year τ Y would have assumed the value Y_τ^0. The difference $(Y_\tau^1 - Y_\tau^0)$ is attributed to the shock injected at t=0. For most endogenous variables nothing is said, nor need be said, about the time paths connecting the base period value Y_0^0 to its control path value in τ (namely, Y_τ^0) nor to its shocked value (namely, Y_τ^1) in that year.

There are, however, some exceptional cases, which require that MO81 be endowed with a minimal dynamic specification. For example, the level of locally owned capital stock in the snapshot year is related, via domestic saving throughout the period $[1,\tau]$, to the size and ownership of the capital stock in the 'base' year (t=0). A control path of real saving is hypothesized linking base and snapshot year data base values. It follows that it is necessary to use not only a full control path data base for the snapshot year but also parts of a data base for the base year. Fortunately the partial data base required for the base year is very small.

Figures 2 to 4 are intended to promote an intuitive understanding of the assumptions embodied in the method. In Figure 2, the curve $\left(\tilde{S}_0^0, \tilde{S}_\tau^0\right)$ shows a hypothetical growth path of real saving through the period

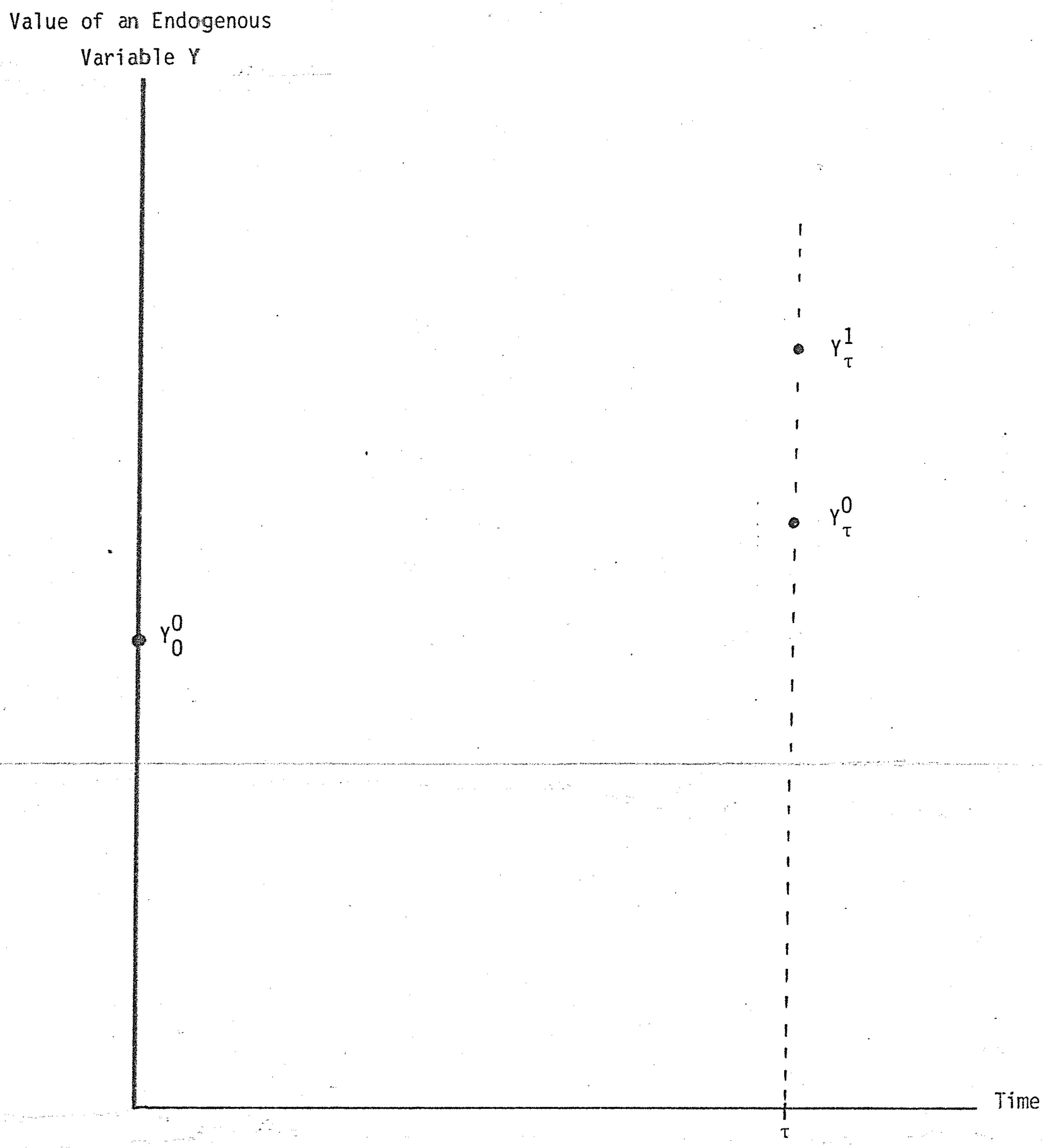

Figure 1: The Nature of Contemporaneous Differential Comparative Static Solutions. Y_0^0 is the base period value of some endogenous variable. Y_τ^0 is the projected value of this variable on the control path generated by some maintained set of assumptions about the time paths of the exogenous variables, and Y_τ^1 its projected value when the time path of an exogenous variable is disturbed by a shock injected at t=0 and maintained thereafter. The shock takes the form of a constant percentage deviation of the exogenous variable from its control path.

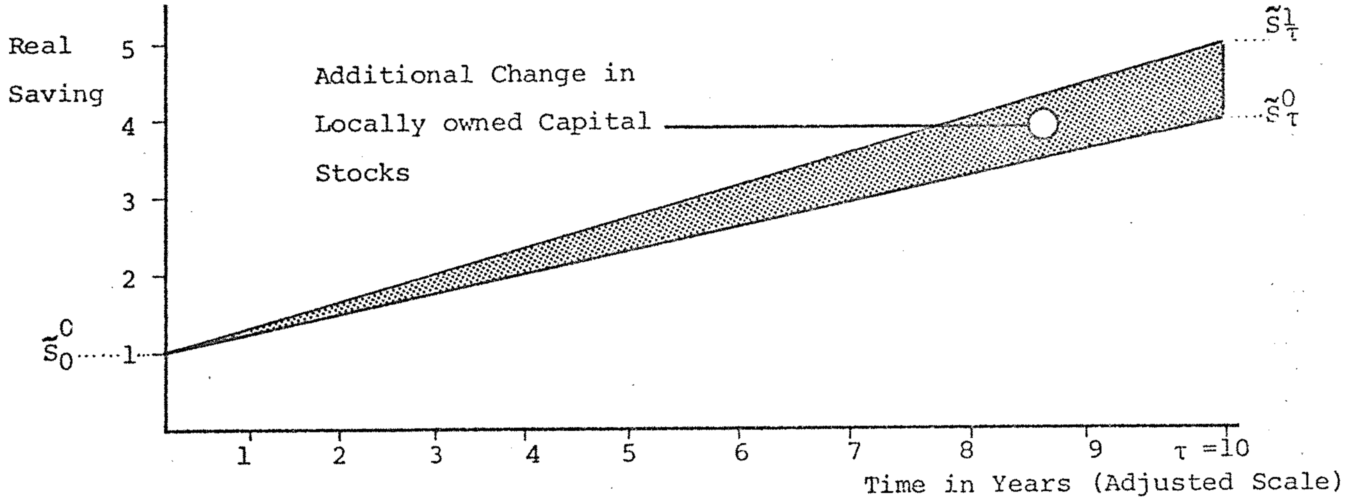

Figure 2: A Benchmark Growth Path for Real Saving

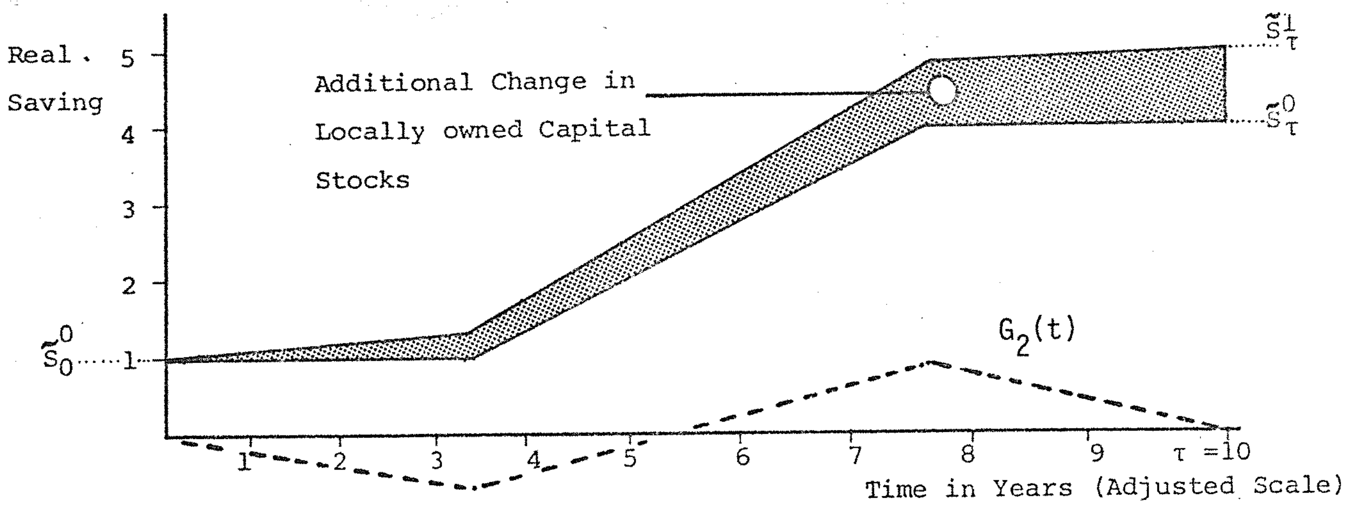

Figure 3: A Second Growth Path which is Area-preserving with respect to the Benchmark

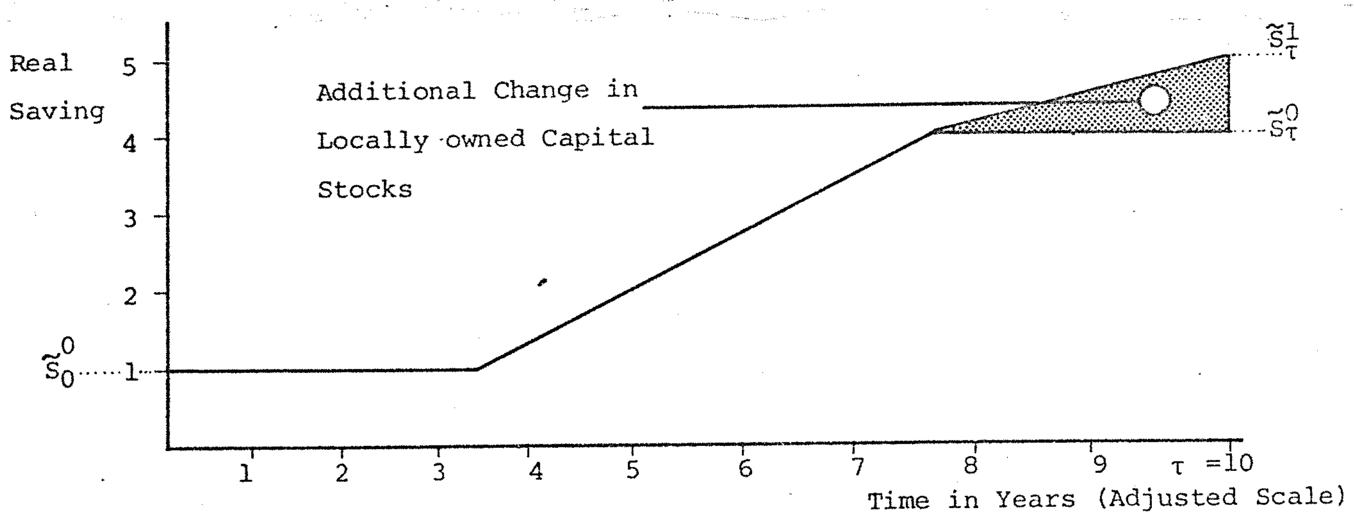

Figure 4: An Exceptional Growth Path which is not Area-preserving

$[0,\tau]$. It is drawn, for simplicity, to represent a process in continuous time; later we will hypothesize similar processes in discrete time. The scale on the time axis is so constructed that the area underneath it for any one-yearly interval represents the contribution made by that year's saving to surviving locally owned capital stocks in the year τ. Because capital stocks acquired with savings made early in the period will have depreciated considerably by year τ, the gradations near the left are closer together. In fact, in order to reflect the assumption that depreciation is geometric, the time scale shown is exponential: we have assumed that savings embodied in capital stock will depreciate by 10% a year; consequently each unit division is ten per cent longer than that on its left.

Whatever functional form is chosen to generate the path $\tilde{S}_0^0$, $\tilde{S}_\tau^0$ it must satisfy three requirements:

1. The curve must pass through $\tilde{S}_\tau^0$.
2. The curve must pass through $\tilde{S}_0^0$.
3. The area beneath it must equal the increase in locally owned capital stocks $\Delta_0^\tau(KQ)$ over $[0,\tau]$. This difference is derived from the two data bases.

Let the hypothetical path of real saving be represented by some functional form

(2.1) $$\tilde{S}_t = F(t;\tilde{S}_0^0,\tilde{S}_\tau^0) + \hat{G}(t) \quad ,$$

where

(2.2a) $$F(0;\tilde{S}_0^0,\tilde{S}_\tau^0) = \tilde{S}_0^0 \quad ;$$

(2.2b) $F(\tau;\ \tilde{S}_0^0,\ \tilde{S}_\tau^0) = \tilde{S}_\tau^0$,

(2.2c) $\int_{t=0}^{\tau} F(t;\ \tilde{S}_0^0, \tilde{S}_\tau^0)\ d\ell = \Delta_0^\tau(KQ)$,

(2.2d) $G(0) = 0$,

(2.2e) $G(\tau) = 0$,

and

(2.2f) $\int_{t=0}^{\tau} G(t)\ d\ell = 0$.

Above, $\ell = L(t)$ is the transformation applied to the time axis. As long as F and G satisfy these requirements, conditions 1, 2 and 3 above will be satisfied. In particular, (2.2a) and (2.2d) jointly guarantee the satisfaction of 2; (2.2b) and (2.2e) guarantee 1; while (2.2c) and (2.2f) guarantee 3.

In (2.1), $\tilde{S}_0^0$ and $\tilde{S}_\tau^0$ are <u>parameters</u> of the function F whose endpoints t=0 and t=τ are taken as given from the viewpoint of the current discussion. Suppose that, as the result of some shock imposed at t=0, the value of $\tilde{S}$ in year τ shifts to $\tilde{S}_\tau^1$. The same functional form can be used to project a new path of real saving

(2.3) $$\tilde{S}_t = F(t;\ \tilde{S}_0^0, \tilde{S}_\tau^1) + G(t)$$

shown by the curve $\left(\tilde{S}_0^0,\ \tilde{S}_\tau^1\right)$. The area between the curves represents the <u>additional</u> increase over the period [0, τ] in locally owned capital stocks surviving to τ as a result of the shock. This area is equal to

(2.4) $$A = \int_{t=0}^{\tau} \left[\left\{F(t;\tilde{S}_0^0,\tilde{S}_\tau^1) + G(t)\right\} - \left\{F(t;\tilde{S}_0^0,\tilde{S}_\tau^0) + G(t)\right\} \right] d\ell \ .$$

Consequently the area is independent of our choice of G(t). This result allows us a useful degree of agnosticism about the actual path of real savings between time 0 and τ. To illustrate: Figure 2 is consistent — within graphical accuracy — with the simple exponential growth path:

$$(2.5) \quad \tilde{S}_t = F\,(t;\tilde{S}_0^0,\tilde{S}_t^n) + G_1(t) = \tilde{S}_0^0 \left(\frac{\tilde{S}_\tau^n}{\tilde{S}_0^0} \right)^{t/\tau} + G_1(t) \qquad \text{where } n = 0 \text{ or } 1 \text{ and } G_1(t) = 0 \,\forall\, t.$$

Figure 3 is consistent with the same function F but with a different G function, $G_2(t)$, depicted by a dotted line, and representing a cyclical component of the adjustment process. (To obtain Figure 3 from Figure 2, add the dotted line G_2 to the paths of Figure 2.) The shaded area in Figure 3 is the same as that in Figure 2 because function F is still the same. By extension the simple exponential growth path yields the same result as a wide variety of alternative growth hypotheses.

Our agnosticism cannot be total, as Figure 4 shows. It is not possible to draw a new function $G_3(t)$ which added to the paths shown in Figure 2 would yield those of Figure 4. Consequently Figure 4 implies that a different function has replaced our simple exponential growth path F.

The question of the relative plausibility of alternative forms for F, such as those implicit in Figures 2 and 4, is in an open one. That is, many functions F could be chosen which would satisfy all three conditions listed above. The exponential form adopted by DPR, though arbitrary, seems to us to be a natural starting point.

It is obvious from (2.4) that the area A is invariant with respect to choice of the function G. This area is also invariant, at least to a first order approximation, to many plausible choices of the function F.

This is important in MO81 experiments for the following reason. The results obtained should not be overly sensitive to the paths connecting the base period values of variables with their values in $t=\tau$. This is because there is nothing in the comparative static ORANI theory appropriate for generating adjustment dynamics. For most variables we can be completely agnostic (as in Figure 1) about adjustment paths. However, even where this is not feasible, as in the case of saving, the relative comprehensiveness of the class of functions (2.1) means that simulation results with MO81 are not overly sensitive to choice of dynamic path. In fact, the paths connecting $\tilde{S}_0^0$ with $\tilde{S}_\tau^0$ and with $\tilde{S}_\tau^1$ in MO81 belong to the sub-class (2.5) - see equation (2.7) below.

2.2 Classes of Equations in MO81

The structural equations of MO81 are reproduced from DPR in Table 1. The notation used therein is explained in Tables 2 and 3. The MO81 data base is given in Tables 4 and 5. These 5 tables are repeated at the end of the paper from which they may be detached for convenient reference. As can be seen from Table 1, MO81 contains six equation blocks: (I) final demands for commodities (by households, by the creators of capital goods, and by foreigners); (II) demands by industries for inputs and their supplies of outputs; (III) zero pure profit conditions; (IV) market 'clearing' equations; (V) miscellaneous definitional equations; and (VI) a macroeconomic closure block containing just four equations. In a Vincent (1980) style closure of MO81, the last block is related recursively to the earlier ones in the sense that no variable endogenized within it appears in any earlier block. Blocks I - V constitute a miniature version of the existing standard ORANI 78 as set out in DPSV. It is mainly in block VI, which has no analogue in ORANI 78, that our current interest lies.

Table 1 - The MO81 Equations : A Linear System in Percentage Changes[a]

Identifier	Equation	Subscript Range[b]	Number	Description
I. FINAL DEMANDS				
(T1)	$x^{(3)}_{(is)} = c^R - \left(p^{(3)}_{(is)} - \sum_{r=1}^{2} S^{(3)}_{(ir)}\, p^{(3)}_{(ir)}\right)$	i=1,...,g, s=1,2.	2g	Household demands for commodities.
(T2)	$x^{(2)}_{(is)j} = y_j - \left(p^{(2)}_{(is)j} - \sum_{r=1}^{2} S^{(2)}_{(ir)j}\, p^{(2)}_{(ir)j}\right)$	i=1,...,g, s=1,2, j=1,...,h.	2gh	Demands for inputs to capital creation.
(T3)	$p^{*}_{(i1)} = -\gamma_i\, x^{(4)}_{(i1)} + f^{(4)}_{(i1)}$	i=1,...,g.	g	Export demand functions.
II. INDUSTRY INPUTS AND OUTPUTS				
(T4)	$x^{(1)}_{(is)j} = z_j - \left(p^{(1)}_{(is)j} - \sum_{r=1}^{2} S^{(1)}_{(ir)j}\, p^{(1)}_{(ir)j}\right)$	i=1,...,g+1, j=1,...,h, s=1,2.	2(g+1)h	Demands for intermediate and primary factor inputs.
(T5)	$x^{(0)}_{(i1)j} = z_j + \left(p^{(0)}_{(i1)} - \sum_{q=1}^{g} H^{(0)}_{(q1)j}\, p^{(0)}_{(q1)}\right)$	i=1,...,g, j=1,...,h.	gh	Commodity supplies by industry.
III. ZERO PURE PROFIT CONDITIONS				
(T6)	$\sum_{q=1}^{g} H^{(0)}_{(q1)j}\, p^{(0)}_{(q1)} = \sum_{i=1}^{g+1} \sum_{s=1}^{2} H^{(1)}_{(is)j}\, p^{(1)}_{(is)j}$	j=1,...,h.	h	Zero pure profits in production.
(T7)	$p^{*}_{(i2)} + t_i + \phi = p^{(0)}_{(i2)}$	i=1,...,g.	g	Zero pure profits in importing.

(a) The variables and coefficients are defined in Tables 2 and 3.

(b) The number of domestically-produced goods is g, the number of imported goods is g and the number of industries is h. In standard applications of ORANI, g=114 and h=112. Some ORANI industries produce several goods and some goods are produced by several industries. In MO81, g=2 and h=2.

... *continued*

Table 1 continued ...

Identifier	Equation	Subscript Range	Number	Description
(T8)	$p^{*}_{(i1)} + v_i + \phi = p^{(4)}_{(i1)}$	i=1,...,g.	g	Zero pure profits in exporting.
(T9)	$\pi_j = \sum_{i=1}^{g} \sum_{s=1}^{2} H^{(2)}_{(is)j} \, p^{(2)}_{(is)j}$	j=1,...,h.	h	Zero pure profits in capital creation.
(T10)	$p^{(k)}_{(is)} = p^{(0)}_{(is)}$	i=1,...,g, s=1,2, k=3,4.	4g	Zero pure profits in the distribution of goods.
(T11)	$p^{(k)}_{(is)j} = p^{(0)}_{(is)}$	i=1,...,g, s=1,2, j=1,...,h, k=1,2.	4gh	
IV. <u>MARKET CLEARING</u>				
(T12)	$\sum_{j=1}^{h} x^{(0)}_{(q1)j} \, W^{(0)}_{(q1)j} = \sum_{k=1}^{2} \sum_{j=1}^{h} x^{(k)}_{(q1)j} \, W^{(k)}_{(q1)j} + \sum_{k=3}^{4} x^{(k)}_{(q1)} \, W^{(k)}_{(q1)}$	q=1,...,g.	g	Demand equals supply for domestically produced commodities.
(T13)	$\sum_{j=1}^{h} x^{(1)}_{(g+1,1)j} \, W^{(1)}_{(g+1,1)j} = \ell$		1	Demand for labour equals employment of labour
(T14)	$x^{(1)}_{(g+1,2)j} = k_j$	j=1,...,h.	h	Demand equals employment of capital in each industry.

... continued

Table 1 continued ...

Identifier	Equation	Subscript Range	Number	Description
V. MISCELLANEOUS EQUATIONS				
(T15)	$x^{(0)}_{(q2)} = \sum_{k=1}^{2} \sum_{j=1}^{h} x^{(k)}_{(q2)j} W^{(k)}_{(q2)j} + x^{(3)}_{(q2)} W^{(3)}_{(q2)}$	q=1,...,g.	g	Import volumes.
(T16)	$m = \sum_{q=1}^{g} M_{(q2)} \left(p^*_{(q2)} + x^{(0)}_{(q2)}\right)$		1	Foreign currency value of imports.
(T17)	$e = \sum_{q=1}^{g} E_{(q1)} \left(p^*_{(q1)} + x^{(4)}_{(q1)}\right)$		1	Foreign currency value of exports.
(T18)	$\Delta B = (Ee - Mm)/100$		1	Balance of trade.
(T19)	$\xi^{(3)} = \sum_{i=1}^{g} \sum_{s=1}^{2} H^{(3)}_{(is)} p^{(3)}_{(is)}$		1	Consumer price index.
(T20)	$c^R = c - \xi^{(3)}$		1	Real aggregate consumption.
(T21)	$y^R = \sum_{j=1}^{h} W^y_j y_j$		1	Aggregate real investment.
(T22)	$\pi = \sum_{j=1}^{h} W^y_j \pi_j$		1	Investment goods price index.
(T23)	$f_R = c^R - y^R$		1	Ratio of real aggregate.

... *continued*

Table 1 continued ...

Identi-fier	Equation	Subscript Range	Number	Description
(T24)	$r_j = \left(p^{(1)}_{(g+1,2)j} - \pi_j\right)Q_j$	j=1,...,h.	h	Rates of return on capital in each industry.
(T25)	$y_j = I^{(1)}_j k_j + I^{(2)}_j B_j(r_j - \omega) + f^{(2)}_j$	j=1,...,h.	h	Investment in each industry.
(T26)	$k = \sum_{j=1}^{h} W^k_j \; k_j$		1	Aggregate capital stock.
(T27)	$t = \sum_{i=1}^{g} \left(\zeta^t_i t_i + p^*_{(i2)} + x^{(0)}_{(i2)} + \phi\right)T^t_i$		1	Aggregate tariff revenue.
(T28)	$v = \sum_{i=1}^{g} \left(\zeta^v_i v_i + p^*_{(i1)} + x^{(4)}_{(i1)} + \phi\right)T^v_i$		1	Aggregate export subsidies.
(T29)	$p^{(1)}_{(g+1,1)j} = I_{(g+1,1)j} \; \xi^{(3)} + f_{(g+1,1)j} + f_{(g+1,1)}$	j=1,...,h.	h	Wage indexation.
(T30)	$r_j = r + f^r_j$	j=1,...,h.	h	Relative rates of return.
	Total number of equations in categories I - V =		9gh+11g+9h+12	

... continued

Table 1 continued ...

Identifier	Equation	Subscript Range	Number	Description
VI. MACROECONOMIC CLOSURE				
(T31)	$c = f_c + \psi_1 \left\{ \sum_{j=1}^{h} \left(p^{(1)}_{(g+1,1)j} + x^{(1)}_{(g+1,1)j} \right) N_{(g+1,1)j} \right\} + \psi_2 t$ $- \psi_3 v + \psi_4 \left\{ q + \sum_{j=1}^{h} \left(p^{(1)}_{(g+1,2)j} + x^{(1)}_{(g+1,2)j} \right) N_{(g+1,2)j} \right\}$		1	Consumption function.
(T32)	$u = (s - \pi)\left(\frac{U+1}{\tau U}\right)$		1	Determination of the domestic ownership share in the capital stock.
(T33)	$q + k = u\Gamma$		1	
(T34)	$s = c - f_c/(1 - F_c)$		1	
	Total number of equations in category VI =		4	
	Total number of equations in the complete model =		9gh+11g+9h+16	

Source: Dixon, Parmenter and Rimmer (forthcoming 1984).

Table 2 - The MO81 Variables

Variable	Subscript Range[(a)]	Number	Description
Variables appearing in categories I - V			
$x^{(3)}_{(is)}$	i=1,...,g, s=1,2.	2g	Household demands for commodities
$x^{(k)}_{(is)j}$	i=1,...,g, s=1,2, j=1,...,h, k=1,2.	4gh	Demands for inputs of commodities for current production (k=1) and capital creation (k=2)
$x^{(1)}_{(g+1,s)j}$	j=1,...,h, s=1,2.	2h	Demands for labor (s=1) and capital (s=2) by industry
$x^{(4)}_{(i1)}$	i=1,...,g.	g	Export volumes
$x^{(0)}_{(q2)}$	q=1,...,g.	g	Import volumes
$x^{(0)}_{(i1)j}$	i=1,...,g, j=1,...,h.	gh	Commodity supplies by industry
z_j	j=1,...,h.	h	Industry activity levels
c		1	Aggregate consumption
c^R		1	Real aggregate consumption
y^R		1	Real aggregate investment
y_j	j=1,...,h.	h	Capital creation for each industry
ℓ		1	Aggregate employment
k_j	j=1,...,h.	h	Employment of capital in each industry
k		1	Aggregate capital employed
m		1	Foreign currency value of imports
e		1	Foreign currency value of exports

(a) The number of domestically-produced goods is g, the number of imported goods is g and the number of industries is h. In standard applications of ORANI, g=114 and h=112. Some ORANI industries produce several goods and some goods are produced by several industries. In MO81, g=2 and h=2.

... *continued*

Table 2 continued ...

Variable	Subscript Range	Number	Description
Variables appearing in categories I - V *(continued)*			
ΔB		1	Balance of trade
$p^{(k)}_{(is)}$	i=1,...,g, s=1,2, k=3,4.	4g	Prices paid by households and exporters for commodities
$p^{(k)}_{(is)j}$	i=1,...,g, j=1,...,h, s=1,2, k=1,2.	4gh	Prices paid by industries for commodity inputs to production and capital creation
$p^{(0)}_{(is)}$	i=1,...,g, s=1,2.	2g	Basic prices of domestic and imported commodities
$p^{(1)}_{(g+1,s)j}$	j=1,...,h, s=1,2.	2h	Prices paid by industries for use of primary factors (s=1 for labour and s=2 for capital)
$p^{*}_{(i1)}$	i=1,...,g.	g	Foreign currency prices of exports
$p^{*}_{(i2)}$	i=1,...,g.	g	Foreign currency prices of imports
π_j	j=1,...,h.	h	Prices of units of capital
π		1	Investment goods price index
$\xi^{(3)}$ or cpi		1	Consumer price index
r_j	j=1,...,h.	h	Rates of return on capital in each industry
r		1	Useful variables for exogenizing relative rates of return while endogenizing absolute rates of return
f^r_j		h	(as above)
$f^{(4)}_{(i1)}$	i=1,...,g.	g	Shifts in foreign export demands
f_R		1	Ratio of real aggregate consumption to real aggregate investment
$f^{(2)}_j$	j=1,...,h.	h	Shift variable in industry investment equations

... continued

Table 2 continued ...

Variable	Subscript Range	Number	Description
<u>Variables appearing in categories I - V</u> *(continued)*			
$f_{(g+1,1)j}$	j=1,...,h.	h	Variable used to allow variations across industries in wage rate movements
$f_{(g+1,1)}$		1	Normally interpreted as the real wage rate
ϕ		1	Exchange rate ($A/$US)
v_i	i=1,...,g.	g	One plus ad valorem export subsidies
t_i	i=1,...,g.	g	One plus ad valorem tariff rates
v		1	Aggregate export subsidy
t		1	Aggregate tariff revenue
ω		1	Expected rate of return in all industries, adjusted for risk
Total number of variables in categories I - V =	9gh + 15g+12h+17		
<u>Additional variables introduced in category VI</u>			
f_c		1	Shift in the average propensity to consume
q		1	Domestic share in the ownership of capital
u		1	Rate of growth in real domestic saving over the period 0 to τ
s		1	Domestic saving
Number of additional variables =		4	
Total number of variables in categories I - VI = 9gh+15g+12h+21			

Source: Dixon, Parmenter and Rimmer (forthcoming 1984).

Table 3 - The MO81 Coefficients and Parameters Appearing in Table 1

Equation	Coefficient or Parameter	Description and Evaluation[a]
(T1)	$S^{(3)}_{(ir)}$	Share of good i from source r in household purchases of good i, e.g., initial value for $S^{(3)}_{(11)} = 19.55/(19.55 + 1.63)$.
(T2)	$S^{(2)}_{(ir)j}$	Share of good i from source r in industry j's purchases of good i to be used as an input to capital creation, e.g., initial value for $S^{(2)}_{(11)1} = 1$, initial value for $S^{(2)}_{(22)1} = 3.26/(9.78 + 3.26)$.
(T3)	γ_i	Reciprocal of the foreign (export) demand elasticity for good i. Values adopted were $\gamma_1 = 0.5$, $\gamma_2 = 0.05$.
(T4)	$S^{(1)}_{(ir)j}$	For i=1,2, this is the share of good i from source r in industry j's purchases of good i to be used as an intermediate input, e.g., initially $S^{(1)}_{(11)1} = 16.28/(16.28 + 1.63)$. For i=3, this is the share of labour (r=1) or the share of capital (r=2) in industry j's payments to primary factors, e.g., initially $S^{(1)}_{(31)1} = 32.57/(32.57 + 8.14 + 8.14)$.
(T5)	$H^{(0)}_{(q1)j}$	Share of total revenue in industry j accounted for by sales of good q, e.g., initially $H^{(0)}_{(11)1} = 73.30/(73.30 + 26.06)$.
(T6)	$H^{(0)}_{(q1)j}$	Covered under (T5).
	$H^{(1)}_{(is)j}$	Share of input (is) in the total costs of production in industry j, e.g., initially $H^{(1)}_{(11)1} = 16.28/99.36$, $H^{(1)}_{(32)1} = 16.28/99.36$, $H^{(1)}_{(31)2} = 32.57/71.67$.
(T7)	None	

... *continued*

Table 3 continued ...

Equation	Coefficient or Parameter	Description and Evaluation[a]
(T8)	None	
(T9)	$H^{(2)}_{(is)j}$	Share of input (is) in the total cost of capital creation for industry j, e.g., initially $H^{(2)}_{(11)1} = 3.26/16.29$, $H^{(2)}_{(12)1} = 0$, $H^{(2)}_{(21)2} = 4.89/8.14$.
(T10)	None	
(T11)	None	
(T12)	$W^{(0)}_{(q1)j}$	Share of the total output of (q1) which is accounted for by industry j, e.g., initially $W^{(0)}_{(11)1} = 73.30/87.96$, $W^{(0)}_{(11)2} = 14.66/87.96$.
	$W^{(k)}_{(q1)j}$	Share of the total purchases of (q1) which is accounted for by industry j for purpose k (k=1, intermediate demand; k=2, input to capital creation). For example, initially $W^{(1)}_{(11)1} = 16.28/87.96$, $W^{(2)}_{(11)2} = 1.63/87.96$, $W^{(2)}_{(21)2} = 4.89/83.07$.
	$W^{(k)}_{(q1)}$	Share of the total purchases of (q1) which is accounted for by final user k (k=3, households; k=4, exports). For example, initially $W^{(3)}_{(11)} = 19.55/87.96$, $W^{(4)}_{(11)} = 34.21/87.96$.
(T13)	$W^{(1)}_{(g+1,1)j}$	Share of the total demand for primary factor of type 1 (i.e., labour) which is accounted for by industry j. For example, the initial value of $W^{(1)}_{(g+1,1)2}$ is 32.57/65.16.
(T14)	None	

... *continued*

Table 3 continued ...

Equation	Coefficient or Parameter	Description and Evaluation[(a)]
(T15)	$W^{(k)}_{(q2)j}$	Share of total purchases of imported good q which is accounted for by industry j for purpose k, e.g., initially $W^{(1)}_{(12)1} = 1.63/16.29$, $W^{(2)}_{(22)2} = 1.63/27.69$. Note : the denominator in these shares is the basic value (including duty) of the sales of good (q2).
	$W^{(3)}_{(q2)}$	Share of total purchases of good (q2) which is accounted for by households. Initially $W^{(3)}_{(12)} = 1.63/16.29$, $W^{(3)}_{(22)} = 11.40/27.69$.
(T16)	$M_{(q2)}$	Share of the total foreign currency value of imports accounted for by imports of good (q2). Initially $M_{(12)} = 14.66/34.21$, $M_{(22)} = 19.55/34.21$.
(T17)	$E_{(q1)}$	Share of the total foreign currency value of exports accounted for by exports of good (q1). Initially $E_{(11)} = 1$, $E_{(21)} = 0$. Note : there are no export taxes or subsidies in the data.
(T18)	E	Foreign currency value of exports. Initially E = 34.21.
	M	Foreign currency value of imports. Initially M = 34.21.
(T19)	$H^{(3)}_{(is)}$	Share of household expenditure devoted to good (is), e.g., initially $H^{(3)}_{(11)} = 19.55/74.93$.
(T20)	None	

... continued

Table 3 continued ...

Equation	Coefficient or Parameter	Description and Evaluation[(a)]
(T21)	W^y_j	Share of total investment accounted for by industry j. Initially $W^y_1 = 16.29/24.43$, $W^y_2 = 8.14/24.43$.
(T22)	W^y_j	Covered under (T21).
(T23)	None	
(T24)	Q_j	$Q_j = (R_j + D_j)/R_j$, i.e., Q_j is the ratio of the gross to the net rate of return in industry j. From Table 5, $D_1 = 8.14/162.89$, $D_2 = 4.07/81.45$ (these are treated as constants). Initially $R_1 = 8.14/162.89$, $R_2 = 4.07/81.45$. Hence, initially $Q_j = 2$ for $j=1,2$.
(T25)	$I^{(1)}_j$, $I^{(2)}_j$	Users of the model set values according to how investment by industry is to be modelled in Section 2.5. In DPR's long-run closure, the H_j are evaluated using values for $K_j(0)$ and K_j from Tables 4 and 5. For example, where $\tau = 10$, the initial value for H_1 is $(162.89/100)^{.1} - 1$.
	B_j	$B_j = 1/\beta_j\Delta_j$, where β_j is the elasticity of the expected rate of return schedule for industry j and Δ_j is the ratio of investment in the solution year to capital stock in the following year. For $j=1,2$, we set $\beta_j = 30$. Initially $\Delta_1 = 16.29/(162.89(.95) + 16.29)$ and $\Delta_2 = 8.14/(81.45(.95) + 8.14)$. <u>Note</u> : none of the results for the DPR closure are affected by the value used for B_j.

... continued

Table 3 continued ...

Equation	Coefficient or Parameter	Description and Evaluation[(a)]
(T26)	W_j^k	Share of the total capital stock accounted for by industry j. Initially, $W_1^k = 162.89/244.34$, $W_2^k = 81.45/244.34$.
(T27)	ζ_i^t	$\zeta_i^t = T_i/(T_i-1)$, i.e., ζ_i^t is the ratio of the power of the tariff on good i to the ad valorem rate. Initially $\zeta_1^t = 16.30/1.63$, $\zeta_2^t = 27.69/8.14$.
	T_i^t	Share of total tariff revenue accounted for by tariffs on good i. Initially, $T_1^t = 1.63/9.77$, $T_2^t = 8.14/9.77$.
(T28)	ζ_i^v	$\zeta_i^v = V_i/(V_i - 1)$, i.e., ζ_i^v is the ratio of the power of the export subsidy on good i to the ad valorem rate.
	T_i^v	Share of total export subsidies accounted for by export subsidies on good i. Note : our data base shows no export subsidies. Hence, in our computations, (T28) and the variable v are deleted.
(T29)	$I_{(g+1,1)j}$	User determined wage-indexing parameter.
(T30)	None	

... *continued*

Table 3 continued ...

Equation	Coefficient or Parameter	Description and Evaluation[a]
(T31)	ψ_i	ψ_i, $i=1,\ldots,4$ are the shares in domestic income accounted for by wage income, tariff revenue, export subsidies and capital income accruing to domestic capitalists. In Table 5, wage income is 65.16, tariff revenue is 9.77, export subsidies are 0 and domestic capitalist income is (24.44)(183.26/244.34) = 18.33. Thus, domestic income is 93.24 and initially we have $\psi_1 = .70$, $\psi_2 = .10$, $\psi_3 = 0$ and $\psi_4 = 0.20$.
	$N_{(g+1,1)j}$	Share of industry j in total wage payments. Initially $N_{(g+1,1)1} = 32.57/65.16$, $N_{(g+1,1)2} = 32.57/65.16$.
	$N_{(g+1,2)j}$	Share of industry j in total returns to capital. Initially $N_{(g+1,2)1} = 16.28/24.44$, $N_{(g+1,2)2} = 8.14/24.44$.
(T32)	$(U+1)/\tau U$	In the base year (see Table 4) domestic income is 40 (wages) plus 6 (tariff revenue) plus 15(112.5/150) (domestically accruing capital income), i.e. domestic income is 57.25. Consumption is 46 leaving savings $S(0) = 11.25$. In the solution year (see Table 5) domestic income is 93.24 (see the discussion of ψ_i earlier in this table). Consumption is 74.93 leaving $S(\tau) = 18.31$. Commodity prices are constant as we move from Table 4 to Table 5. In particular, initially, $\Pi(\tau)/\Pi(0) = 1$. Hence, the initial value for U is $(18.31/11.25)^{.1} - 1 = 0.05$. With $\tau = 10$, we find that the initial value for the coefficient in (T32) is $1.05/.50 = 2.10$.

... continued

Table 3 continued ...

Equation	Coefficient or Parameter	Description and Evaluation[a]
(T33)	Γ	See equation (2.10). With $\tau = 10$, $D = 0.05$, $Q(0) = .75$, $K(0) = 150$ and U, $Q(\tau)$ and $K(\tau)$ having initial values 0.05, .75 and 244.34, Γ has an initial value of 0.160.
(T34)	$1/(1-F_c)$	Initially F_c equals (74.93/93.24) = .80, i.e. F_c is the ratio of consumption to domestic income. This gives an initial value for the coefficient in (T34) of 5.1.

(a) Except when otherwise indicated, the initial share values were computed from the solution year input output data, i.e., Table 5 .

Source: Dixon, Parmenter and Rimmer (forthcoming 1984).

Table 4 - Input-output Data Base for MO81 for Year 0, the Base Year

			Intermediate inputs to industries 1 and 2		Gross fixed capital formation by industries 1 and 2		Household consumption	Exports	Negative of import duty	Row Totals
Domestic commodities		1	10	8	2	1	12	21		54
		2	15	1	6	3	26	0		51
Imported commodities		1	1	8	0	0	1		-1	9
		2	5	2	2	1	7		-5	12
Labour			20	20						40
Gross operating surplus	Depreciation		5	2.5						7.5
	Net profit		5	2.5						7.5
Total costs			61	44	10	5	46	21	-6	181
Domestic commodity outputs		1	45	9						54
		2	16	35						51
Domestically-owned capital stocks			75	37.5						112.5
Foreign-owned capital stocks			25	12.5						37.5
Total capital			100	50						150

Source: Dixon, Parmenter and Rimmer (forthcoming 1984).

Table 5 - Input-output Data Base for MO81 for Year τ, the Solution Year[a]

		Intermediate inputs to industries 1 and 2		Gross fixed capital formation by industries 1 and 2		Household consumption	Exports	Negative of import duty	Row Totals
Domestic commodities	1	16.28	13.03	3.26	1.63	19.55	34.21		87.96
	2	24.43	1.63	9.78	4.89	42.35	0		83.07
Imported commodities	1	1.63	13.03	0	0	1.63		-1.63	14.66
	2	8.14	3.26	3.26	1.63	11.40		-8.14	19.55
Labour		32.57	32.57						65.16
Gross operating surplus: Depreciation		8.14	4.07						12.22
Gross operating surplus: Net profit		8.14	4.07						12.22
Total costs		99.36	71.67	16.29	8.14	74.93	34.21	-9.77	294.84
Domestic commodity outputs	1	73.30	14.66						87.96
	2	26.06	57.01						83.07
Domestically-owned capital stocks		122.17	61.09						183.26
Foreign-owned capital stocks		40.72	20.36						61.08
Total capital		162.89	81.45						244.34

(a) $\tau=10$. All flows shown here are obtained from the corresponding flows in Table 5 by multiplying by $(1.05)^{10}$.

Source: Dixon, Parmenter and Rimmer (forthcoming 1984).

2.3 Macroeconomic Closure Block

Equation (T31) in Table 1 gives the log differential or percentage-change form of the consumption function, which may be simplified notationally as follows:

$$(2.6) \qquad c = f_c + [\psi_1 a + \psi_2 t^* - \psi_3 v + \psi_4 (q + d)] \quad ,$$

where the lower case Roman letters represent percentage deviations of variables from their control path values in year τ (the 'snapshot' year). The key to the notation is:

f_c : average propensity to consume (apc)
a : labour income (nominal)
t^*: aggregate tariff revenue (nominal)
v : aggregate export subsidy (nominal)
q : share of the capital stock in Australia owned by domestic residents
d : income to capital (nominal).

The coefficients (ψ_i; i=1,...,4) are the shares in domestic income accounted for by wage income, tariff revenue, export subsidies and returns on capital accruing to domestic residents. If the apc is treated as exogenous, with f_c =0, then (2.6) represents a consumption function passing through the origin. The alternative exists to allow f_c to be endogenous, in which case additional equation(s), which define some other sort of consumption function, must be added.

Apart from taxes and subsidies on international trade, the consumption effect, c, in the snapshot year is driven by labour income, a, and income to capital, d, taking explicit account of changes, q, in the share of the capital stock which is domestically owned. The variables a and d respectively are endogenized by employment and the wage rate on the one hand, and by the demand for capital and rental rates, on the other. These variables in turn are endogenized within blocks I - IV. It remains to endogenize q. It is at this point that explicit recognition of intertemporal links connecting the data bases of the base period 0 and the projected (or snapshot) period τ becomes unavoidable. DPR aimed to model these links in a manner which avoids, as far as possible, commitment to a full dynamic specification. Thus we would hope to generate comparative static solutions which are compatible, to a good degree of approximation, with a wide variety of possible adjustment paths between 0 and τ .

DPR make the following assumptions about capital accumulation by domestic residents:

(a) Depreciation occurs at an exogenous geometric rate D. In the implemented versions of their theory, depreciation rates are uniform across the two industries distinguished.

(b) In any year t between the base year 0 and the snapshot year τ , the share of domestic residents in the title to newly created capital is just the ratio of domestic saving to total capital formation. This ratio is not industry specific.

(c) The domestic share of the total capital stock in the base period ($Q(0)$) and in the snapshot period (in the absence of policy shocks) ($Q(\tau)$) are 'known' respectively from historical data and the control path scenario on the growth of the economy.

(d) The real value of the annual flow of saving grows geometrically between 0 and τ; that is:

(2.7) $$\tilde{S}(t) \equiv \frac{S(t)}{\Pi(t)} = \frac{S(0)}{\Pi(0)} (1 + U)^t \qquad (t=1,\ldots,\tau) \quad ,$$

where S and Π respectively are the nominal flow of saving by domestic residents and the capital goods price index, and U is the rate of growth in real saving.

As noted in Section 2.1, this last assumption introduces a primitive dynamics hitherto lacking in ORANI and its miniatures.

Since the depreciation rate is D, domestically owned capital which has been accumulated between 0 and τ and which survives to τ (see DPR, eqns (3.45) to (3.48)) is:

$$\Delta_0^\tau (KQ) = \sum_{t=0}^{\tau-1} [S(t)/\Pi(t)] \, (1-D)^{\tau-t-1}$$

$$\text{(from 2.7)} = \frac{S(0)}{\Pi(0)} \sum_{t=0}^{\tau-1} (1+U)^t (1-D)^{\tau-t-1}$$

(2.8) $$= \frac{S(0)}{\Pi(0)} \left\{ \frac{(1+U)^\tau - (1-D)^\tau}{D + U} \right\} \quad ,$$

where K and Q respectively are the aggregate capital stock and the share of this stock which is owned by domestic residents. Note that the operator Δ_0^{τ} takes differences between the values of a variable at different points of time. It should also be noted that Δ_0^{τ} (KQ) has a numerical value given by the control path data base.

Let k, q and u respectively be the percentage differentials in $K(\tau)$, $Q(\tau)$ and in U induced by an exogenous shock injected at t=0 and maintained thereafter. From (2.8), DPR obtain

(2.9) $$k + q = \Gamma u \quad ,$$

where

(2.10) $$\Gamma = \left\{ \left(\frac{U\tau}{1+U}\right) \left[\frac{(1+U)^{\tau}}{(1+U)^{\tau} - (1-D)^{\tau}} \right] - \frac{U}{(D+U)} \right\} \times \Delta_0^{\tau}(KQ)/[K(\tau)Q(\tau)] \quad .$$

The coefficient Γ may be derived from the control path data base. (2.9) is equation (T33) of Table 1. It relates the induced changes at $t=\tau$ in the capital stock, and in the Australian share thereof, to the induced change over the interval $[1, \tau]$ in the growth rate of the (flow) of real saving. Equation (T32) of Table 1 relates this induced change in the growth rate of real saving to the change induced at τ in nominal saving and in the capital goods price index. (T32) is obtained simply by contemporaneous logarithmic differentiation of equation (2.7) evaluated at $t=\tau$. Finally equation (T34) is obtained by applying the same operation to

$$(2.11) \qquad S(\tau) = \left(\frac{1-F_c(\tau)}{F_c(\tau)}\right) C(\tau) ,$$

which relates nominal saving, S, the average propensity to consume, F_c, and nominal consumption, C (all in year τ).

2.4 A New Equation

We have found it convenient to append to MO81 an additional equation which facilitates welfare analysis. Consider a shock in an exogenous variable introduced at t=0 (a fall in the overseas price of a commodity for which Australia is a price-taker, say). Suppose that this shock is 'good', in the long run, for Australian residents. The benefits could show up as (i) an increase in wealth at τ (viz. k+q>0); or (ii) as a higher average level of consumption over the latent period $[1,\tau]$; or as a mixture of both.

Let D* be the time preference discount rate. Then the present value in period 0 of the consumption stream over the latent period is

$$(2.12) \qquad G^* = \sum_{t=1}^{\tau} \frac{C(t)}{\Xi(t)} (1-D^*)^t$$

where $\{C(t)\}$ and $\{\Xi(t)\}$ respectively are the sequences of money consumption and of the consumer price index. As in the case of saving, it is convenient to adopt a simple growth path for real consumption:

$$(2.13) \qquad \frac{C(t)}{\Xi(t)} = \frac{C(0)}{\Xi(0)} (1+W)^t \qquad (t=1,\ldots,\tau) .$$

Define W* by

(2.14) $$W^* = W - D^* - WD^* \ .$$

Then, substituting (2.13) into (2.12), we obtain

(2.15) $$G^* = \frac{C(0)}{\Xi(0)} (1+W^*)[(1+W^*)^{\tau}-1]/W^* \ .$$

The percentage change in G* due to the shock injected at t=0 is

(2.16) $$g^* = \Phi^* w \ ,$$

where

(2.17) $$\Phi^* = \frac{W(1-D^*)[(1+W^*)^{\tau}(\tau W^*-1)+1]}{W^*(1+W^*)[(1+W^*)^{\tau}-1]}$$

where w is the percentage change induced in W by the shock injected at t=0. (Do not confuse the coefficient Φ^* with Φ, which is the nominal exchange rate in M081 notation.) If we take the contemporaneous logarithmic differential of (2.17) with t set to τ, we obtain

(2.18) $$c^R = c - \xi = A^* w \ ,$$

where

(2.19) $$A^* = \tau W/(1+W) \ ,$$

c^R, c and ξ respectively being the percentage deviations from their control values at $t=\tau$ of real consumption, nominal consumption, and the CPI. Combining equations (2.16) and (2.18) we see that

(2.20) $$g^* = Ac^R ,$$

in which

(2.21) $$A = (1+W)\ \Phi^*(W\tau)^{-1} ;$$

that is, the percentage change induced by the shock injected at t=0 in the present value of real consumption over the latent period $[1, \tau]$ is proportional to the percentage change c^R induced in real consumption in the snapshot year τ.

(2.21) is the additional equation which we add to block VI of MO81's structure. It allows us to consider the welfare impact at $t=\tau$ on domestic residents of a shock occurring at t=0 in terms of two components of their prosperity: (a) the induced change (q+k) in their wealth at τ; and (b) the induced change in the discounted value of consumption over the latent interval $[1,\tau]$.

2.5 Investment Theory

Apart from the five equations of the augmented macroeconomic closure block, one element of earlier blocks is crucial for current purposes; namely, the equations describing investment. These equations determine, in the year projected, (a) the proportion of GDP which investment represents and (b) the allocation of investment activity in this year among industries.

The relevant equations are (T25) in Table 1; namely

(2.22) $$y_j = I_j^{(1)} k_j + I_j^{(2)} B_j (r_j - \omega) + f_j^{(2)} \qquad (j=1,2) ,$$

where y_j, k_j, and r_j respectively are the percentage changes at τ in the real annual flow of gross investment, in the capital stock in use, and in the rate of return (all in industry j). The variable ω is intepreted as follows. When the investments $Y_1(\tau)$, $Y_2(\tau)$ are made in τ, the prospective rates of return for $(\tau+1)$ change. Equation (2.22) is derived (see DPR Section 3.2) on the assumption that the shares of the industries in total investment are such as to equalize the risk-adjusted values of the prospective rates of return for $(\tau+1)$ in both industries. $\Omega(\tau)$ is the prospective economy-wide rate of return in $(\tau+1)$ as foreseen in τ. ω is the percentage change in $\Omega(\tau)$ induced by the shock injected at t=0. The variable $f_j^{(2)}$ allows an exogenous shift to be made in industry-specific investment. The coefficient B_j is defined in Table 3. $I_j^{(1)}$ and $I_j^{(2)}$ are binary variables with values either zero or unity. As is now explained, their settings determine the appropriateness of the theory embodied in (2.22) for explaining investment in the short and long runs.

In short run closures of ORANI, typically we assume that year τ is a year about two years after the imposition of our exogenous shocks. (For empirical evidence on this point, see Cooper and McLaren (1980, 1983) and Cooper (1983).) As explained above, the k_j are set exogenously to zero in a neo-classical short-run closure (but not, however, in neo-Keynesian short-run closures -- see, e.g., Wright and Cowan (1980) or Dixon, Parmenter and Powell (1979), Section 3.5). The value of $I_j^{(1)}$ is thus immaterial in this case. r_j and ω are endogenous variables in neo-classical short-run closures, and $I_j^{(2)}$ is set exogenously to one. (In ORANI proper, investment in government enterprise dominated industries is linked to aggregate investment in the privately dominated industries.) Equation (2.22) then reduces to

(2.23) $$r_j = (y_j/B_j) + \omega \quad .$$

This says that the percentage change in the rate of return in industry j in year $\tau=2$ due to the shock at t=0 is equal to the prospective percentage change ω in year $(\tau+1) = 3$ in the economy-wide rate of return, plus an industry specific component (y_j/B_j) which increases when y_j increases $(B_j>0)$. The positive relationship between r_j and y_j is explained by the fact that shocks which increase the rate of return in the short run in a particular industry also increase that industry's share in total investment.

How is total investment - I - determined in short-run closures of ORANI? The structural equations of ORANI 78 (and of blocks I - V of MO81), are sufficient to endogenize GDP, but not its broad composition. From the national accounting identity

(2.24) $$GDP = C + I + G + BT \quad ,$$

we see that three major components of national income must be exogenized. Typically the three chosen are C, I and G, while the balance of trade surplus, BT, is kept endogenous. Usually the assumptions that

(2.25) $$I^R \propto C^R$$

and

(2.26) $$G^R \propto C^R$$

are made, so that closure is achieved by specifying an exogenous value for real consumption. It is the function of the new behavioural equation (2.6) to replace the compositional tie (2.25) between two components of expenditure. However we note that in existing short-run closures of ORANI78 the total volume of gross real investment I^R, is supplied exogenously. An increase in an industry's share of total investment hence means an increase in its volume of investment.

It will be noted that none of the relations introduced into the (augmented) block VI of MO81 is suitable for endogenizing aggregate investment in a short-run closure. But of course this block was introduced expressly for long-run closures.

In the long-run closure recommended by DPR, $I_j^{(1)}$ and $I_j^{(2)}$ are set to unity and zero respectively in (2.22), yielding

$$y_j - k_j = f_j^{(2)} \qquad (j=1,2) \quad . \tag{2.27}$$

The left-hand-side is the percentage change in the gross growth rate of the capital stock of industry j in year τ. We shall denote it $\tilde{h}_j = y_j - k_j$. It is related to the corresponding net rate of growth in year τ, h_j, by (see DPR, equation (3.35))

$$\tilde{h}_j = (y_j - k_j) = H^* h_j \quad , \tag{2.28}$$

where

$$H^* = H_j(\tau)/[H_j(\tau) + D_j] \quad , \tag{2.29}$$

in which $H_j(\tau)$ is the net growth rate in industry j's capital stock in year τ, and D_j is the (time invariant) depreciation rate. DPR ask the question: Is it reasonable to expect that a shock introduced at t=0 will have an everlasting effect on the growth rates of various industries? Or is it more reasonable to assume that the relative sizes of industries adjust by virtue of endogenous differential growth rates over the latent interval $[1, \tau]$, but that by τ growth rates return to their pre-shock values? They opt for the latter position. Equation (2.27) is part of MO81; equation

(2.29) is not formally so. However, by setting each $f_j^{(2)}$ exogenously to zero, each h_j also is effectively exogenized at zero. Since in such a long-run closure $y_j = k_j$ for all j, the mechanisms responsible for determining the sizes of industries also determine investment by each industry in the snapshot year τ. One of the unsatisfactory features of Vincent's (1980) long-run closure of standard ORANI78 is that y_j, h_j and ω were determined endogenously, but without a suitable theoretical basis for such determination.

For use below, we conclude this section by defining the contemporaneous percentage differential at τ in the net economy-wide growth rate of the capital stock. This is an aggregate version of (2.28); i.e.,

$$\tilde{h} = y^R - k = \tfrac{1}{2}h \quad . \tag{2.30}$$

The constant $\frac{1}{2}$ appearing on the right of (2.30) reflects the fact that in the MO81 data base, the net growth rate in each industry is equal to the common rate of depreciation.

3. RESUMÉ OF RESULTS WITH MO81

In this section we duplicate DPR's results and report them in much more detail. We show how MO81 results for the Vincent closure can be obtained from the DPR closure, and vice-versa. This leads us to consider the trade-off between consumption and wealth. Movements around the prosperity frontier having the latter variables as axes are achieved in MO81 by variations in the average propensity to consume. We study the sensitivity of MO81 solutions to such variation. Finally, we consider the sensitivity of our results to the length of the long run, τ .

3.1 A Comparison of the Vincent and DPR Closures

While in the DPR closure the average propensity to consume and the growth rates in the snapshot year of the capital stocks in each industry, h_j, are held exogenous, the Vincent closure (used in earlier attempts to adapt ORANI to long-run analysis) holds constant the balance of trade and the ratio of aggregate consumption to investment. These assumptions were made as ORANI lacks the extra equations introduced by DPR in MO81.

The first two columns of Table 6 show respectively the effects of a one per cent increase in the power of the tariff on the main import-competing commodity according to the Vincent (1980) and the recommended (DPR) closures. Remarkably both closures yield identical net impacts on gdp (row 1), even though the compositions vary widely. One need not dwell on this happenstance, as varying the data base for MO81 will cause the gdp projections to vary between the two closures. (Nevertheless it would

Table 6 - Extended Tariff Simulation Results from M081 in Vincent and Recommended Closures

Variable			Closure: Vincent	Recommended (DPR)				
			1% Tariff Shock†	Shock: 1% Tariff†	1% $(-\tilde{h})$	$.3416\tilde{h}$	1% f_c	$-.1539f_c$
			(1)	(2)	(3)	(4)	(5)	(6)
1	gdp	real GDP	-.0522	-.0522	-.1460	.0498	.3239	-.0499
2	k	capital stock	-.4027	-.3998	-.0772	.0264	.1901	-.0293
3	z_1	industry activity levels	-.4801	-.4728	.2363	-.0807	-.4770	.0734
4	z_2		.3345	.3275	-.3299	.1126	-.6865	-.1057
5	π	price of capital	.3374	.3380	-.1962	.0670	.4391	-.0676
6	y^R	real investment	-.0612	-.3998	-1.0772	.3678	.1901	-.0293
7	m	imports	-.2721	-.2769	-.3982	.1360	.8525	-.1312
8	e	exports	-.2721	-.2729	.2615	-.0893	-.5855	.0901
9	cpi	C P I	.3013	.3019	-.2037	.0696	.4561	-.0702
10	$f^1_{(31)}$	real wage	-.2369	-.2365	-.1679	.0573	.3758	-.0579
11	c^R	real consumption	-.0612	.0474	-.1459	.0498	1.0294	-.1585
12	(bt)	balance of trade*	Exog	.0014	.2271	-.0776	-.4950	.0762
13	s	money saving	1.0232	.3494	-.3496	.1194	-3.6033	.5547
14	(tr)	tariff revenue	2.2659	2.2560	-.3939	.1345	.8098	-.1247
15	f_c	average propensity to consume	-.1539	Exog	Exog	Exog	1	-.1539
16	f_r	$c^R - y^R$	Exog	.4472	.9313	-.3180	.8393	-.1292
17	$-\tilde{h}$	$k-y^R$ = - growth rate**	-.3416	Exog	1	-.3416	Exog	Exog
18	gnp	real GNP	.0927	.0474	-.1459	.0498	.0294	-.0045
19	$k+\pi$	rentals on capital	-.0653	-.0618	-.2734	.0934	.6292	-.0969
20	$q+k=\beta$	Aust. owned capital	.2304	.0038	-.5015	.0176	-1.3581	.2091
21	$q+k+\pi$	rentals on item 20	.5678	.3418	-.2478	.0846	-.9190	.1415
22	$A\ c^R=g^*$	consumption gain	-.0361	.0280	-.0861	.0294	.6075	-.0935
23	q	domestical capital share	.6331	.4036	.0256	-.0087	-1.5482	.2383
24	c	money consumption	.2402	.3494	-.3496	.1194	1.4856	-.2287

† A one per cent shock in the power of the tariff on good 2 which is equivalent to a 3.4 per cent increase in the ad valorem tariff.

* The balance of trade entry is measured as per cent GDP. The other numbers in the body of the table are differentials in natural logarithms x 100; i.e., 'percentage differences' at τ = 10 years relative to control.

** $\tilde{h}$ is the percentage change in the economy-wide rate of growth of the capital stock before depreciation. For the M081 data base, the percentage change in the net growth rate is twice the value of h.

seem worthwhile to establish analytically which features of the MO81 data base bring about the equality of gdp under the two closures). The gnp projections (row 18), however, differ widely, the Vincent closure yielding about twice the value of the DPR closure. Whereas in the Vincent closure real consumption (row 11) and investment (row 6) are tied together (and hence tend to mirror movements in GDP), in the DPR closure consumption moves with GNP and investment moves so as to keep the growth rate of the capital stock in the snapshot year at the value it would have taken in the absence of the shock (see Section 2 above).

Before discussing the difference between the gnp results in the Vincent and DPR closures, it is worth explaining the slightly surprising result that in both long-run closures gnp rises, in spite of the fall in gdp. In conventional short-run applications of ORANI, and in short-run closures of MO81, the tariff rise yields a fall in both gnp and gdp, as we might expect. Why do these long-run closures not reproduce this feature?

Before attempting an answer, we should make clear our convention concerning price deflators for GDP and GNP. To keep our explanation of the divergences between these two income measures as uncluttered as possible, we have deflated both GDP and GNP by the CPI, calling the resultant quotients 'real' GDP and GNP. We now derive an expression for the GDP/GNP gap, where in our notation the contemporaneous percentage differentials in real GDP and GNP are written as gdp and gnp, the corresponding nominals being (gdp + cpi) and (gnp + cpi) respectively.

Let S_L, S_A, S_F (with $S_K = S_A + S_F$; $S_A = QS_K$; $S_F = (1-Q)\ S_K$), and S_T be the shares in the control value of GDP in the snapshot year represented by returns to labour, Australian-owned capital, foreign-owned capital, and tariff revenue net of export subsidies. Then the accounting identity

(3.1) Nominal GDP = Nominal Factor Payments to Labour
+ Nominal Factor Payments to Capital
+ Nominal Net Tariff Revenue,

in percentage change form becomes

$$
\begin{aligned}
(3.2)\qquad gdp + cpi &= S_L\ (\ell + f^{1}_{(31)} + cpi) \\
&+ S_A\ (k_A + p^{1R}_{(32)} + cpi) \\
&+ S_F\ (k_F + p^{1R}_{(32)} + cpi \\
&+ S_T\ (t + cpi)\quad ,
\end{aligned}
$$

in which the lower case letters are the contemporaneous percentage differentials at τ of the following variables:

ℓ	aggregate labour demand
$f^{1}_{(31)}$	real wage
$p^{1R}_{(32)}$	real rental on capital
k_A	capital owned by Australians
k_F	capital owned by foreigners
t	real tariff revenue.

The real version of (3.2) is obtained by erasing cpi everywhere it occurs. Recalling that Q is the share of total capital owned by Australians, and that K is the total stock, we have:

$$(3.3) \qquad gdp = S_L\left(\ell + f^1_{(31)}\right) + S_A\left(q + k + p^{1R}_{(32)}\right) + S_F\left(-Q^*q + k + p^{1R}_{(32)}\right) + S_T t ,$$

where

$$(3.4) \qquad Q^* = Q/(1-Q) \text{ [= 3 in the M081 data base].}$$

But GNP differs from GDP only in that returns to the foreign owners of capital are excluded from the former. It follows that

$$(3.5) \qquad gnp = \left[S_L\left(\ell + f^1_{(31)}\right) + S_A\left(q+k+p^{1R}_{(32)}\right) + S_T t\right]\Big/(1 - S_F) ,$$

which is the real equivalent of the square-bracketed term in (2.6).

Thus

$$(3.6) \qquad gdp = (1-S_F)gnp - S_A q + S_F\left(k + p^{1R}_{(32)}\right) .$$

Next, we rearrange (3.6) and then back-substitute for gnp from (3.5), obtaining

$$(3.7) \qquad (gdp-gnp) = \left[(1-S_K)\ S_F\left(k + p^{1R}_{(32)}\right) - S_L S_F\left(\ell + f^1_{(31)}\right) - S_A q - S_F S_T t\right]\Big/(1-S_F) .$$

This enables us to partition the difference between gdp and gnp into the effects of (percentage differentials in)

Table 7 - Comparison of the Effects of a One Per Cent Rise in the Power of the Tariff on Good 2, in Short- and Long-Run Closures of MO81

Endogenous Variables	Selected Values from Snapshot Year Data Base	Per Cent Response in Endogenous Variables[(a)]	
		Short-run	Long-run
Aggregate Labour Demand		-.2679	0
Real Wage		0	-.2365
Aggregate Capital		0	-.3998
Average Real Rental per Unit of Capital		-.4088	.0361
Real Labour Revenue	65.16	-.2679	-.2365
Real Capital Revenue	24.43	-.4088	-.3637
Domestic Real Capital Revenue	18.33	-.4088	.0399
Real Tariff Revenue	9.77	1.9250	1.9541
Real GDP	99.36	-.0868	-.0522
Domestic Share of Capital	.75	0	.4036
Real GNP	93.25	-.0657	.0474

Notes: All monetary quantities deflated by the CPI. The average propensity to consume is exogenous in each case. Full details of the closures are given in Appendix Table A1.

(a) Zero values correspond to variables which are exogenous in the closure under examination.

(i) real rents paid to capital $\left(k + p^{1R}_{(32)}\right)$;

(ii) real labour income $\left(\ell + f^{1}_{(31)}\right)$;

(iii) the share of the capital stock owned by Australians (q);

and

(iv) the real value of tariffs collected (t).

In the case of (i) and (ii), we are further able to partition these terms into quantity and real price effects.

In a neo-classical short-run closure of MO81 the gap (gdp-gnp) is -.0211, whereas in the DPR long-run closure this gap is -.0996 (see Table 7). From (3.7) we see that the difference between these two gaps is explainable in terms of differences, between the two closures, in the values of the four variables listed above. For items (i) to (iv) these differences are -.0451, -.0314, -.4036 and -.0291 respectively (see Table 7). The corresponding share-based coefficients on the right of (3.7) (whose values are derived from Table 5) are +.0493909, -.0429508, -.1964825 and -.0064399 respectively. Consequently the difference between closures in the gdp-gnp gaps is due almost entirely to the differences in the values of q projected by these closures, the actual contributions of factors (i) through (iv) being -.0023, +.0013, +.0793 and +.0002. This dominance of the relative changes in Australian ownership of capital in explaining the differences between the closures is a consequence of the following factors:

(a) The coefficient of q in (3.7) is much larger in absolute value than the other coefficients.

(b) Moving between the short-run and DPR closures does not greatly affect the cdcs differentials in income to capital or in income to labour.

(c) The coefficient of the tariff revenue variable in (3.7) is very small.

Factor (b) owes its explanation to the tendency for offsetting movements to occur in the price and quantity components of each income type. This is well illustrated in the first six lines of Table 7. These results reflect the fact that in the short run, capital stocks are fixed, not only in aggregate, but also within industries. In the long run, aggregate labour is fixed, but is mobile between industries. (Thus the two closures are not fully symmetrical with respect to the factors.) The change in the tariff on good two is a sector-specific shock which causes real revenue to capital to decline in the short-run closure. In the long run closure, it causes a slow-down in capital inflow, which eliminates the fall in the rate of return which would otherwise occur. This responsiveness of foreign capital flows in long-run closures has an analogue in the labour market. In some parts of Europe, governments import migrant workers to alleviate short term labour shortages. These 'Gastarbeiter' repatriate much of their earnings to their native country. Further, if an economic downturn affects the host country, they are sent home. Thus domestic labour income, and by extension GNP, are insulated from fluctuations in the economic climate in the host country. Both Vincent and DPR closures incorporate this 'Gastarbeiter' effect, in this case making capital, instead of labour, the migratory factor.

We return to our comparison of gnp results within long-run closures. The gdp projection is identical for the DPR and Vincent closures (Table 6). The increase in real gnp in the Vincent closure relative to the DPR closure of .0453 (=.0927-.0474 -- see row 18 of Table 6) once again is principally accounted for by the contribution of the increased domestic share of capital. From equation (3.5),this contribution is $[S_A/(1-S_F)]q$. Hence the component of the increase in gnp in the Vincent closure relative to the DPR closure which is due to the differing changes in the domestic share of the ownership of the capital stock, from row 23 of Table 6 is

$$(3.8) \qquad .1964825(q_{Vincent} - q_{DPR}) = .1964825(0.6331 - .4036) = .0451 \text{ per cent}$$

(where .1964825 is the share of income to Australian owned capital in GNP). Other terms, as before, are of very minor importance.

How is the increased (Vincent vs DPR) local ownership of capital financed? In row 22 of Table 6 we see that in the Vincent closure consumption over the latent period falls by .0361 per cent relative to control, whereas in the DPR closure it rises by 0.0280 per cent. Thus the increase (relative to control) of 0.0927 per cent in local ownership in the Vincent closure is purchased at the expense of a fall in consumption of .0361 per cent. This is reflected in the fall of .1539 per cent in the average propensity to consume (APC) (row 15). In the DPR closure the much smaller gain in asset accumulation (.0038 per cent relative to control) is compensated for by a gain of .0280 per cent in real consumption over the latent period. The latter reflects the maintenance of an exogenous APC in the DPR closure.

The percentage differential k_F in foreign owned capital (relative to control) in year τ is

(3.9) $$k_F = k - Q^*q .$$

In the M081 data base Q* is 3 -- see Table 5. Hence from rows 2 and 23 of Table 6 we can calculate that

(3.10) $$[(k_F)_{DPR} - (k_F)_{Vincent}]$$

$$= - 1.6106 + 2.3020$$

$$= 0.6914 \text{ per cent.}$$

At a fixed level of capital inflow in the snapshot year, this higher foreign owned capital stock would require the generation of a higher balance of trade surplus in the snapshot year in the DPR closure. In the Vincent closure the balance of trade is exogenous, whereas an endogenous increase in the balance of trade surplus equivalent to 0.0014 per cent of GDP is generated in the DPR closure. However, the rates of capital inflow differ markedly between the closures.

The capital inflow is defined as the net change in the foreign ownership of Australian assets. It therefore may be computed either from the flow of payments side of the account, or from the asset side. The identity linking the two is

$$R^F + M - X = \pi Y^R - S ,$$

i.e.,

(3.11) $$R^F - (BT) = \pi Y^R - S ,$$

where R^F is rental payments to foreigners, (BT) is the balance of trade surplus, Π the capital goods price index, Y^R aggregate real investment, and S the nominal flow of saving, all in the snapshot year.

We now show that the calculated differentials between these variables in the two closures shown in Table 6 are consistent with (3.11). We start with the term R^F. The rental price of capital in both closures has to move equiproportionately with the capital goods price index in order to maintain the exogenous rates of return which are common to both closures. Hence the percentage change (relative to control) in nominal rentals payable to foreigners in the snapshot year is $(k_F + \pi)$. The difference between this value in the DPR and the Vincent closures is thus equal to

(3.12) $$[(k_F)_{DPR} - (k_F)_{Vincent} + \pi_{DPR} - \pi_{Vincent}]$$

(from (3.10) and row 5 of Table 6)

$$= 0.6916 + .3380 - .3374$$

$$= .06922 \text{ per cent.}$$

As can be deduced from Table 5, foreign rentals in the data base for year $\tau = 10$ represent 6.14823 per cent of GDP at market prices. The difference (3.12) in rental payments between the two closures thus represents (.006922 x 6.14823) = 0.04256 per cent of GDP. Given an incremental balance of trade surplus worth 0.0014 per cent of GDP in the DPR closure and zero in the Vincent closure, the above calculation suggests that foreign capital inflow on asset account in the DPR closure runs at the rate of (0.0426 - 0.0014) = 0.0412 per cent of GDP in the snapshot year faster than in the Vincent closure.

The gap between investment and domestic saving in τ is equal to net capital inflow on asset account. This gap is the RHS of (3.11), whose percentage change form is

(3.13a) (percentage change in capital inflow on asset account) $= \text{coeff}_1 \ (\pi + y^R) - \text{coeff}_2 \ s$,

where, from the data base (Table 5),

(3.13b) $$\text{coeff}_1 = \Pi Y^R/(\Pi Y^R - S)$$

$$= 24.43/(24.43 - 18.31)$$

$$= 3.9918$$

and

(3.13c) $$\text{coeff}_2 = S/(\Pi Y^R - S)$$

$$= 2.9918 \ .$$

Hence the percentage change in net capital inflow on asset account represented by the difference between the DPR and the Vincent closures is

(3.14) $$[\text{coeff}_1 \ (\pi_{DPR} - \pi_{Vincent} + y_{DPR} - y_{Vincent})$$

$$- \text{coeff}_2 \ (s_{DPR} - s_{Vincent})]$$

$$= 3.9918(.3380 - .3374 - .3998 + .0612)$$

$$- 2.9918 \ (.3494 - 1.0232)$$

$$= 0.6666 \text{ per cent} \ .$$

In the snapshot year data base the ratio of net capital inflow on asset account to GDP is 6.12/99.37 = 0.06159, so that the difference between the two closures due to differing capital inflow, expressed as a percentage of GDP, is 0.6666 x .06159 = 0.0411 per cent. This agrees, apart from rounding error, with the result obtained from the other side of the account.

3.2 Moving between the Closures

Columns 3 to 6 of Table 6 can be used to illustrate the relationship between two different closures of MO81. Results of one closure may be manipulated to give the results of another closure without repetition of the solution procedure which gave rise to the original results. The more similar the closures -- that is, the more nearly the partitions into endogenous and exogenous sets coincide -- the easier the process is. There are two possible reasons for proceeding in this way:

(a) Analytical : in order to gain an understanding of the crucial differences between two closures.

(b) Computational: it may often be easier to compute a solution from the results of a similar closure, than to compute the new solution from scratch.

We have both purposes in mind. Firstly we wish to highlight some differences between the Vincent and the DPR closures; secondly, we can illustrate on the miniature level the process whereby existing ORANI programs can produce results, which, after manipulation, implement a DPR style closure, even though these programs are incapable of directly implementing such a closure.

The basic theory may be found in DPSV (pp.246-7). Assume an ORANI result of the form

(3.15) $$z_1 = C z_2$$

is obtained, where C is a matrix of elasticities relating the endogenous variables, z_1, to the values of the exogenous variables, z_2. The particular composition of z_1 and z_2 determine which closure we have implemented. We can partition (3.15) as

(3.16) $$\begin{bmatrix} \tilde{z}_1 \\ u \end{bmatrix} = \begin{bmatrix} C_{11} & C_{12} \\ C_{21} & C_{22} \end{bmatrix} \begin{bmatrix} \tilde{z}_2 \\ v \end{bmatrix}$$

in such a way that $(\tilde{z}_2^T, u^T)^T$ is the vector of variables corresponding to the exogenous set in the closure we wish to arrive at.

Then

(3.17a) $$\begin{bmatrix} \tilde{z}_1 \\ v \end{bmatrix} = D \begin{bmatrix} \tilde{z}_2 \\ u \end{bmatrix}$$

where

(3.17b) $$D = \left[\begin{array}{cc} (C_{11} - C_{12} C_{22}^{-1} C_{21}) & C_{12} C_{22}^{-1} \\ \hline -C_{22}^{-1} C_{21} & C_{22}^{-1} \end{array}\right] .$$

An intuitive explanation can be gleaned directly from Table 6. Assume that we wish to move from the DPR closure to the Vincent closure. The results for these in columns 1 and 2 are alternative solutions of the same M081 equations; however, to achieve each closure, different variables have been set exogenously. In column 1 (rows 15,17) we see that in the Vincent closure the endogenous values of f_c and $-\tilde{h}$ are -.1539 and -.3416. If these values were given to the exogenous variables f_c and $-\tilde{h}$ in the DPR closure and the results of these shocks were added to the results of the one per cent tariff shock in that closure, the Vincent closure response to a one per cent tariff shock would be obtained. Looking at columns 2,4, and 6 of the Table, we see that they sum to column 1.

The required values for f_c and $-\tilde{h}$ could also have been found from the results of the DPR calculation alone, by finding values of f_c and $-\tilde{h}$ which sterilize the effects of the tariff shock on the balance of trade and the ratio of consumption to investment (f_r). Thus

(3.18a) $-.2271\ \tilde{h}\ -.4950\ f_c\ =\ -.0014$ (Balance of Trade, $\tilde{bt}$)

and

(3.18b) $-.9313\ \tilde{h} + .8393\ f_c\ =\ -.4472$ (consumption/investment ratio, f_r)

jointly yield $-\tilde{h} = -.3416$ and $f_c = -.1539$. Hence the Vincent and DPR simulated responses of a given mutually endogenous variable to a tariff shock will be identical if, and only if, the fourth and sixth columns of the appropriate row sum to zero. Another way to interpret Table 6 is as showing how the difference between a Vincent and a DPR result may be divided into the effects of a changed theory of investment, and of a changed theory of consumption. From columns 4 and 6 of Table 6 we see that in most cases, these effects are quantitatively important. Real GDP, in which the two effects are exactly offsetting in the MO81 data base, is an exceptional case.

To translate results from the Vincent to the DPR closure it would have been necessary to obtain elasticities of endogenous variables with respect to f_r and (bt), as well as to the power of the tariff. Then the process would simply reverse the transition outlined above. In Section 4 of this paper a similar method is used to convert standard ORANI results into a form consistent with a long-run closure based on DPR.

3.3 Two Dimensions of Welfare

Part of the motivation for adding long-run closure equations to ORANI arose from questioning whether GDP was an appropriate measure of welfare. The objection was that GDP as sum of factor incomes included some income accruing to foreigners.

Because it excludes this component, GNP would seem to be a better measure. However, although GNP is a better measure of Australians' income at a point in time, it does not reflect, except indirectly, the stock of wealth held by Australians. We have found it conceptually helpful to postulate two measures of welfare, namely, accumulated real consumption over the τ years leading up to the solution year, and the amount of domestically owned capital in that year. (At the risk of a minor inconsistency, we continue to work without discounting for pure time preference, i.e. $D^* = 0$.) Crude as these measures are, they make explicit the fundamental trade-off between consumption in the present, and the opportunity for consumption in the future.

Considering these two measures as the axes of prosperity, it is possible to construct a graph showing the various combinations of g^* and q+k which result from shocks to the exogenous variables. Figure 5, which is based on results from the DPR closure reported above, is such a chart. The size of the shock has in each case been adjusted so that a unit distance from the origin is attained. The purpose is to focus on the direction of the effect of a shock rather than its magnitude.

The diagram can be summed up by the observation that the majority of points lie in a cluster in the north-east quadrant. These shocks may be considered beneficial to local residents. Most of the remainder are clustered in the south-west quadrant about the extension of a line connecting the origin to the first group. This second group of shocks could be considered injurious to local residents. The only remaining points correspond to shocks f_c in the APC and t_2 in the tariff on good 2.

It is possible to explain this striking result as follows. Imagine that some external shock has an effect on GNP. Assume the APC remains unchanged. Then, in percentage change form:

(3.19) $c^R = gnp = c - cpi$ (T31)

(3.20) $q+k = C^*(s-\pi)$ (T32),(T33)

(3.21) $s = c$ (T34)

and

(3.22) $g^* = Ac^R$ (2.20), Section 2.4

Assuming $cpi = \pi$, given our parameter file (see Table 3) we may deduce

(3.23) $g^* = A(q+k)/C^* = 1.756(q+k)$.

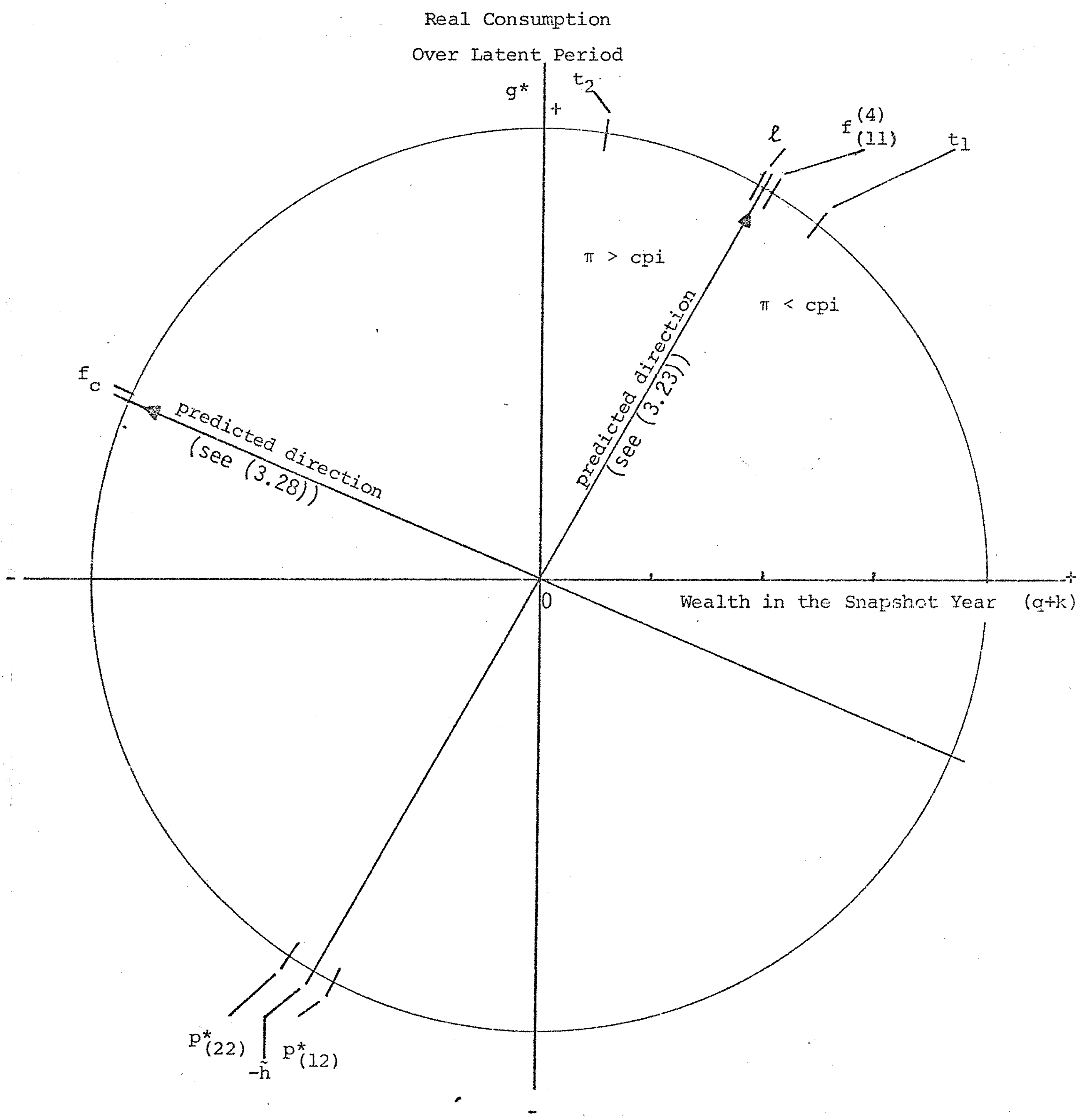

Figure 5: Direction in Prosperity Space of Effects of Different Shocks

Under the hypothesis of equality between the consumer and producer goods price indices, all the shocks should lie along the graph of (3.23), which is shown in Figure 5 as the line running through the origin from south-west to north-east. In fact, the shocks differentially affect the two price indices, so that they lie along rays whose directions are indicated in Figure 5 by the intersections of the short line segments with the unit circle.

Evidently the point f_c, corresponding to variation in the APC, cannot be expected to lie on the graph of (3.23), since in constructing it we assumed that the APC remained unchanged. The dispersion of the other points can be explained purely by the divergence between cpi, the consumer price index, and π, the investment price index. For example, referring to our data base (Table 5) we see that the tariff on good 2 falls more heavily on capital goods than on household consumption. This leads to π exceeding cpi and thus, for a given nominal amount of saving, less real investment can be made. Therefore this tariff effect lies above and to the left of the trend line (3.23). The tariff on good 1, contrarywise, favours investment, and lies to the right. Similar reasoning can explain the dispersions of $p_{(12)}$ and $p_{(22)}$, the foreign prices of imported goods 1 and 2.

As previously noted, t_2 — the tariff on good 2 — is the only shock to cause gnp (and hence c^R) to move in the opposite direction to gdp. This may be linked to its greater distance from the π = cpi line. Recall that, in the DPR closure, capital is assumed in elastic supply while employment is fixed. Consequently wages fall relative to rentals as gdp declines. The exogenously fixed rates of return tie π to the capital rentals (equation (T24), Table 1). Hence cpi, which is largely a weighted average of wages and capital rentals, must fall relative to π. An exogenous increase in employment, ℓ, again causes a fall in wages relative to rentals. Both t_2 and ℓ appear on the unit circle above and to the left of the π = cpi line.

In symmetrical fashion we may suppose that if a change in f_c had zero effect on gnp and

(3.24)	$c^R = f_c + gnp = f_c = c - cpi$		(T31)
(3.25)	$q+k = C^*(s-\pi)$		(T32), (T33)
(3.26)	$s = c - f_c/(1-F_c)$		(T34)
(3.27)	$g^* = Ac^R$		(2.20), Section 2.4

and assuming π = cpi,

then

(3.28) $$g^* = \frac{A(F_c-1)}{F_cC^*} = -.429(q+k).$$

The graph of (3.28) intersects the unit circle almost precisely at the point occupied by the exogenous variable f_c. However, our initial assumption that GNP is unaffected by changes in the APC, although an acceptable approximation for this particular data base and parameter file, is not likely to apply widely. In general, the effect of an increase in F_c upon GNP is the sum of two factors -- the effect on GDP, and on the share of capital rentals accruing to Australians. Some prior estimate of the net effect is necessary to perform calculations such as those above.

It is sometimes possible, by means of simple hand calculations, to predict the effect of a shock on the highly complex ORANI model with a surprising degree of accuracy (see e.g., Dixon, Parmenter and Powell (1983)). These Back-of-the-Envelope or BOTE calculations, although by their nature approximate, prove a handy tool for ORANI users, not only in checking or predicting results, but also in providing an insight into the workings of the model. The methods outlined above require only an estimate of the effect on GNP of some shock, and the simplifying assumption that the consumption and investment price indices move together, to predict the extents to which an increase in GNP will be taken out as increases in consumption and/or domestic investment. Even if the GNP effect is not known, the ratio of percentage changes in g* and q+k may still be determined.

3.4 Sensitivity of DPR Results to Shock-induced Variation in the APC

By holding the APC exogenous, normally at zero, we announce our relative ignorance of its long-run determinants, or the difficulty of endogenizing them. To the extent that our simple proportional consumption function is a misspecification of reality, administration of any shock to ORANI should be accompanied by some change to the APC. The actual magnitude of this shock remains unknown; this section uses prior restrictions on the extent of variations in the APC to gauge their maximum possible influence on the rest of the system.

On the basis of an exogenous APC, the previous section establishes, as a rule of thumb, that shock-induced variations in GNP will be taken out as variations in consumption and wealth, and that measured in percentage change form these increments will bear a constant ratio to each other regardless of the nature of the original shock. Deviations from this rule depend solely on the differential movement of the consumer and investment goods price indices.

ORANI results are a linear approximation, in percentage change form, to a non-linear system in level magnitudes. Iteration of the ORANI solution procedure can produce a result to any desired degree of accuracy; from experience we know that the first order result is accurate for small changes (DPSV). The linear nature of the ORANI results means that the effect of a combination of shocks is represented as the sum of the effects of individual shocks.

Suppose, then, that some shock brings about an increase in GNP and so in consumption and the domestically owned capital stock. Even bearing in mind compositional effects, we can be confident that while our resultant position may not lie on our predicted line on the (q+k, g*) diagram, it will at least be in the positive quadrant. The next step is to suppose, as a result of this welfare increase, society revises its consumption-saving decision. This change may be represented as a shock, f_c, to the APC. The net result of these changes, may, in accordance with the linear nature of an ORANI solution, be represented as a simple vector sum of the original shock and the induced shock in f_c. The range of possible outcomes, even if we do not know the f_c shock, may be represented as a line in (q+k, g*) space, passing through the point arrived as as result of the external shock alone, and bearing the slope

$$\frac{\partial g^*}{\partial f_c} \Big/ \frac{\partial (q+k)}{\partial f_c},$$

where $\partial g^*/\partial f_c$ and $\partial (q+k)/\partial f_c$ are taken from our simulation result. (The simulation result with the unit shocks, it will be remembered, may be considered either as a matrix of elasticities of levels magnitudes, or as the Jacobian of a system in percentage change form.)

Figure 6 uses results for the DPR data base on the effects of an f_c shock and a tariff shock on good 2; it is obviously similar in conception to the textbook diagram of a possibilities frontier. Measured in the appropriate metric, the distance between the origin and the frontier along any ray is constant, and represents the differential in opportunities for 'prosperity' generated by the unitary tariff shock. The results of the simulation (from Table 6) were:

Responses (percent)	Shocks	
	1 per cent t_2	1 per cent f_c
q+k	.0038	-1.3581
g*	.0280	.6075

Consequently the welfare possibilities or prosperity frontier is a line passing through the point (.0038, .0280) with slope .6075/-1.3581 = -.4473.

Consider now the position on the frontier generated by the tariff shock when f_c is set to zero. This will be referred to as the 'endowment point'. Simple arithmetic determines what values of q+k, g* and f_c correspond to the endowment point and the intercepts, of the possibility frontier with the q+k and g* axes; these ordered triads are

$(q+k, g^*, f_c)$	
(0, .0297, .0028)	g* axis intercept
(.0664, 0, -.0461)	q+k axis intercept
(.0038, .0280, 0)	endowment point.

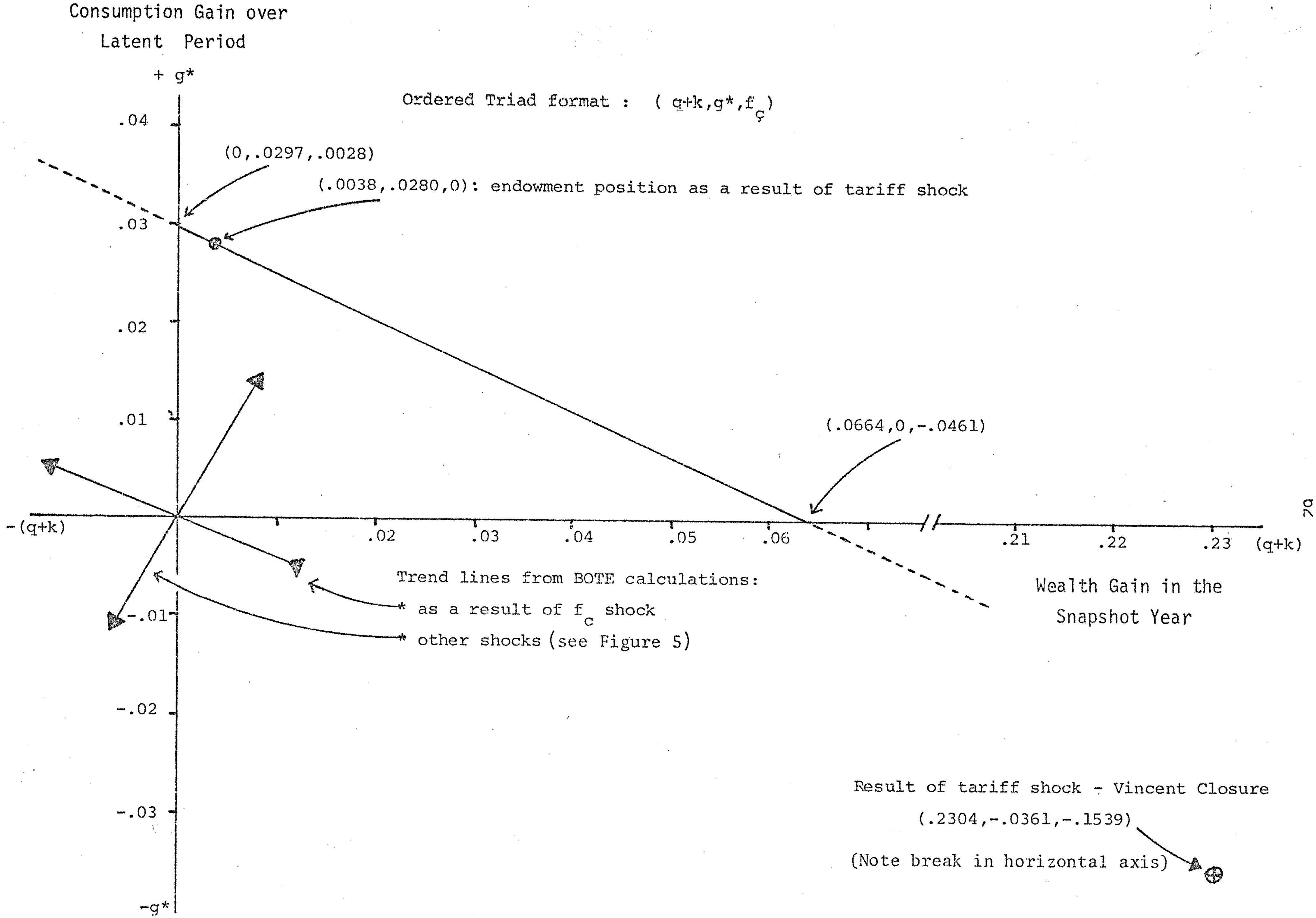

Figure 6: Possibilities Frontier in Prosperity Space

The next step is to make the assumption that society will behave as a single consumer which considers both QK and G* to be normal goods. In that case only that part of the possibility frontier which passes through the positive quadrant of (q+k), (g*) space may be considered as a potential choice set. Consequently, the shock induced variation in f_c is limited to the region between .0028 and -0.0461.

A different assumption with identical effect might be that the government, in response to some shock, or in conjunction with a policy-induced shock, so wished to adjust aggregate consumption, via various instruments, that the welfare gain did not result in a decrease in either QK or G* but instead resulted in at least some increase in each. The same limits on f_c would follow.

Plausible as these assumptions are, it is not intended that the limits upon f_c be interpreted as inflexible boundaries. Rather, the aim is to establish, through the width of the plausible interval of f_c values, a standard of measurement for the sensitivity of simulation results to changes in f_c induced by the tariff and other shocks.

As an example we can test the sensitivity of our simulation result that the 1 per cent power of the tariff shock produced a .0474 increase in GNP. Referring to Table 6 we see that a one percent f_c shock causes a .0294 per cent increase in GNP. However, the width of the plausible f_c interval, relative to the 1 per cent tariff shock, was only -(.0028 + .0461) = -.0489. This variation in f_c will only produce -.0489 x .0294 = -.0014 percent variation in GNP. Therefore the ratio of the f_c

induced variation to the tariff-induced variation is (-.0014/(.0474)) = -.0303. So variation in the APC could at most allow the projected percentage gain in GNP to vary by 3 per cent from the value obtained on the assumption of a constant APC. Our initial projection of gnp is at least 97 percent accurate, with respect to shock-induced variation in the APC.

Retracing our steps, the ratio of f_c-induced to tariff-induced variation is

$$\text{(3.29)} \qquad \frac{\partial gnp}{\partial f_c} \left\{ \frac{\dfrac{\partial(q+k)}{\partial\ t_2}}{\dfrac{\partial(q+k)}{\partial\ f_c}} - \frac{\dfrac{\partial g^*}{\partial t_2}}{\dfrac{\partial g^*}{\partial f_c}} \right\} \Bigg/ \frac{\partial gnp}{\partial t_2} \quad .$$

Of the terms differenced within the large parentheses, the first is the value of f_c which produces the g* intercept on the prosperity frontier, while the second is the value of f_c producing the q+k intercept. The bracketed term as a whole, therefore, is the width of the 'plausible' interval for f_c. The two terms jointly constituting the numerator of (3.29), therefore, give an interval for the plausible range of variation which might be indirectly induced in gnp by t_2, via changes in the APC. The denominator of (3.29) gives the direct impact on gnp of a change in t_2, holding the APC constant. The ratio (3.29) thus gives a sensitivity measure indicating the robustness of the tariff results to departures from exogeneity of the APC. By substituting other variables for gnp and t_2 in (3.29), we may deduce, from the same simulation results, the reliability of various endogenous changes to various shocks. Some results are shown in Table 8.

Table 8 - Sensitivity of MO81 to Variations in the Average Propensity to Consume in the Tariff Simulation

A. Ratios of Variation in Endogenous Variables Induced by Maximum Plausible Variation in the APC to Primary Variation in these Variables induced by the Tariff Shock

Endogenous Variables	Exogenous Variables				
	t_1	t_2	ℓ	$-\tilde{h}$	$p^*_{(22)}$
gnp	.0384	.0303	.0356	-.0362	-.0450
k	-.1667	-.0232	.1938	-.4414	-.1441
m	-.4164	-.1505	1.5061	-.3846	11.696
y	-.1667	-.0232	.1938	-.0317	-.1441
z_1	-.2753	.0493	-.3103	-.3626	.5159
z_2	-.2473	.1025	.6323	-.3738	2.1592

B. Elasticity Data Underlying Part A of this Table*

	f_c	t_1	t_2	ℓ	$-\tilde{h}$	$p^*_{(22)}$
q+k	-1.3581	.0243	.0038	.1838	-.0515	-.1071
g*	.6075	.0318	.0280	.3328	-.0861	-.1638
gnp	.0294	.0538	.0474	.5640	-.1459	-.2275
k	.1901	-.0801	-.3998	.6701	-.0772	-.4598
m	.8525	-.1438	-.2769	.3867	-.3982	.0282
y	.1901	-.0801	-.3998	.6701	-1.0503	-.4598
z_1	-.4770	.1225	-.4728	1.0503	.2363	-.3222
z_2	.6865	-.1950	.3275	.7417	-.3299	.1108
"Bracketed"	n.a	.0702	.0489	.6832	.1796	.3485

*The figures above are elasticities of endogenous variables (left) with respect to exogenous variables (top) in the DPR closure (f_c exogenous); they form the data for the results shown above. The bottom line is the bracketed term in displayed formula (3.29) in the text -- that is, the width of the plausible interval for f_c. n.a. = not applicable. $\tilde{h}$ is defined in the footnote to Table 6.

Table 8A shows the effect on a given endogenous variable of the plausible variation in f_c induced by a given exogenous shock, as a fraction of the direct effect of that shock. For example we see that variation in f_c, following a change to the labour supply, ℓ, could affect the activity level of industry 1, z_1, by 31% of the direct effect of the change in ℓ on z_1. The signs of results in table A, while not important in this context, indicate (if positive) that a one per cent increase in f_c causes an effect - on a given endogenous variable - of the same sign as a one per cent increase in the exogenous variable. This can be seen from Table B, which is also of use in understanding the magnitudes displayed in Table A. To illustrate, we see from Table A that induced variation in the APC could account for 11 times the direct effect on the foreign currency value of imports(m), of a shock to the foreign price of the import competing good 2, $P^*_{(22)}$. Thus, results of this particular experiment rely heavily on our assumptions regarding the APC. Table B shows us why. A one per cent increase in $P^*_{(22)}$, holding the APC constant, causes .1071 per cent and .1638 per cent decreases in QK and G* respectively. But if, instead of holding the APC constant, we enforced only the weaker restriction that the welfare loss shows up as <u>some</u> decrease in <u>both</u> QK and G*, we would implicitly allow a range of variation in the APC of .3485 per cent (see bottom right Table B). Going to the first column, we see that for a one per cent increase in the APC, .8525 per cent extra imports are sucked in. So the plausible variation of .3485 in f_c would correspond to a variation in the foreign currency value of imports of .34 x .85 = .29 per cent. Looking at the last column we see that our model economy must have a near-unitary elasticity of import demand, for a rise in the foreign price of good 2 affects the total bill by only .028 as much. Thus the indirect effect (.29 per cent) is around 11 times the direct effect (.0282), as we see in Table 8A.

A value in Table 8A of less than .5 in absolute value shows that the indirectly caused variation could be no more than half the directly caused variation in a given endogenous variable, with respect to some exogenous shock. The generally low absolute values are therefore encouraging, as they indicate the assumption of a fixed APC is not too crucial, in most cases. Further, calculations such as those presented in Table 8A highlight those cases where simulation results will be most sensitive to the form of consumption modelling adopted.

The plausible interval for f_c (with regard to the 1 per cent tariff shock) is quite narrow. If it were mapped into levels terms, the APC (initially set at .803) would lie between .7998 and .8037 . Yet, over a short period of time, fluctuations far greater than this are commonly observed. These fluctuations are caused by short-term mechanisms not reflected in ORANI and so must be regarded merely as 'noise'.

Finally, the reasoning above applies also to shock-induced decreases in welfare. The normality supposition again limits f_c to lie between its intercept values on the (q+k) and g* axes. The position arrived at in (q+k,g*) space as a result of the Vincent closure is also shown in Figure 5. Not only is it outside the positive quadrant but it also lies well off the possibilities frontier. This reflects again, the different account given by the Vincent closure of consumption and investment behaviour.

3.5 The Role of the Length of the Long-Run τ and the Importance of Thrift

In DPR's long-run closure of MO81, it is supposed that, following a shock in year 0, the adjustment of real saving takes place over the τ years prior to the solution year. Thus, in the case of an increase in saving, the effect on the domestic share of the capital stock in year τ is larger for larger values of the unknown parameter τ (the length of the long run). This effect is implemented through equations (T32) and (T33) of MO81 (see Table 6), which, condensed together, give:

$$(3.30) \qquad q + k = C^*(s-\pi) \quad ,$$

where C* is a function of the depreciation rate, D, the control path growth rates of real saving and of domestically owned capital stocks, and of τ. The coefficient C* is an increasing function of τ.

Three of the most distinctive features of the DPR closure of MO81 are that:

(1) rates of return are exogenous and capital is mobile;

(2) consumption is related to GNP rather than being exogenous;

(3) GNP is related to savings.

The third feature is crucially related to the value of τ. In investigating the sensitivity of results to variation in τ we are also investigating the importance of the relation between saving and domestically owned capital stock. This is because the only other role of τ in the DPR closure is in calculating the change, g^*, in real consumption over the previous years (see equations (2.16) to (2.19)). While g^* is endogenous in the DPR closure, this role does not allow a change in τ to affect the solution values of any other endogenous variables. Thus by experimenting with different values for τ we are concentrating purely on the effect of savings upon domestically owned capital, and hence upon GNP and consumption.

To gain information on the sensitivity of results to differing values of τ, a simulation almost identical to the central simulation reported in Table 6 was run. The average propensity to consume was held exogenous as in the DPR closure and the same data base was used. The only difference was that τ was set to 2 years instead of 10.

Results for $\tau = 2$ and $\tau = 10$ are reported in Table 9. As usual the figures represent the cdcs percentage changes in selected endogenous variables with respect to selected exogenous variables. The exogenous variables are T_2, the power of tariff on the import-competing good (good 2); aggregate employment L; and the average propensity to consume F_C. Looking at the first two columns we see that the results for $\tau = 10$ and $\tau = 2$ are very similar except for the variables (q+k) and g^*. The beneficial effect on GNP and hence savings is hardly translated, when $\tau = 2$, into greater domestic holdings of capital stock and thus greater domestic income. So the GNP rise is less when $\tau = 2$. Given an exogenous average propensity to consume (APC), consumption therefore will also be less. But apart from the variables (q+k) and g^*, the effect is hardly noticeable. Regardless of the value of τ, foreign holdings of capital, and the capital stock in general, are very responsive to the tariff shock. The responsiveness of the total capital stock to the value of τ, however, is very slight. Thus the 'Gastarbeiter' effect operates equally in both cases.

Table 9 - Sensitivity of Principal Endogenous Variables in the DPR Closure of MO81 to the Length of the Long Run : Comparison of τ = 2 and τ = 10 Years (a)

τ	Endogenous Variables	Exogenous Variables: Power of Tariff t_2	Overall Employment ℓ	Average Propensity to Consume f_c
2	z_1 activity level industry 1	-.4725	1.0654	-.5886
10		-.4728	1.0503	-.4770
2	z_2 activity level industry 2	.3270	.7200	.8471
10		.3275	.7417	.6865
2	k aggregate capital stock	-.4000	.6641	.2346
10		-.3998	.6701	.1901
2	gnp	.0467	.5314	.2702
10		.0474	.5640	.0294
2	q+k locally owned capital	.0014	.0657	-.4855
10		.0038	.1838	-1.3581
2	g* consumption gain over period $(0,\tau)$ (b)	.0364	.4147	.9911
10		.0280	.3328	.6075

(a) The numbers in the body of the table are the percentage deviations of the endogenous variables from their control path values in year τ as the result of a sustained shock, commencing in year 0, of one per cent in the indicated exogenous variables (relative to their control paths).

(b) In this computation time-preference discounting was ignored, i.e., D* in equation (2.12) was set to zero.

The result of the operation of the relation between saving and the domestically owned capital stock may be discerned from column 3 of Table 9. This relationship may simply be described as a weak damper, or weak negative feedback on the relation between variations in the average propensity to consume and in other endogenous variables. For example, a rise in the APC directly raises consumption overall, and hence affects many other variables. Secondarily it directly reduces saving, leading to lower values of the domestically owned capital stock, domestic income, and consumption. But this second indirect effect is much smaller than the first, although opposite in sign. When this negative feedback is reduced, by setting $\tau = 2$, the net effect of a change in the average propensity to consume is magnified in the case of all variables reported in Table 9 except (q+k).

We may conclude that the long-run closure results are not highly sensitive to the setting of τ except when there is a shock to the APC, or if we are interested in the variables (q+k) and/or g*. Therefore, for many purposes the strength of the relation between domestic saving and the domestic share of the capital stock is not crucial. However, for welfare analysis, (q+k) and g* are crucial variables (see Section 2.4 above), and hence the value of τ is important from this point of view.

So much for the <u>explicit</u> role of the parameter τ. We must recognise that τ plays an important implicit role in that all basic parameter values and even the economic relevance of the long-run closure itself are highly conditional on its chosen value, although the former are not computationally related to the setting of τ in a simulation. If, for example, the export elasticities had been adjusted simultaneously with the changing of τ from 10 to 2, quite different results might have emerged. The theory underlying the long-run closure does not recognise corner solutions brought about (say) by the failure of depreciation to eliminate, with sufficient speed, capital stock made redundant by the shock. Thus, to be plausible, the selected value of τ must allow sufficient time for natural decay of redundant capital to bring about any shrinkage made neccessary by the shock. In a world in which the growth rates over $[0,\tau]$ of all industries are expected to be positive, this would not seem to be a problem, at least in the case of small to moderate shocks, and values of τ of (say) 5 years or more.

4. IMPLEMENTATION OF THE DPR SCHEME IN ORANI PROPER

The problem of implementing a DPR-style long-run closure of ORANI falls into three parts. Firstly, account must be taken of the extra structural detail in ORANI vis-a-vis MO81. This is done in Subsections 4.1 - 4.3. Secondly, an appropriate solution procedure must be found to solve the augmented ORANI. This is discussed in Subsection 4.4. Thirdly, some additional data collection may be necessary. Preliminary consideration to this issue is given in Subsection 4.5.

4.1 Elaboration of the DPR Investment Theory

In DPR and in this paper, it has been assumed that depreciation rates, the foreign shares of the capital stock, and the creation costs of units of capital are uniform across industries. It seems appropriate to relax these assumptions when incorporating the new equations into ORANI proper. Indeed, depreciation rates and the price of a unit of capital are already disaggregated in standard ORANI. Allowing Q_j (the domestic share of the capital stock in industry j) to vary across industries leaves open the possibility that a shock which bears most heavily on predominantly Australian owned industries will have different effects than one which primarily influences those industries where foreign equity is relatively high. Equation (3.20) would then become

(4.1) $$q_j + k_j = C_j^* (s_j - \pi_j) \qquad (j = 1,113),$$

where s_j is to be interpreted as the percentage change in the money value of domestically financed investment in industry j, and π_j is the percentage change in the investment goods price index for industry j.

Variation of Q_j across industries implies a difference between the behaviour of local and overseas investors. Thus, in addition to our theory of industry investment,

(4.2) $$y_j = k_j ,$$

which does not identify ownership, we need a theory to explain the distribution of domestically sourced investment. The percentage change formula,

(4.3) $$s_j - \pi_j = W_{1j}k_j + W_{2j}q_j + W_{3j}b^* + W_{4j}y_j + W_{5j}f_{sj}$$

where

W_{1j}, W_{2j}, W_{3j}, W_{4j} and W_{5j} are parameters

and

f_{sj} is an exogenous shift variable,

is flexible enough to encompass several such theories -- the particular theory chosen will vary between industries. Aggregate locally sourced investment, it should be noted, is determined by our modelling (see below) of government and private expenditure and the partition of each of these into consumption and investment. The endogenous variable b* is necessary, then, to scale local industry investments so that their aggregate tallies with this modelling.

To illustrate some possibilities among several, imagine first that local investors in all industries follow the pattern of total investment. Then

(4.4) $$S_j = B^* \Pi_j Y_j ,$$

where

(4.5) $$B^* = (\sum_j S_j) / (\sum_j \Pi_j Y_j) .$$

In this case the local share in investment in any particular industry j is equal to the local share in real total investment over all industries. In percentage change form:

(4.6) $s_j - y_j = \pi_j + b^*$ (i.e., $W_{1j}=0$, $W_{2j}=0$, $W_{3j}=1$, $W_{4j}=1$, $W_{5j}=0$).

Such behaviour, if it took place over all industries over many periods, would lead to convergence of the Q_j's.

On the other hand, we might wish to assume that the observed dispersion across industries of local ownership shares reflects some taste on the part of local investors to invest in particular industries. To model this, let

(4.7) $S_j = B^* Q_j Y_j \Pi_j$ $j=1,\ldots,H$

which implies that the flow of locally financed investment in industry j is proportional to the local share in that industry, and to the total flow of investment into that industry. The constant of proportionality is that value of B* which ensures that the domestic investment budget constraint is satisfied. This constraint merely states that the total monetary value of all locally sourced investment must be equal to domestic saving. Thus, if S_f is overseas investment by Australians,

(4.8) $S = \sum_j S_j + S_f$ (domestic investment budget constraint).

B* must take a value compatible with this constraint. Thus, in percentage change form B* becomes an endogenous variable b*:

(4.9) $s_j - \pi_j = b^* + q_j + y_j$ (i.e. $W_{2j}=W_{3j}=W_{4j} = 1$, $W_{1j}=W_{5j}=0$).

If Q_j for some industry is to remain unaffected by the shock:

(4.10) $s_j - \pi_j = \frac{1}{C^*} k_j$ (i.e. $W_{1j} = 1/C^*$, other $W_{ij} = 0$).

Where industries have varying parameterisations, W_{nj}, it is difficult to place any economic interpretation on B*, except to say that it represents the influence on any industry investment theory of the aggregate locally sourced investment constraint. Alternatively, in the parlance of linear programming, it may be regarded as the "slack" variable which ensures satisfaction of the constraint. Accordingly, some sizeable subset of the W_{3j} must be non-zero.

The variable S_f was introduced above in order to accord with reality and with the ORANI database. The explanation for variations in S_f is initially bound up with the performance of overseas economies which are not modelled in ORANI. Therefore overseas investment by Australians effectively is taken to be exogenous. To preserve homogeneity we allow the Australian dollar value of overseas investment by Australians to depart from its control path value in year τ by the same percentage as the real value of investments made locally; i.e, we assume

(4.11) $s_f = s$,

where

s_f = percentage change in \$A value of investment overseas by Australian residents;

and

s = percentage change in \$A value of all investment financed by Australians.

4.2 Modelling Domestic Income in ORANI

The MO81 specification of GNP is:

(4.12) GNP = Wages + Tariffs + Q x (Capital Rentals).

A similar specification may be developed for ORANI. From the income side, nominal GDP at market prices is:

(4.13) GDP = factor payments + other cost tickets + sales taxes + tariffs - export subsidies.

To obtain from this a measure of GNP, we subtract the net rentals on factors owned by foreigners.

(4.14) $$GNP = GDP - \sum_j (1-Q_j)\, P_j K_j + \Phi P_f K_f + (BI) \quad ,$$

where Q_j = locally owned share of capital stock in industry j,

P_j = rental price of capital stock in industry j,

K_j = capital stock in industry j,

Φ = the exchange rate,

P_f = average foreign rental price of capital,

K_f = foreign capital stock owned by Australians,

and

(BI) = a balancing item.

BI — the balancing item — is necessary to account for extraordinary insurance payments, net transfers overseas (such as aid), and withholding taxes. Assuming BI is small we may safely model it as:

(4.15) $$BI = F_{BI} \, GNP ,$$

where F_{BI} is an exogenous shifter variable.

4.3 Partition of GNP into Domestic Expenditures

Within the ORANI framework domestic income may be disposed of in four ways:

1. as household consumption (C^R);
2. as government consumption G^R -- roughly the total of "other demands";
3. as investment by households in private enterprise dominated industries (where investments are expected to yield a cash return in the future);
4. as investment in government dominated industries (where although these investments may yield some cash return, their primary purpose is to yield a stream of government services in the future).

Although all four expenditures are at the expense of the consumer, he/she is only allowed to determine (1) and (3) in accordance with the residual part of GNP left when (2) and (4) have been subtracted. That is, government consumption and investment are modelled exogenously to the householder's consumption/saving decision.

On the other hand, the amount of government consumption may influence the householder's desire to consume; government and private consumption, it may be supposed, are imperfect substitutes. It is the purpose of this section to suggest a means of capturing this effect. Secondly, we aim to model the intertemporal substitution implicit in the consumption/saving decision, albeit in a simple way.

We represent aggregate consumer behaviour by a single consumer choosing between present consumption and an increase in wealth. Let the representative agent's utility be

(4.16) $U_1 = U_1$ (effective consumption, effective wealth next period)

where

effective consumption = U_2 (private consumption, government consumption)

and

effective wealth = U_3 (private wealth, government wealth).

Wealth, in turn, is related to investment by

(4.17) $W_{t+1} = W_t$ (1-Depreciation Rate) + Investment,

where here the depreciation rate is an appropriate economy-wide average. Denoting

C^R = real private consumption,

G^R = real government consumption,

$\tilde{S}^P$ = real private investment by Australian residents,

W^P = privately owned wealth,

$\tilde{S}^G$ = real government investment,

W^G = government wealth,

Θ, P_2, Π^*, P_4 = appropriate price indices,

D_1, D_2 = depreciation rates,

and choosing Cobb-Douglas forms, the consumer's problem may be formally stated as follows. Choose $\tilde{S}^P$, C^R to maximize U, where

(4.18) $$U = \left\{(C^R)^{\alpha}(G^R)^{(1-\alpha)}\right\}^{\mu}\left\{[(W^P(1-D_1) + \tilde{S}^P]^{\Theta}[W^G(1-D_2) + \tilde{S}^G]^{(1-\Theta)}\right\}^{(1-\mu)}$$

(in which α , μ and Θ are parameters), subject to

(4.19) $$C^R\Xi + G^R P_2 + \tilde{S}^P_{\Pi}* + \tilde{S}^G P_4 - GNP = 0.$$

The Lagrangean is

(4.20) $$L* = U + \lambda[GNP - C^R\Xi - G^R P_2 - \tilde{S}^P\Pi* - \tilde{S}^G P_4].$$

The first order conditions are (4.19) and

(4.21) $$\partial L*/\partial C^R = (\alpha\mu U/C^R) - \lambda\Xi = 0,$$

and

(4.22) $$\partial L*/\partial\tilde{S}^P = U(1-\mu)\Theta/[W^P(1-D_1) + \tilde{S}^P] - \lambda\Pi^* = 0.$$

Thus

(4.23) $$\Xi C^R = \frac{\alpha\mu\Pi*}{(1-\mu)\Theta}[W^P(1-D_1) + \tilde{S}^P].$$

We also need to identify aggregate investment by Australian residents and government investment as the Australian components of investment in two exhaustive subsets of industry, namely, J (the set of industries dominated by private enterprises) and its logical complement:

(4.24) $$\tilde{S}^P = \left[\sum_{j\in J} S_j + S_f\right] / \Pi*$$

(4.25) $$\tilde{S}^G = \left[\sum_{j\notin J} S_j\right] / P_4 .$$

The two types of wealth may be identified in similar fashion:

$$(4.26) \qquad W^P = \left[\sum_{j \in J} Q_j K_j \Pi_j + K_f \Pi_f \Phi \right] \Big/ P_5$$

and

$$(4.27) \qquad W_g = \left[\sum_{j \notin J} Q_j K_j \pi_j \right] \Big/ P_6 \qquad ,$$

where P_5 and P_6 are two more appropriate price indices.

The value of $\alpha\mu/[(1-\mu)\Theta]$ may be drawn from our data base. In calling this value F^*_{c0} we recognize that although a consumption-related parameter, it is no longer the average propensity to consume (F_c) defined in M081. As in M081 we shall explore the consequences of variations in this 'parameter', denoting it by F^*_c (without the second subscripts when so treated). This will enable us to test the sensitivity of our results to our assumed theory of consumption behaviour. Our consumption function then becomes:

$$(4.28) \qquad C^R \Xi = F^*_c(W^P(1-D_1) + \tilde{S}^P)\Pi^* \ .$$

To implement this, substitutions for W^P, and $\tilde{S}^P$ are made using (4.26) and (4.24).

Our aim is to add to the existing ORANI framework, the equations shown in levels form in Table 10, and in percentage changes in Table 11.

4.4 A Solution Procedure for Augmented ORANI

As intimated earlier, rather than modify existing ORANI programs to include new equations, we intend to use a backsolution

Table 10 - Levels Forms of Equations for Add-on Long-run ORANI Module

(1)	$GNP = GDP - \sum_j (1-Q_j)P^k_j K_j + \Phi P^k_f K_f + (BI)$	National Income
(2)	$(BI) = F_{BI} GNP$	Balancing Item
(3)	$C = F^*_c \Pi^* \beta^*$	Consumption function
(4)	$GNP = C + G + S$	Disposition of GNP
(5)	$Q_j K_j = F_j(S_j/\Pi_j)$	Relation between Australian wealth and Australian saving
(6)	$K_f = F_f(S_f/(\Pi_f \Phi))$	Overseas ownership of capital by Australian residents
(7)	$S_j/\Pi_j = H_j(Q_j, K_j, Y_j, \text{shifters})$	Industry pattern of investments by Australian residents
(8)	$S_f \doteq F_{5f} S$	Property of Australian residents to invest overseas
(9)	$S = \sum_j S_j + S_f$	Saving-investment identity for Australian residents
(10)	$\beta = [\sum_j Q_j K_j \Pi_j + K_f \Pi_f \Phi]\Pi_\beta$	Real asset holding of Australian residents
(11)	$G^* = F_{G^*}(C^R)$	Relation between consumption gain over the latent period and real consumption in the snapshot year
(12)	$\beta^* = [\sum_{j \in J} Q_k K_j \Pi_j (1-D_j) + K_f \Pi_f \Phi (1-D_f)]/\Pi_{\beta^*}$	Real private Australian wealth next period
(13)	$\Pi^* = \sum_j N_8^{**j} \Pi_j + N_8^{**f} (\Pi_f + \Phi)$	Price index Australian 'private' saving

Notes : (a) GDP and G are calculated by specially written backsolutions from an ORANI solution. G is the sum of "other demands" (DPSV p.105) while GDP is calculated as in equation (4.13) of this section.

(b) Π^*, Π_{β^*} and Π_β are the price indices for $\tilde{S}_p$, β^*, and β. They are expenditure-weighted sums of component prices.

(c) Functions F_j, F_f, H_j and F_{g^*} are described previously, (equations (2.8), (4.1), (4.3) and (2.12) respectively. The full forms are too cumbersome to present here.

(d) Equation (3) defines Π^*, the price index for S_p. The shares N^{**n} relate to equation (4.24) in the text.

Table 11 - Percentage Change Forms of Additional Equations

		No. of Equations
(1)	$gnp = N_1^{*1}(gdp) - \sum_j N_1^{**j}(k_j + p_j^k) + N_1^{*3}(bi) + N_1^{*4}(\phi + p_f^k + k_f) + N_1^{*2j} q_j$	1
(2)	$(bi) = (gnp) + f_{BI}$	1
(3)	$c = f_c^* + \pi^* + \beta^*$	1
(4)	$gnp = N_4^{*1} c + N_4^{*2} s + N_4^{*3} g$	1
(5)	$q_j + k_j = C_j^*(s_j - \pi_j)$	H
(6)	$k_f = C_f^*(s_f - \pi_f - \phi)$	1
(7)	$s_j - \pi_j = W_j^1 q_j + W_j^2 k_j + W_j^3 b^* + W_j^4 Y_j + W_j^5 f_y^1 + W_j^6 f_y^2$	H
(8)	$s_f = f_{sf} + s$	1
(9)	$s = \sum_j N_5^{**j} s_j + N_5^{**f} s_f$	1
(10)	$\hat{\beta} = \sum_j N_6^{**j}(q_j + k_j) + N_6^{**f} k_f$	1
(11)	$g^* = A\, c^R$	1
(12)	$\hat{\beta}^* = \sum_{j \in J} N_7^{**j}(q_j + k_j) + N_7^{**f} K_f$	1
(13)	$\pi^* - \sum_{j \in J} N_8^{**} \pi_j + N^{**f}(\pi_f + \phi)$	1
		Total 2h + 11

Notes: Shares N_n^{*m}, N_n^{**m} and W_n^m are derived from the levels forms of these equations. In equation (7), the number of locally sourced investment shifters has been reduced to two, rather than the full h. At small loss in flexibility, the number of new variables is reduced by half. The LHS of equations (7) and (8) may be substituted into (5), (6) and (9) to eliminate s_j and s_f. This leaves h+8 equations. In ORANI, h = 112.

The newly defined variables are:	No.
endogenous: $q_j, s_j, k_f, s_f, s, g^*, gnp, bi, \pi^*, \hat{\beta}^*, \hat{\beta}, b,$	2h + 10
exogenous : $\pi_f, f_{bi}, f_y^1, f_y^2, f_{sf}, p_f^K, f_c^*$	7

Because the number of new equations is one greater than the number of new endogenous variables, the additional module is capable of endogenising one extra ORANI variable, namely c^R.

procedure so that the results from a standard ORANI run may be modified to produce a new solution which both incorporates the additional equations, and changes the exogenous/endogenous partition of the original ORANI run. Thus we reap two major benefits:

(a) a great amount of programming effort is saved, and the probability of introducing bugs into tried and tested ORANI programs is avoided.

(b) the computations are divided into two stages. Any variations in macro assumptions or newly collected data affect only the second, simpler stage. Thus, for example, assumptions regarding the distribution of local investment would, if altered, necessitate the recomputation of only the second part. The advantages for model development are apparent, even if, at some later time, it were decided to produce new unified and extended ORANI programs.

The Initial ORANI Run

The first step is to produce a standard ORANI simulation result, reflecting, through choice of exogenous variables, and through our choice of data and parameter files, our long-run view-point. For example, the capital-labour substitution elasticity should also be assigned a long-run value (unity, say), rather than the value of 0.5 used in short-run simulations (see Caddy (1976), (1977)). Some important exogenous variables in the initial solution envisaged are:

r (j=1,...,113)	-	the industry rates of return
ℓ	-	aggregate employment
t^{**}	-	a vector of shocks of policy-analytical interest; for example, the tariffs.
c^R	-	real consumption.

One purpose of the backsolution procedure will be to produce a solution where f_c (the percentage change in the consumption function variable) is exogenous and c^R endogenous, from the initial ORANI result in which the rọles of these variables are reversed. This is necessary because f_c is not explicitly defined in the original ORANI programs. Appropriate steps must also be taken to ensure that the rate of growth of each type of capital in the snapshot year is undisturbed by the initial shock; i.e., that

$$(4.29) \qquad y_j = k_j \ .$$

This is achieved by setting ω and each r_j to zero in (2.22), which is an ORANI structural form equation when $I_j^{(1)} = I_j^{(2)} = 1$ (see DPSV, eqns (19.7)-(19.9), p.121).

The full result of this initial ORANI run is a matrix of elasticities, E, showing the percentage change of any endogenous ORANI variable with respect to a one per cent change in any exogenous variable. Such a matrix would be extremely large; only small parts of it are actually necessary.

Theory of the Backsolution Method

Extending our previous notation, call:

y^* - the ORANI variables which are endogenous in both the initial and final closures;

y_o^* - members of y^* appearing in the additional equations;

z^* - variables unique to the additional equations;

z_1^* - members of z^* which are endogenous to the 2nd stage of the solution procedure;

z_2^* - exogenous members of z^*;

E(.,*) - ORANI elasticities of (.) with respect to (*) from the initial run.

The percentage change form of our additional equations may be written:

(4.30)
$$A \begin{pmatrix} y_o^* \\ z_1^* \\ c^R \\ t^{**} \\ z_2^* \end{pmatrix} = 0$$

where A is a coefficient matrix of constants (derived ultimately from our database). We now use the theory outlined above in (3.15) to (3.17b).

From the ORANI run we obtain

(4.31)
$$y_o = [E(y_o,t^{**}),E(y_o,c^R)] \begin{bmatrix} t^{**} \\ c^R \end{bmatrix} .$$

We can substitute this into our additional equations to get

(4.32)
$$\tilde{A} \begin{pmatrix} z_1^* \\ c^R \\ t^{**} \\ z_2^* \end{pmatrix} = 0 \quad .$$

(Note modified coefficient matrix $\tilde{A}$.) Partitioning yields:

$$(4.33) \qquad \begin{bmatrix} z^*_1 \\ c^R \end{bmatrix} = -\tilde{A}_1^{-1}\tilde{A}_2 \begin{pmatrix} t^{**} \\ z^*_2 \end{pmatrix} ,$$

which gives final results for z^*_1 and c^R. Finally, the remaining results are obtained as:

$$(4.34) \qquad y^* = \left[E(y^*,t^{**}), E(y^*,c^R)\right] \begin{pmatrix} t^{**} \\ z^*_2 \end{pmatrix} .$$

The matrix $\tilde{A}_1$ is only of order of magnitude H (viz.,113) so the computing of its inverse is handled by standard library subroutines.

4.5 Data Requirements

In addition to a standard ORANI data base for the solution year we require for both the base and solution years, but not for intervening years:

$$\left.\begin{matrix} Q_j K_j \\ K_f \\ c^R \\ S_j \\ S_f \end{matrix}\right\} \quad \text{for } t = 0 \text{ and } \tau \quad .$$

All of these data are required in the second, but not in the first, stage of the solution. At present it seems that the data necessary for a fully disaggregated data base of Australian owned capital stocks may not be available. However, it seems likely that most results will be rather insensitive to the detailed structure of ownership. Thus the methods used to generate missing information will be related to the influence, discerned from experimental runs, of varying assumptions about foreign ownership upon other variables.

APPENDIX Table A1 : Guide to Closures of M081 Reported in Text

Closure No:		1	2	3	4
Variable	No.	Vincent	DPR:τ=10	DPR:τ=2	Modified Short-run
$p^*_{(i2)}$	g	These variables (down to and including $f_j^{(2)}$) exogenous in all reported closures			
$f^{(4)}_{(i2)}$	g				
t_i	g				
v_1	g { 1				
$x^{(4)}_{(2,1)}$	1				
ϕ	1				
r	1				
$f_{(g+1,1)j}$	g				
$f_j^{(2)}$	g				
k_j	g	N	N	N	X
r_j	g	X	X	X	N
ℓ	1	X	X	X	N
$f_{(g+1,1)}$	1	N	N	N	X
c^R	1	N	N	N	N
f_c	1	N	X	X	X
f_R	1	X	N	N	N
y^R	1	N	N	N	X
h	1	N	X	X	N
ΔB	1	X	N	N	N
run		long	long	long	short
τ		10	10	2	n.a.
$\Gamma = 0$		no	no	no	yes
Mentioned in Section(s):		1,2,3	1,2,3	3.5	3.1

Key to remainder of Table

N = endogenous
X = exogenous
g = no. of commodities/industries
n.a. = not applicable
Γ = 0 implies that saving has no effect on domestically owned capital stocks.
For key to variables, see Table 2.

No. of exogenous variables for every closure = 7g + 5. In the M081 data base, g = 2.

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Attachment

Additional set of Tables 1-5 which may be detached for convenience.

Table 1 - The M081 Equations : A Linear System in Percentage Changes[(a)]

Identifier	Equation	Subscript Range[(b)]	Number	Description
I. FINAL DEMANDS				
(T1)	$x^{(3)}_{(is)} = c^R - \left(p^{(3)}_{(is)} - \sum_{r=1}^{2} S^{(3)}_{(ir)}\, p^{(3)}_{(ir)}\right)$	i=1,...,g, s=1,2.	2g	Household demands for commodities.
(T2)	$x^{(2)}_{(is)j} = y_j - \left(p^{(2)}_{(is)j} - \sum_{r=1}^{2} S^{(2)}_{(ir)j}\, p^{(2)}_{(ir)j}\right)$	i=1,...,g, s=1,2, j=1,...,h.	2gh	Demands for inputs to capital creation.
(T3)	$p^{*}_{(i1)} = -\gamma_i\, x^{(4)}_{(i1)} + f^{(4)}_{(i1)}$	i=1,...,g.	g	Export demand functions.
II. INDUSTRY INPUTS AND OUTPUTS				
(T4)	$x^{(1)}_{(is)j} = z_j - \left(p^{(1)}_{(is)j} - \sum_{r=1}^{2} S^{(1)}_{(ir)j}\, p^{(1)}_{(ir)j}\right)$	i=1,...,g+1, j=1,...,h, s=1,2.	2(g+1)h	Demands for intermediate and primary factor inputs.
(T5)	$x^{(0)}_{(i1)j} = z_j + \left(p^{(0)}_{(i1)} - \sum_{q=1}^{g} H^{(0)}_{(q1)j}\, p^{(0)}_{(q1)}\right)$	i=1,...,g, j=1,...,h.	gh	Commodity supplies by industry.
III. ZERO PURE PROFIT CONDITIONS				
(T6)	$\sum_{q=1}^{g} H^{(0)}_{(q1)j}\, p^{(0)}_{(q1)} = \sum_{i=1}^{g+1} \sum_{s=1}^{2} H^{(1)}_{(is)j}\, p^{(1)}_{(is)j}$	j=1,...,h.	h	Zero pure profits in production.
(T7)	$p^{*}_{(i2)} + t_i + \phi = p^{(0)}_{(i2)}$	i=1,...,g.	g	Zero pure profits in importing.

(a) The variables and coefficients are defined in Tables 2 and 4.

(b) The number of domestically-produced goods is g, the number of imported goods is g and the number of industries is h. In standard applications of ORANI, $g=115$ and $h=113$. Some ORANI industries produce several goods and some goods are produced by several industries. In M081, $g=2$ and $h=2$.

... continued

Table 1 continued ...

Identifier	Equation	Subscript Range	Number	Description
(T8)	$p^{*}_{(i1)} + v_i + \phi = p^{(4)}_{(i1)}$	$i=1,\ldots,g.$	g	Zero pure profits in exporting.
(T9)	$\pi_j = \sum_{i=1}^{g} \sum_{s=1}^{2} H^{(2)}_{(is)j}\, p^{(2)}_{(is)j}$	$j=1,\ldots,h.$	h	Zero pure profits in capital creation.
(T10)	$p^{(k)}_{(is)} = p^{(0)}_{(is)}$	$i=1,\ldots,g,$ $s=1,2,$ $k=3,4.$	4g	Zero pure profits in the distribution of goods.
(T11)	$p^{(k)}_{(is)j} = p^{(0)}_{(is)}$	$i=1,\ldots,g,$ $s=1,2,$ $j=1,\ldots,h,$ $k=1,2.$	4gh	
IV. MARKET CLEARING				
(T12)	$\sum_{j=1}^{h} x^{(0)}_{(q1)j}\, W^{(0)}_{(q1)j} = \sum_{k=1}^{2} \sum_{j=1}^{h} x^{(k)}_{(q1)j}\, W^{(k)}_{(q1)j} + \sum_{k=3}^{4} x^{(k)}_{(q1)}\, W^{(k)}_{(q1)}$	$q=1,\ldots,g.$	g	Demand equals supply for domestically produced commodities.
(T13)	$\sum_{j=1}^{h} x^{(1)}_{(g+1,1)j}\, W^{(1)}_{(g+1,1)j} = \ell$		1	Demand for labor equals employment of labor.
(T14)	$x^{(1)}_{(g+1,2)j} = k_j$	$j=1,\ldots,h.$	h	Demand equals employment of capital in each industry.

... *continued*

Table 1 continued ...

Identifier	Equation	Subscript Range	Number	Description
V. MISCELLANEOUS EQUATIONS				
(T15)	$x^{(0)}_{(q2)} = \sum_{k=1}^{2} \sum_{j=1}^{h} x^{(k)}_{(q2)j} W^{(k)}_{(q2)j} + x^{(3)}_{(q2)} W^{(3)}_{(q2)}$	q=1,...,g.	g	Import volumes.
(T16)	$m = \sum_{q=1}^{g} M_{(q2)} \left[p^{*}_{(q2)} + x^{(0)}_{(q2)}\right]$		1	Foreign currency value of imports.
(T17)	$e = \sum_{q=1}^{g} E_{(q1)} \left[p^{*}_{(q1)} + x^{(4)}_{(q1)}\right]$		1	Foreign currency value of exports.
(T18)	$\Delta B = (Ee - Mm)/100$		1	Balance of trade.
(T19)	$\xi^{(3)} = \sum_{i=1}^{g} \sum_{s=1}^{2} H^{(3)}_{(is)} p^{(3)}_{(is)}$		1	Consumer price index.
(T20)	$c^{R} = c - \xi^{(3)}$		1	Real aggregate consumption.
(T21)	$y^{R} = \sum_{j=1}^{h} W^{y}_{j} y_{j}$		1	Aggregate real investment.
(T22)	$\pi = \sum_{j=1}^{h} W^{y}_{j} \pi_{j}$		1	Investment-goods price index.
(T23)	$f_{R} = c^{R} - y^{R}$		1	Ratio of real aggregate.

... *continued*

Table 1 continued ...

Identifier	Equation	Subscript Range	Number	Description
(T24)	$r_j = \left(p^{(1)}_{(g+1,2)j} - \pi_j\right)Q_j$	j=1,...,h.	h	Rates of return on capital in each industry.
(T25)	$y_j = I^{(1)}_j k_j + I^{(2)}_j B_j(r_j - \omega) + f^{(2)}_j$	j=1,...,h.	h	Investment in each industry.
(T26)	$k = \sum_{j=1}^{h} W^k_j k_j$		1	Aggregate capital stock.
(T27)	$t = \sum_{i=1}^{g} \left(\zeta^t_i t_i + p^*_{(i2)} + x^{(0)}_{(i2)} + \phi\right)T^t_i$		1	Aggregate tariff revenue
(T28)	$v = \sum_{i=1}^{g} \left(\zeta^v_i v_i + p^*_{(i1)} + x^{(4)}_{(i1)} + \phi\right)T^v_i$		1	Aggregate export subsidies.
(T29)	$p^{(1)}_{(g+1,1)j} = I_{(g+1,1)j}\ \xi^{(3)} + f_{(g+1,1)j} + f_{(g+1,1)}$	j=1,...,h.	h	Wage indexation.
(T30)	$r_j = r + f^r_j$	j=1,...,h.	h	Relative rates of return.
	Total number of equations in categories I - V =		9gh+11g+9h+12	

... continued

Table 1 continued ...

Identifier	Equation	Subscript Range	Number	Description
VI. <u>MACROECONOMIC CLOSURE</u>				
(T31)	$c = f_c + \psi_1 \left(\sum_{j=1}^{h} \left(p^{(1)}_{(g+1,1)j} + x^{(1)}_{(g+1,1)j} \right) N_{(g+1,1)j} \right) + \psi_2 t - \psi_3 v + \psi_4 \left(q + \sum_{j=1}^{h} \left(p^{(1)}_{(g+1,2)j} + x^{(1)}_{(g+1,2)j} \right) N_{(g+1,2)j} \right)$		1	Consumption function.
(T32)	$u = (s - \pi)\left(\frac{U + 1}{\tau U}\right)$		1	Determination of the domestic ownership share in the capital stock.
(T33)	$q + k = u\Gamma$		1	
(T34)	$s = c - f_c/(1 - F_c)$		1	
	Total number of equations in category VI =		4	
	Total number of equations in the complete model =		9gh+11g+9h+16	

Source: Dixon, Parmenter and Rimmer (forthcoming 1984).

Table 2 - The MO81 Variables

Variable	Subscript Range[(a)]	Number	Description
Variables appearing in categories I - V			
$x^{(3)}_{(is)}$	i=1,...,g, s=1,2.	2g	Household demands for commodities
$x^{(k)}_{(is)j}$	i=1,...,g, s=1,2, j=1,...,h, k=1,2.	4gh	Demands for inputs of commodities for current production (k=1) and capital creation (k=2)
$x^{(1)}_{(g+1,s)j}$	j=1,...,h, s=1,2.	2h	Demands for labor (s=1) and capital (s=2) by industry
$x^{(4)}_{(i1)}$	i=1,...,g.	g	Export volumes
$x^{(0)}_{(q2)}$	q=1,...,g.	g	Import volumes
$x^{(0)}_{(i1)j}$	i=1,...,g, j=1,...,h.	gh	Commodity supplies by industry
z_j	j=1,...,h.	h	Industry activity levels
c		1	Aggregate consumption
c^R		1	Real aggregate consumption
y^R		1	Real aggregate investment
y_j	j=1,...,h.	h	Capital creation for each industry
ℓ		1	Aggregate employment
k_j	j=1,...,h.	h	Employment of capital in each industry
k		1	Aggregate capital employed
m		1	Foreign currency value of imports
e		1	Foreign currency value of exports

(a) The number of domestically-produced goods is g, the number of imported goods is g and the number of industries is h. In standard applications of ORANI, g=115 and h=113. Some ORANI industries produce several goods and some goods are produced by several industries. In MO81, g=2 and h=2.

... *continued*

Table 2 continued ...

Variable	Subscript Range	Number	Description
Variables appearing in categories I - V *(continued)*			
ΔB		1	Balance of trade
$p_{(is)}^{(k)}$	i=1,...,g, s=1,2, k=3,4.	4g	Prices paid by households and exporters for commodities
$p_{(is)j}^{(k)}$	i=1,...,g, j=1,...,h, s=1,2, k=1,2.	4gh	Prices paid by industries for commodity inputs to production and capital creation
$p_{(is)}^{(0)}$	i=1,...,g, s=1,2.	2g	Basic prices of domestic and imported commodities
$p_{(g+1,s)j}^{(1)}$	j=1,...,h, s=1,2.	2h	Prices paid by industries for use of primary factors (s=1 for labor and s=2 for capital)
$p_{(i1)}^{*}$	i=1,...,g.	g	Foreign currency prices of exports
$p_{(i2)}^{*}$	i=1,...,g.	g	Foreign currency prices of imports
π_j	j=1,...,h.	h	Prices of units of capital
π		1	Investment-goods price index
$\xi^{(3)}$ or cpi		1	Consumer price index
r_j	j=1,...,h.	h	Rates of return on capital in each industry.
r		1	Useful variables for exogenizing relative rates of return while endogenizing absolute rates of return
f_j^r		h	
$f_{(i1)}^{(4)}$	i=1,...,g.	g	Shifts in foreign export demands
f_R		1	Ratio of real aggregate consumption to real aggregate investment
$f_j^{(2)}$	j=1,...,h.	h	Shift variable in industry investment equations

... continued

Table 2 continued ...

Variable	Subscript Range	Number	Description
Variables appearing in categories I - V *(continued)*			
$f_{(g+1,1)j}$	j=1,...,h.	h	Variable used to allow variations across industries in wage rate movements
$f_{(g+1,1)}$		1	Normally interpreted as the real wage rate
ϕ		1	Exchange rate ($A/$US)
v_i	i=1,...,g.	g	One plus ad valorem export subsidies
t_i	i=1,...,g.	g	One plus ad valorem tariff rates
v		1	Aggregate export subsidy
t		1	Aggregate tariff revenue
ω		1	Expected rate of return in all industries, adjusted for risk
Total number of variables in categories I - V =		9gh + 15g+12h+17	
Additional variables introduced in category VI			
f_c		1	Shift in the average propensity to consume
q		1	Domestic share in the ownership of capital
u		1	Rate of growth in real domestic saving over the period 0 to τ
s		1	Domestic saving
Number of additional variables =		4	
Total number of variables in categories I - VI =		9gh+15g+12h+21	

Source: Dixon, Parmenter and Rimmer (forthcoming 1984).

Table 3 - The MO81 Coefficients and Parameters Appearing in Table 1

Equation	Coefficient or Parameter	Description and Evaluation[a]
(T1)	$S^{(3)}_{(ir)}$	Share of good i from source r in household purchases of good i, e.g., initial value for $S^{(3)}_{(11)} = 19.55/(19.55 + 1.63)$.
(T2)	$S^{(2)}_{(ir)j}$	Share of good i from source r in industry j's purchases of good i to be used as an input to capital creation, e.g., initial value for $S^{(2)}_{(11)1} = 1$, initial value for $S^{(2)}_{(22)1} = 3.26/(9.78 + 3.26)$.
(T3)	γ_i	Reciprocal of the foreign (export) demand elasticity for good i. Values adopted were $\gamma_1 = 0.5$, $\gamma_2 = 0.05$.
(T4)	$S^{(1)}_{(ir)j}$	For i=1,2, this is the share of good i from source r in industry j's purchases of good i to be used as an intermediate input, e.g., initially $S^{(1)}_{(11)1} = 16.28/(16.28 + 1.63)$. For i=3, this is the share of labor (r=1) or the share of capital (r=2) in industry j's payments to primary factors, e.g., initially $S^{(1)}_{(31)1} = 32.57/(32.57 + 8.14 + 8.14)$.
(T5)	$H^{(0)}_{(q1)j}$	Share of total revenue in industry j accounted for by sales of good q, e.g., initially $H^{(0)}_{(11)1} = 73.30/(73.30 + 26.06)$.
(T6)	$H^{(0)}_{(q1)j}$	Covered under (T5).
	$H^{(1)}_{(is)j}$	Share of input (is) in the total costs of production in industry j, e.g., initially $H^{(1)}_{(11)1} = 16.28/99.36$, $H^{(1)}_{(32)1} = 16.28/99.36$, $H^{(1)}_{(31)2} = 32.57/71.67$.
(T7)	None	

... continued

Table 3 continued ...

Equation	Coefficient or Parameter	Description and Evaluation[(a)]
(T8)	None	
(T9)	$H^{(2)}_{(is)j}$	Share of input (is) in the total cost of capital creation for industry j, e.g., initially $H^{(2)}_{(11)1} = 3.26/16.29$, $H^{(2)}_{(12)1} = 0$, $H^{(2)}_{(21)2} = 4.89/8.14$.
(T10)	None	
(T11)	None	
(T12)	$W^{(0)}_{(q1)j}$	Share of the total output of (q1) which is accounted for by industry j, e.g., initially $W^{(0)}_{(11)1} = 73.30/87.96$, $W^{(0)}_{(11)2} = 14.66/87.96$.
	$W^{(k)}_{(q1)j}$	Share of the total purchases of (q1) which is accounted for by industry j for purpose k (k=1, intermediate demand; k=2, input to capital creation). For example, initially $W^{(1)}_{(11)1} = 16.28/87.96$, $W^{(2)}_{(11)2} = 1.63/87.96$, $W^{(2)}_{(21)2} = 4.89/83.07$.
	$W^{(k)}_{(q1)}$	Share of the total purchases of (q1) which is accounted for by final user k (k=3, households; k=4, exports). For example, initially $W^{(3)}_{(11)} = 19.55/87.96$, $W^{(4)}_{(11)} = 34.21/87.96$.
(T13)	$W^{(1)}_{(g+1,1)j}$	Share of the total demand for primary factor of type 1 (i.e., labor) which is accounted for by industry j. For example, the initial value of $W^{(1)}_{(g+1,1)2}$ is 32.57/65.16.
(T14)	None	

... *continued*

Table 3 continued ...

Equation	Coefficient or Parameter	Description and Evaluation[a]
(T15)	$W^{(k)}_{(q2)j}$	Share of total purchases of imported good q which is accounted for by industry j for purpose k, e.g., initially $W^{(1)}_{(12)1} = 1.63/16.29$, $W^{(2)}_{(22)2} = 1.63/27.69$. Note : the denominator in these shares is the basic value (including duty) of the sales of good (q2).
	$W^{(3)}_{(q2)}$	Share of total purchases of good (q2) which is accounted for by households. Initially $W^{(3)}_{(12)} = 1.63/16.29$, $W^{(3)}_{(22)} = 11.40/27.69$.
(T16)	$M_{(q2)}$	Share of the total foreign currency value of imports accounted for by imports of good (q2). Initially $M_{(12)} = 14.66/34.21$, $M_{(22)} = 19.55/34.21$.
(T17)	$E_{(q1)}$	Share of the total foreign currency value of exports accounted for by exports of good (q1). Initially $E_{(11)} = 1$, $E_{(21)} = 0$. Note : there are no export taxes or subsidies in the data.
(T18)	E	Foreign currency value of exports. Initially $E = 34.21$.
	M	Foreign currency value of imports. Initially $M = 34.21$.
(T19)	$H^{(3)}_{(is)}$	Share of household expenditure devoted to good (is), e.g., initially $H^{(3)}_{(11)} = 19.55/74.93$.
(T20)	None	

... *continued*

Table 3 continued ...

Equation	Coefficient or Parameter	Description and Evaluation[a]
(T21)	W_j^y	Share of total investment accounted for by industry j. Initially $W_1^y = 16.29/24.43$, $W_2^y = 8.14/24.43$.
(T22)	W_j^y	Covered under (T21).
(T23)	None	
(T24)	Q_j	$Q_j = (R_j + D_j)/R_j$, i.e., Q_j is the ratio of the gross to the net rate of return in industry j. From Table 5, $D_1 = 8.14/162.89$, $D_2 = 4.07/81.45$ (these are treated as constants). Initially $R_1 = 8.14/162.89$, $R_2 = 4.07/81.45$. Hence, initially $Q_j = 2$ for j=1,2.
(T25)	$I_j^{(1)}$, $I_j^{(2)}$	Users of the model set values according to how investment by industry is to be modelled in Section 2.5. In DPR's long-run closure, the H_j are evaluated using values for $K_j(0)$ and K_j from Tables 4 and 5. For example, where $\tau = 10$, the initial value for H_1 is $(162.89/100)^{.1} - 1$.
	B_j	$B_j = 1/\beta_j\Delta_j$ where β_j is the elasticity of the expected rate of return schedule for industry j and Δ_j is the ratio of investment in the solution year to capital stock in the following year. For j=1,2, we set $\beta_j = 30$. Initially $\Delta_1 = 16.29/(162.89(.95) + 16.29)$ and $\Delta_2 = 8.14/(81.45(.95)+8.14)$. <u>Note</u> : none of the results for the DPR closure are affected by the value used for B_j.

... *continued*

Table 3 continued ...

Equation	Coefficient or Parameter	Description and Evaluation[a]
(T26)	W_j^k	Share of the total capital stock accounted for by industry j. Initially, $W_1^k = 162.89/244.34$, $W_2^k = 81.45/244.34$.
(T27)	ζ_i^t	$\zeta_i^t = T_i/(T_i-1)$, i.e., ζ_i^t is the ratio of the power of the tariff on good i to the ad valorem rate. Initially $\zeta_1^t = 16.30/1.63$, $\zeta_2^t = 27.69/8.14$.
	T_i^t	Share of total tariff revenue accounted for by tariffs on good i. Initially, $T_1^t = 1.63/9.77$, $T_2^t = 8.14/9.77$.
(T28)	ζ_i^v	$\zeta_i^v = V_i/(V_i - 1)$, i.e., ζ_i^v is the ratio of the power of the export subsidy on good i to the ad valorem rate.
	T_i^v	Share of total export subsidies accounted for by export subsidies on good i. Note : our data base shows no export subsidies. Hence, in our computations, (T28) and the variable v are deleted.
(T29)	$I_{(g+1,1)j}$	User determined wage-indexing parameter.
(T30)	None	

... continued

Table 3 continued ...

Equation	Coefficient or Parameter	Description and Evaluation[a]
(T31)	ψ_i	ψ_i, $i=1,\ldots,4$ are the shares in domestic income accounted for by wage income, tariff revenue, export subsidies and capital income accruing to domestic capitalists. In Table 5, wage income is 65.16, tariff revenue is 9.77, export subsidies are 0 and domestic capitalist income is (24.44)(183.26/244.34) = 18.33. Thus, domestic income is 93.24 and initially we have $\psi_1 = .70$, $\psi_2 = .10$, $\psi_3 = 0$ and $\psi_4 = 0.20$.
	$N_{(g+1,1)j}$	Share of industry j in total wage payments. Initially $N_{(g+1,1)1} = 32.57/65.16$, $N_{(g+1,1)2} = 32.57/65.16$.
	$N_{(g+1,2)j}$	Share of industry j in total returns to capital. Initially $N_{(g+1,2)1} = 16.28/24.44$, $N_{(g+1,2)2} = 8.14/24.44$.
(T32)	$(U+1)/\tau U$	In the base year (see Table 4) domestic income is 40 (wages) plus 6 (tariff revenue) plus 15(112.5/150) (domestically accruing capital income), i.e. domestic income is 57.25. Consumption is 46 leaving savings $S(0) = 11.25$. In the solution year (see Table 5) domestic income is 93.24 (see the discussion of ψ_i earlier in this table). Consumption is 74.93 leaving $S(\tau) = 18.31$. Commodity prices are constant as we move from Table 4 to Table 5. In particular, initially, $\Pi(\tau)/\Pi(0) = 1$. Hence, the initial value for U is $(18.31/11.25)^{.1} - 1 = 0.05$. With $\tau = 10$, we find that the initial value for the coefficient in (T32) is 1.05/.50 = 2.10.

... continued

Table 3 continued ...

Equation	Coefficient or Parameter	Description and Evaluation
(T33)	Γ	See equation (2.10). With $\tau = 10$, $D = 0.05$, $Q(0) = .75$, $K(0) = 150$ and U, $Q(\tau)$ and $K(\tau)$ having initial values 0.05, .75 and 244.34, Γ has an initial value of 0.160.
(T34)	$1/(1-F_c)$	Initially F_c equals (74.93/93.24) = .80, i.e. F_c is the ratio of consumption to domestic income. This gives an initial value for the coefficient in (T34) of 5.1.

(a) Except when otherwise indicated, the initial share values were computed from the solution-year input-output data, i.e., Table 5 .

Source: Dixon, Parmenter and Rimmer (forthcoming 1984).

Table 4 - Input-output Data Base for MO81 for Year 0, the Base Year

		Intermediate inputs to industries 1 and 2		Gross fixed capital formation by industries 1 and 2		Household consumption	Exports	Negative of import duty	Row Totals
Domestic commodities	1	10	8	2	1	12	21		54
	2	15	1	6	3	26	0		51
Imported commodities	1	1	8	0	0	1		-1	9
	2	5	2	2	1	7		-5	12
Labor		20	20						40
Gross operating surplus { Depreciation		5	2.5						7.5
Gross operating surplus { Net profit		5	2.5						7.5
Total costs		61	44	10	5	46	21	-6	181
Domestic commodity outputs	1	45	9						54
	2	16	35						51
Domestically-owned capital stocks		75	37.5						112.5
Foreign-owned capital stocks		25	12.5						37.5
Total capital		100	50						150

Source: Dixon, Parmenter and Rimmer (forthcoming 1984).

Table 5 - Input-output Data Base for MO81 for Year τ, the Solution Year[(a)]

			Intermediate inputs to industries 1 and 2		Gross fixed capital formation by industries 1 and 2		Household consumption	Exports	Negative of import duty	Row Totals
Domestic commodities		1	16.28	13.03	3.26	1.63	19.55	34.21		87.96
		2	24.43	1.63	9.78	4.89	42.35	0		83.07
Imported commodities		1	1.63	13.03	0	0	1.63		-1.63	14.66
		2	8.14	3.26	3.26	1.63	11.40		-8.14	19.55
Labor			32.57	32.57						65.16
Gross operating surplus	Depreciation		8.14	4.07						12.22
	Net profit		8.14	4.07						12.22
Total costs			99.36	71.67	16.29	8.14	74.93	34.21	-9.77	294.84
Domestic commodity outputs		1	73.30	14.66						87.96
		2	26.06	57.01						83.07
Domestically-owned capital stocks			122.17	61.09						183.26
Foreign-owned capital stocks			40.72	20.36						61.08
Total capital			162.89	81.45						244.34

(a) τ=10. All flows shown here are obtained from the corresponding flows in Table 5 by multiplying by $(1.05)^{10}$.

Source: Dixon, Parmenter and Rimmer (forthcoming 1984).