Impact Project

Impact Centre
The University of Melbourne
153 Barry Street, Carlton
Vic. 3053 Australia
Phones: (03) 341 7417/8
Telex: AA 35185 UNIMEL
Telegrams: UNIMELB, Parkville

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A TARIFF EXPERIMENT ON THE INTERFACED ORANI-MACRO SYSTEM

by

Russel J. Cooper
Macquarie University

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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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CONTENTS

TABLES

APPENDIX 3

Details of Responses to the 10 Percent Government Spending Shock Around $t^* = 7.94$ Quarters for Doubly Endogenous Variables, with ORANI Adjustment Speeds Set at Parameter Values Given in Table 3

		Solution Values for Alternative t^*		
		t^*=7.93	t^*=7.94	t^*=7.95
y_g	MACRO Solution	1.07387	1.07283	1.07174
	ORANI Solution	1.07276	1.07276	1.07276
P	MACRO Solution	1.35629	1.35800	1.35968
	ORANI Solution	1.35800	1.35800	1.35800
L_h	MACRO Solution	1.55702	1.55683	1.55666
	ORANI Solution	1.55680	1.55680	1.55680
i	MACRO Solution	1.86113	1.85417	1.84735
	ORANI Solution	1.85417	1.85417	1.85417
Sum of Squared Differences		.00005	.00000	.00005

APPENDIX 2

Details of Modifications Made to Basic RBA79 Model by Jonson, McKibbin and Trevor (1981)

Using the notation of the above authors, the four modifications were as follows:

(i) non-accommodating monetary policy: This is handled by including the proportional deviation of the stock of money from a target value in the bond rate equation. Using the control solution as the target value, this amounts to simply adding D log M to the Dr equation for purposes of simulation.

(ii) a more flexible exchange rate: This is handled by including the proportional deviation of international reserves from a target level in the exchange rate equation. Again using the control solution as the target value, the simulation merely requires the addition of -D log R to the D log E equation.

(iii) rapid adjustment of capital flows: Here the coefficient of $(\log \hat{Pf} - \log F)$ in the D log F equation is changed by a factor of 5 from .1777561 to .8887805. Because of the dependence of $\hat{f}$ on both endogenous and exogenous variables, this leads to a series of changes to the D log F row of the F_M and G_M matrices introduced above in section 2.3.

(iv) a faster response of expectations about changes in the exchange rate to changes in relative prices: Here the coefficient of log EP_w/P in the log $\hat{f}$ term in the D log F equation is changed by a factor of 4 from .7656684 to 3.0626736. This also affects a series of elements of the D log F row of F_M and G_M.

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1. INTRODUCTION

In previous work Cooper and McLaren (1980, 1981, 1982) have developed a methodology for interfacing a large general equilibrium model in the Johansen (1960) class with a small macrodynamic model. In this paper their methodology is used to interface ORANI78 [Dixon, Parmenter, Sutton and Vincent (1982)] with MACRO [which is essentially RBA79 - see Jonson, McKibbin and Trevor (1981)]. The interfacing parameters are set by reference to a preliminary neutral experiment in which government spending is shocked. A 25 percent across-the-board increase in tariffs is then injected into the interfaced ORANI-MACRO system.

This tariff experiment differs from those reported on ORANI in stand-alone mode [e.g., Dixon et al. (1982) Ch. 7] in the following way. In the stand-alone experiments the tariff changes are fed directly into ORANI without affecting major macro variables which are exogenous to ORANI. The results are interpreted as the effects of tariff changes in a fixed macroeconomic environment. In the experiments on the interfaced system, however, the tariff shock is allowed (via MACRO) to affect the macroeconomic environment. This provides a second channel of influence through which the tariff affects the values of variables in ORANI.

The net impact of the tariff changes on variables endogenous to the system can be decomposed into two components:

(a) the effects of relative price changes in a fixed macroeconomic environment - these 'macroeconomically compensated' effects correspond to the ORANI stand-alone results;

and

(b) the effects of the induced change in the macroeconomic environment.

The latter can be represented in the form of 'as if' shocks to the macro variables which are exogenous to ORANI. An interesting result is that these 'as if' shocks are countervailing and hence have overall minor effects. As a consequence the results of a tariff shock to the macroeconomically closed ORANI-MACRO system hardly differ from those produced by ORANI in stand-alone mode.

Section 2 of the paper contains preliminary material covering the interfacing technique, the underlying models and specific modifications made to the models. Section 3 details the experiments: firstly the preliminary experiment aimed at calibrating the interface parameters, then the main experiment (i.e., the tariff shock), and finally the method of computation of the 'as if' shocks. Results are presented in Section 4 and concluding remarks are offered in Section 5.

APPENDIX 1

The ORANI Elasticities Matrix C_o

	E	W/P	C_R	I_R	K(0)	g_1	t_3
Y_g	0.0	-0.4476	0.1092	0.1497	0.5675	0.1060	-0.0049
P	1.0	1.7285	2.0805	0.2299	-1.9715	0.1259	0.0722
L_h	0.0	-0.6968	0.1389	0.2167	0.4221	0.1555	-0.0082
i	0.0	0.6692	1.4576	0.4281	-0.7924	0.1832	-0.0611
P_{wl}	1.0	0.3515	0.2793	0.0156	-0.4885	0.0154	0.0152
x	0.0	-2.2016	-2.5060	-0.3792	2.8457	-0.1514	-0.1123
P_x	0.0	0.2402	0.2546	0.0317	-0.3073	0.0150	0.0115
$x\ P_x$	0.0	-1.9614	-2.2515	-0.3475	2.5384	-0.1364	-0.1009

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2. PRELIMINARIES

2.1 Synopsis of the Interfacing Method

The interfaced system follows the design principles developed in Cooper and McLaren (1980, 1981, 1982). Briefly, the MACRO model is specified as a first order differential equation system:

$$DY_M = A_M Y_M + B_M Z_M \ ,$$

where Y_M refers to a vector of the logarithms of MACRO endogenous variables, Z_M is a vector of the logarithms of MACRO exogenous variables, and D = time derivative operator = d/dt. In terms of deviations from control, this system has a solution in proportional-change form:

$$y_M(t) = C_M(t)\ z_M \ ,$$

where

$$C_M(t) = A_M^{-1}[e^{A_M t} - I]B_M$$

and where z_M represents proportional changes (relative to control) which occur in the levels of Z_M at time 0 and which are maintained throughout the interval [0,t], while $y_M(t)$ represents the proportional change in Y_M relative to its control value at t.

The ORANI model, on the other hand, is characterised by a set of equilibrium conditions relating the levels of endogenous variables to the levels of exogenous variables. The difference between two potential future equilibrium positions occasioned by a sustained shock is:

$$y_O = C_O\ z_O \ ,$$

where C_O is a matrix of constant (for practical purposes) elasticities and z_O and y_O are respectively vectors of the exogenous shocks and endogenous responses in proportional-change form.

The mechanics of the interfacing procedure are to endow ORANI with a within-solution-period dynamics to enable the passing of shocks and feedbacks between MACRO and ORANI. This introduces the need to

specify certain speeds of adjustment in ORANI, and these are determined experimentally.

The two models may be written together as:

$$D \begin{pmatrix} Y_M \\ Y_O \end{pmatrix} = \begin{bmatrix} A_M & 0 \\ 0 & A_O \end{bmatrix} \begin{pmatrix} Y_M \\ Y_O \end{pmatrix} + \begin{bmatrix} B_M & 0 \\ 0 & B_O \end{bmatrix} \begin{pmatrix} Z_M \\ Z_O \end{pmatrix},$$

where the speed of adjustment parameters A_O and the matrix B_O must be chosen such that

$$A_O^{-1}[e^{A_O t^*} - I]\, B_O = C_O$$

in order for the dynamic version of ORANI to be consistent at t* (the ORANI response interval) with the original ORANI comparative static specification.

To allow interaction between the models we recognise that certain variables which are exogenous in one model may be endogenised by the other. We define selection matrices R_M, R_O, Q_M, Q_O such that

$$R_M Z_M = Q_O Y_O$$

and

$$R_O Z_O = Q_M Y_M.$$

R_M selects from MACRO's exogenous variables those which are endogenous to ORANI; Q_O selects from ORANI's endogenous variables those which are exogenous to MACRO, etc. These equations define the causal links from ORANI to MACRO and from MACRO to ORANI respectively.

Next define P_M, P_O such that

$$R_M' R_M + P_M' P_M = I$$

and

$$R_O' R_O + P_O' P_O = I.$$

Thus P_M, P_O select from Z_M, Z_O those variables not selected by R_M, R_O. The interfaced system may now be written:

5. CONCLUSION

This paper has reported the results of two experiments on the ORANI-MACRO system. In the first it proved possible to choose parameters at the interface of the two component models in a way which virtually eliminated divergences between them under the impact of a stimulus to government spending. These parameters were adopted as the basis for the interfaced system.

In the second experiment, a tariff shock was applied to the system so interfaced. In this case, there emerged some incompatibilities between the ORANI and MACRO sides of the model. Whilst it might be possible to reduce or eliminate these by using a tariff-shock-specific interface, there are two arguments against so proceeding. First, there is merit in having a general purpose interface which does not require modification each time a different type of shock is injected. Second, given the different purposes for which the models were constructed, the divergences between ORANI and MACRO under the tariff shock are not unexpected. In particular, we would expect the ORANI part of the system to handle the tariff shock better, and where differences between the two sides of the model exist with respect to double endogeneities, it is the ORANI story which has been accepted.

The major conclusion to emerge from this study is that endogenizing the macroeconomic environment of ORANI in the context of a moderate tariff shock, such as a 25 percent across-the-board change, at the aggregate level leads only to second order effects. This is because the changes in the macroeconomic environment triggered by the tariff shock are largely self-cancelling. For example, the effects on gross domestic product of induced changes in investment and consumption are of opposite sign.

It has not been possible in a paper of this length to trace through the chain of events, starting with the tariff shock, which leads the MACRO model to present ORANI with the particular changes in the macroeconomic environment reported above. Hopefully it will prove possible to investigate these mechanisms in a later paper.

TABLE 5

COMPONENTS OF CHANGE IN MAJOR ORANI ENDOGENOUS VARIABLES DUE TO CHANGES IN MACROECONOMIC ENVIRONMENT INDUCED BY A 25 PERCENT INCREASE IN ALL TARIFFS*

	ORANI Endogenous Variable	Macroeconomic Environment: ORANI Exogenous Variable Subjected to "As If" Shock					Composite Macroeconomic Effect
		Exchange Rate $\log E$	Real Wage $\log W/P$	Real Consumption $\log C_R$	Real Investment $\log I_R$	Capital Stocks $\log K(0)$	
$\log Y_g$	Output	-	0.028	0.027	-0.034	0.014	0.034
$\log P$	Prices	-0.256	-0.107	0.519	-0.053	-0.047	0.057
$\log L_h$	Employment	-	0.043	0.035	-0.050	0.010	0.038
$\log i$	Real Imports	-	-0.041	0.364	-0.098	-0.019	0.206
$\log (x P_x)$	Value of Exports	-	0.121	-0.562	0.080	0.061	-0.301

* All figures shown are percentage changes in the endogenous variables listed at the left relative to the control values of these variables at 7.94 quarters after the change in tariffs.

$$D \begin{pmatrix} Y_M \\ Y_O \end{pmatrix} = \begin{bmatrix} A_M & B_M R_M' Q_O \\ B_O R_O' Q_M & A_O \end{bmatrix} \begin{pmatrix} Y_M \\ Y_O \end{pmatrix} + \begin{bmatrix} B_M P_M' P_M & 0 \\ 0 & B_O P_O' P_O \end{bmatrix} \begin{pmatrix} Z_M \\ Z_O \end{pmatrix},$$

where

$$B_O = [e^{A_O t^*} - I]^{-1} A_O C_O.$$

This system has the form

$$DY = AY + BZ$$

and hence has solution in proportional change form

$$y(t) = C(t) z,$$

where

$$C(t) = A^{-1} [e^{At} - I] B.$$

Certain variables are explained by both the MACRO and ORANI models. These double endogeneities appear twice in the solution vector $y(t)$. Let S_M, S_O select these values as recorded in the MACRO and ORANI subsets respectively. The calibration of the interface parameters - the elements of A_O together with t^* - may be based experimentally on the minimisation of

$$[S_M\, y(t) - S_O\, y(t)]'\, W\, [S_M\, y(t) - S_O\, y(t)],$$

where W is a weighting matrix.

2.2 The ORANI Model

The ORANI model is the version ORANI78 documented in Dixon et al. (1982). Only a subset of the complete ORANI model is required for the interface procedure. This subset must include among the endogenous variables all double endogeneities plus all variables exogenous to MACRO which are to be endogenised by ORANI. The ORANI exogenous set must include all variables subject to shock plus all variables exogenous to ORANI which are to be endogenised by MACRO. The relevant ORANI variables are listed in Table 1.

The table of elasticities - the derivatives of elements of Y_0 with respect to elements of Z_0 - (the matrix C_0) is given in Appendix 1. The numerical values of these elasticities correspond to the underlying numerical data base and parameter values of ORANI78 used in the tariff experiment reported in Dixon et al. (1982), Chapter 7. The split of variables into endogenous and exogenous sets corresponds to the standard short-run neoclassical mode with a slack labour market. The table of elasticities is therefore a subset of a standard basic solution of ORANI78. It may be noted that the numeraire of the model is the exchange rate and, with respect to this variable, the model is homogeneous of degree zero in reals and one in nominals.

endogenous variables to the "as if" shock applied to the ORANI exogenous variable indicated by the column heading. As noted above, the composite macroeconomic effect on each ORANI endogenous variable is small compared to the size of the macroeconomically compensated ORANI response.

Comparison of columns I and III of Table 4 reveals that MACRO and ORANI want to tell somewhat different stories about the impact of the tariff rise. By construction, their output responses were made identical (-0.089%) by selection of a suitable value of t_3 (the average tariff level). It will be noted that the MACRO responses in employment and output are equal, whereas ORANI shows the standard neo-classical short run result in which the employment response is a multiple (namely, 1.9) of the output response. Imports decline according to both sides of the interfaced model; the MACRO response, however, is 2 to 3 times larger in absolute value. The key to this is the behaviour of the price level in MACRO, which is the glaring inconsistency. It seems here difficult to accept the MACRO result that a twenty-five percent increase in tariffs could be deflationary. Given this result, however, the consequent increase in the competitiveness of the domestic economy leads in MACRO to a substantial decline in imports. It may be expected that, in the presence of an experiment involving a non-neutral shock, the model which has been built more specifically for analysis of the type of shock in question would give the more reasonable results. In the above case it is not surprising that the ORANI results for a tariff shock would be the more reasonable.

4.3 The "As If" Shocks

Corresponding to the tariff experiment are the following "as if" shocks to the designated ORANI exogenous variables:

ORANI Exogenous Variable	"As If" Shock (percent)
log E Exchange Rage	-0.25616
log W/P Real Wages	-0.06162
log C_R Real Consumption	0.24956
log I_R Real Investment	-0.22983
log K(0) Initial Capital	0.02392

When applied to ORANI in stand-alone mode, these shocks, together with the original shock of 25 to log t_3, will reproduce the results in column I of Table 4. The contribution of the macroeconomic effect of the individual "as if" shocks is indicated in Table 5. The figures in the body of the table represent the responses of the ORANI

TABLE 1

A PARTIAL LISTING OF VARIABLES APPEARING IN ORANI78

	Variables Endogenous to ORANI: The Vector Y_0	
1.	log y_g	Real Gross Domestic Product
2.	log P	Price Deflator for Aggregate Production ($A)
3.	log L_h	Aggregate Employment Demand (labour-hours)
4.	log i	Real Imports
5.	log P_{wl}	Price of Wool ($A)
6.	log x	Real Exports
7.	log P_x	Price of Exports ($US)
8.	log (x P_x)	Foreign Currency Value of Exports ($US)
	Variables Exogenous to ORANI: The Vector Z_0	
1.	log E	Exchange Rate ($A/$US)
2.	log (W/P)	Real Wages
3.	log C_R	Real Household Expenditure
4.	log I_R	Real Private Investment
5.	log K(0)	Initial Capital Stocks
6.	log g_1	Government Expenditure
7.	log t_3	Average Level of Tariffs

2.3 The MACRO Model

The MACRO model is based upon the RBA79 model developed by Peter Jonson and co-workers at the Reserve Bank of Australia. The parameter matrices A_M, B_M were obtained for the standard RBA79 model. This model is documented in the appendix to Jonson, McKibbin and Trevor (1981), the form of presentation corresponding to the "structural" representation:

$$DY_M = E_M DY_M + F_M Y_M + G_M Z_M.$$

The relatively sparse matrix E_M is deducible from their specification. F_M, G_M are related to A_M, B_M as
$A_M = (I - E_M)^{-1} F_M$, $B_M = (I - E_M)^{-1} G_M$.

Four sets of modifications were made to the basic RBA79 model. The first set corresponds to those documented in Jonson, McKibbin and Trevor (1981). These modifications allow for non-accommodating monetary policy, a more flexible exchange rate, more rapid adjustment of capital flows, and a faster response of expectations about changes in the exchange rate to changes in relative prices. (Further details are available in Appendix 2.)

The second set of modifications is the exogenisation of the export sector in MACRO. It is argued that ORANI provides a more detailed model of the export sector by disaggregating into those industries in which Australia is a major supplier in the world market and those in which it is not. Both exports and price of exports equations are deleted from MACRO. The relevant rows of E_M, F_M and G_M are deleted and the relevant columns of F_M are appended to G_M.

Thirdly, the term defining the marginal product of capital in the investment equation is redefined to exclude explicit dependence on the government spending variable, since simulations involving a shock to this variable would appear to lead to an extreme form of crowding out as a result of an immediate drop in the marginal product of private capital. (In G_M we set the coefficient of (Dk) with respect to log

Column I shows how the ORANI story must be modified to allow for the impact of the tariff shock on the macroeconomic environment. These results in column I are based on the interface parameters shown in Table 3. The overwhelming impression gained by comparison of columns I and II is that the change in the macroeconomic environment induced by the tariff shock has only second order consequences to major macroeconomic aggregates.

TABLE 4
PRINCIPAL RESULTS OF A 25 PERCENT TARIFF INCREASE IN THE ORANI-MACRO SYSTEM*

Endogenous Variable		ORANI Response within the Interfaced System (I)	Standard ORANI Response (II)	MACRO Response within the Interfaced System (III)
y_g	Output	-0.089	-0.123	-0.089
P	Prices	1.862	1.805	-0.374
L_h	Employment	-0.167	-0.205	-0.082
i	Imports	-1.322	-1.528	-3.625
(x P_x)	Value of Exports ($US)	-2.824	-2.523	n.a.
E	Exchange Rate ($A/$US)	n.a.	n.a.	-0.237
W/P	Real Wages	n.a.	n.a.	0.104
k	Rate of Net Investment	n.a.	n.a.	0.003
K	Capital Stock	n.a.	n.a.	0.112
d	Household Expenditure	n.a.	n.a.	-0.053

* Based on the interface parameters shown in Table 3 and t_3 = 0.15923. Figures in the table are percentage deviations from control at 7.94 quarters after the tariff shock. n.a.=not applicable.

This table also shows the values, at these parameter settings, of the doubly endogenous variables. These figures correspond to a shock of 10.0 to log g_1, government expenditure, and may be interpreted as percentage responses to a ten percent shock. The government spending experiment has been successful in finding a setting for the interface parameters which eliminates inconsistency between the ORANI and MACRO models under a neutral shock.

4.2 Results of the Tariff Experiment

Using the above parameter values, this experiment shocked t_3, the average tariff variable in ORANI, by 25%. A search over t_3 to determine the appropriate corresponding shock to $(1 + t_3)$, the power of the tariff variable in MACRO, subject to the criterion of minimising the squared difference between the ORANI and MACRO projections of the output double endogeneity, led to the following results:

Shock to $(1 + t_3)$:	3.434%
Implied Value of t_3 :	15.923%
Value of real output (y_g) as computed by both the MACRO and ORANI components of the interfaced system:	-0.089%

This implied value of t_3 (approximately 16 percent) is of broadly comparable size to more direct estimates by the Industries Assistance Commission (1980, Table 2.1). Using weights based on the unassisted value of domestic production of commodities, the average tariff levels on manufactured products were put at 24 percent in 1968-69, and at 15 percent in 1977-78.

The principal results of the tariff experiment are given in Table 4. The main feature to note is the strong similarity between columns I and II, and the extent of the divergence between them and column III.

Column II shows the 'macroeconomically compensated' values of the responses of the major macroeconomic aggregates to a 25 percent increase in tariffs. This is the standard ORANI, stand-alone, story.

g_1 equal to zero, where (Dk) is the change in the rate of net investment and g_1 is as previously defined.)

Fourthly, an identity and a behavioural equation are appended to the MACRO solution to provide consistency in the definition of double endogeneities. The identity is:

$$d \log y_g = (\bar{y}/\bar{y}_g)\, d \log y + [(1-\bar{y})/\bar{y}_g]\, d \log K.$$

The right hand side variables y and k are the MACRO endogenous variables output (net of depreciation) and capital. The equation defines real gross output y_g consistently with the ORANI definition. $\bar{y}$, $\bar{y}_g$ are the sample mean values of the MACRO variables y and y_g.

The behavioural equation is:

$$d \log L_h = d \log L + \eta(d \log y - d \log y^*).$$

MACRO defines aggregate employment, L, in persons. To convert to the ORANI definition (labour-hours), it is assumed that the proportional change in hours worked per person is related simply (with factor of proportionality η) to the proportional deviation of output from a "standard hours" level of output, y^*. For purposes of simulation the "standard hours" level of output is taken as the control solution. The value of η is chosen experimentally to maximise the consistency between the MACRO and ORANI labour-hours equations, jointly with the determination of other interface parameters in the government spending shock experiment.

The MACRO model incorporating the above modifications is referred to below as MACRO81. It consists of 26 equations (RBA79 less Exports less Price of Exports plus Gross Output plus Labour-Hours). The full system is employed in the interfaced model. For expositional purposes a listing of some of the more relevant MACRO variables is given in Table 2.

TABLE 2

A PARTIAL LISTING OF VARIABLES APPEARING IN MACRO81

Variables Endogenous to MACRO81 (A Subset of Y_M)	
1. log y_g	Real Gross Domestic Product
2. log P	Price Deflator for Aggregate Production ($A)
3. log L_h	Aggregate Employment Demand (labour-hours)
4. log i	Real Imports
5. log E	Exchange Rate ($A/$US)
6. log W	Nominal Wages (average weekly earnings, $A)
7. log d	Aggregate Real Household Expenditure (including investment in dwellings)
8. k	Proportional Change in Net Investment (=DK/K)
9. log K	Business Fixed Capital Stock

Variables Exogenous to MACRO81 (A Subset of Z_M)	
1. log P_{wl}	Price of Wool ($US)
2. log x	Real Exports
3. log P_x	Price of Exports ($A)
4. log g_1	Government Expenditure
5. log $(1+t_3)$	Power of Tariff
6. log P_i	Price of Imports ($US)
7. log P_w	World Prices ($US)

4. RESULTS

4.1 Calibration of the Interface Parameters

In the government spending shock experiment, an intensive search over an eight-dimensional space led to the parameter values shown in column I of Table 3.

TABLE 3

ESTIMATED VALUES OF INTERFACE PARAMETERS

ORANI Variables		Adjustment Speeds (Diagonal elements of $e^A{}_o$) (I)	Solution Values at t* of the Double Endogeneities** (II)
y_g	Output	$\beta_1 = 4.39$	1.073
P	Domestic Prices	$\beta_2 = 74.4$	1.358
L_h	Employment	$\beta_3 = 9.8$	1.557
i	Imports	$\beta_4 = 5.9$	1.854
P_{wl}	Price of Wool	$\beta_5 = 10$	n.a.
$x, P_x, (x\ P_x)$	Export Sector	$\beta_6 = .5$	n.a.

ORANI Response Interval : t* = 7.94 quarters

Hours parameter in MACRO : $\eta = .45$

** Result shown in column II applies to both the ORANI and MACRO projections of the doubly endogenous variable within the interfaced ORANI-MACRO system. At the given parameter settings, the two projections are in fact identical to the fourth decimal place. Further details are provided in Appendix 3, where a comparison is given with solution values for t* set at 7.93 and 7.95 quarters.

n.a. Not applicable (variable is not doubly endogenous).

The vector of "as if" shocks, $\tilde{z}_0$, is useful for a number of purposes.

(i) In conjunction with the original shock, $\bar{z}_0$, it can be applied to the complete disaggregated ORANI model in stand-alone mode, endogenising the macroeconomic environment.

(ii) It represents a summary of the average macroeconomic effects of the original shock, $\bar{z}_0$.

(iii) Application of each component of $\tilde{z}_0$ separately to the ORANI stand-alone elasticities matrix yields a breakdown of the individual contribution of the various macroeconomic influences arising from the original shock, $\bar{z}_0$.

2.4 Interrelationships Among the Models

From the listings of ORANI and MACRO variables in Tables 1 and 2 respectively it is evident that the following variables are endogenous to both models:

Double Endogeneities

log y_g	Output
log P	Prices
log L_h	Employment
log i	Imports

In terms of the notation introduced in Section 2.1, the matrix S_M selects these variables from the MACRO subset of the combined set of endogenous variables for the interfaced system, while S_0 selects the same variables from the ORANI subset.

An important aspect of the interface concerns the passing of stimuli from one model to another. Variables exogenous to MACRO and endogenised by ORANI are:

ORANI to MACRO Feedbacks

log P_{wl}	Price of Wool
log x	Quantity of Exports
log P_x	Price of Exports

The matrix R_M selects these variables from Z_M, while the matrix Q_0 selects the same variables from Y_0. In the case of the price variables, the stimuli are adjusted by the exchange rate in MACRO to correct for differences in currency units.

A set of variables of particular interest in view of the role of MACRO in endogenising the macroeconomic environment of ORANI is the following group of ORANI exogenous variables:

MACRO to ORANI Feedbacks (ORANI Definitions)

log E	Exchange Rate
log (W/P)	Real Wages
log C_R	Real Household Expenditure
log I_R	Real Gross Private Investment (including investment in dwellings)
log K(0)	Initial Capital Stocks

For expositional purposes, one may think of the matrix R_O selecting these variables from z_O. The matrix Q_M is then required to select the same variables from Y_M. In practice the composition of the Q_M matrix is somewhat complicated because of the need to select various combinations of MACRO endogenous variables to correspond to the definitions of certain ORANI exogenous variables. Following is a list of variables which are involved in these constructions.

Variables Involved in Construction of
MACRO to ORANI Feedbacks (MACRO Definitions)

log E	Exchange Rate
log W	Nominal Wages
log P	Price Deflator for Aggregate Production
log D	Aggregate Real Household Expenditure (including investment in dwellings)
k	Net Investment Rate (=DK/K)
log K	Business Fixed Capital Stock

The selection required to endogenise log E in ORANI is straightforward. The procedure employed to endogenise log(W/P) amounts to ensuring that the relevant row of Q_M selects log W - log P from Y_M. In the case of the endogenisation of log C_R we find that the relevant MACRO variable, log d, includes investment in dwellings. The relevant row of Q_M may be specified to pass the appropriate fraction of the stimulus from MACRO variable log d to ORANI variable log C_R. The endogenisation of log K(0) in ORANI involves a straightforward selection of log K in the relevant row of Q_M. In the case of the endogenisation of log I_R we note that two MACRO variables, k and log K, provide stimuli to the net and replacement investment components of log I_R, respectively. Additionally, since log I_R includes dwelling investment, a proportion of MACRO variable log d has

indication of the imposition of the correct macroeconomic environment on ORANI in stand-alone mode. Let J_O select the same variables from the ORANI endogenous vector y_O. Now the stand-alone ORANI model may be represented as

$$y_O = C_O z_O = \tilde{C}_O \tilde{z}_O + \bar{C}_O \bar{z}_O ,$$

where $\bar{z}_O$ are the direct shocks due to the nature of the experiment and $\tilde{z}_O$ are the "as if" shocks to variables which, in an interfaced model, would be endogenised by MACRO. In the present context, $\tilde{z}_O$ is a five-element vector containing the "as if" shocks to the following ORANI exogenous variables:

1.	E	Exchange Rate ($A/$US)
2.	W/P	Real Wages
3.	C_R	Real Household Expenditure
4.	I_R	Real Private Investment
5.	K(0)	Initial Capital Stocks .

Now if we let J_O select five macro-type variables from the ORANI endogenous set then, in the equation

$$J_O y_O = J_O \tilde{C}_O \tilde{z}_O + J_O \bar{C}_O \bar{z}_O$$

the matrix $J_O \tilde{C}_O$ will be square and, with careful choice, nonsingular. The simulation of the macroeconomic environment requires that

$$J_O y_O = H_O y(t^*) ,$$

but this can be ensured by choosing $\tilde{z}_O$ such that

$$\tilde{z}_O = (J_O \tilde{C}_O)^{-1} (H_O y(t^*) - J_O \bar{C}_O \bar{z}_O) .$$

By making use of this formula it is a simple matter, after determination of interfaced results for $y(t^*)$, to compute the "as if" shocks $\tilde{z}_O$. In the present context the obvious choice for the five macro-type variables to be selected by J_O would be the double endogeneities listed in section 2.4 plus ($x P_x$), the foreign currency value of exports.

above formula. Alternatively, since there are figures for the ORANI database year for the tariff levels t_i for all ORANI industries, one could argue that t_3 on the right hand side of the above equation should be an average of these. If the latter course were followed, however, a choice of weights would be necessary. Output weights might be favoured over import weights because the latter give zero weight to prohibitive tariffs. Alternatively, an 'ideal' weighting scheme could be derived by taking into account the differing potentials of marginal changes in different commodity tariffs to affect the aggregate volume of trade (see Dixon, Parmenter and Powell (forthcoming 1983)). However if, say, output related weights were chosen and it was then found that the double endogeneity y_g did not line up for this experiment (there being no free parameters to ensure consistency) then there might be some grounds for concern in using the micro weights in the computation of a macro effect.

A simple procedure which avoids these difficulties is to choose t_3 experimentally. Thus the tariff experiment is to be repeated, ranging over values of t_3 and hence over shocks to the power of the tariff variable in MACRO, using as a criterion the consistency between ORANI and MACRO of the real output double endogeneity y_g.

3.3 "As If" Shocks

One way of thinking about MACRO in the interfaced model is as the source of a macroeconomic environment for ORANI experiments. Since only a small portion of ORANI is explicitly involved in the interfaced model, in order to apply this environment to the full ORANI model it would be convenient if ORANI in stand-alone mode could be shocked in such a way as to replicate the macroeconomic environmental effects of an interfaced simulation. The procedure for determination of these "as if" shocks is as follows.

Let $y(t^*)$ represent the ORANI-MACRO solution vector, evaluated at t^*, to an interfaced experiment, such as the tariff experiment outlined above. Let H_o select from $y(t^*)$ those ORANI responses in the interfaced system which it is desired to replicate in an ORANI stand-alone experiment. That is, the replication of certain ORANI-MACRO results (e.g. for macro-type variables in ORANI) is taken as an

an influence. The relevant row of Q_M may therefore be specified to select these stimuli in appropriate proportions. The proportions are determined by the importance of net relative to replacement investment (in gross investment in construction and equipment), and by the importance of investment in construction and equipment relative to investment in dwellings, calculated as mean values over the MACRO model's estimation period.

3. DESCRIPTION OF THE EXPERIMENTS

3.1 The Preliminary Experiment

A preliminary, neutral, experiment consisting of a ten percent shock to real government expenditure is to be used to determine the optimal values of the interface parameters. The parameters are:

(i) the speeds of adjustment. These are the elements of the matrix A_0. For parsimony of parameterisation this matrix is chosen to be diagonal. This has the advantage of assigning at most one adjustment speed parameter to each ORANI equation. Since usually only the aggregate versions of ORANI equations are used explicitly in the interfaced system, this provides a simple identification of an adjustment speed which may subsequently be applied to some subset of the general ORANI disaggregated families of equations. For the model specification given above the matrix A_0 is of dimension 8 and the respective adjustment speeds relate to the following variables:

ORANI Variable		Adjustment Speed
1. y_g	Real Gross Domestic Product	β_1
2. P	Price Deflator for Aggregate Production	β_2
3. L_h	Aggregate Employment Demand (labour-hours)	β_3
4. i	Real Imports	β_4
5. P_{wl}	Price of Wool	β_5
6. x	Real Exports	β_6
7. P_x	Price of Exports ($US)	β_6
8. x P_x	Foreign currency Value of Exports	β_6

Since variable 8 must be assigned an adjustment speed which is consistent with variables 6 and 7, these are constrained to a common adjustment speed (β_6). The remaining five adjustment speeds are freely chosen. The parameterisation is in fact made upon e^{A_0}, so that the field of search is the six-dimensional positive orthant.

(ii) the ORANI response interval. This is the ORANI "short run", t* : the length of time during which the effects calculated from an ORANI stand-alone experiment would be expected to be working themselves out. A priori this interval is expected to be in the range 6 to 8 quarters and an intensive search over 5 to 12 quarters is to be carried out.

(iii) the hours parameter in the appended MACRO labour-hours equation. In the absence of re-estimation, it seems appropriate that any alterations to the models which require the introduction of new parameters should be undertaken in such a way as to determine the parameter values jointly with the interface parameters. This increases the dimensionality of the problem but seems somewhat less arbitrary than a two-step procedure.

The criterion for choice of the interface parameters is the minimisation of the weighted sum of squared deviations of the double endogeneities (listed in section 2.4) when evaluated at t*, and the weights in the criterion are all equal.

3.2 The Tariff Experiment

With the interface parameters set to values determined by the preliminary experiment, the ORANI-MACRO model is to be used to simulate the effects of a twenty-five percent across the board rise in the level of tariffs. The ORANI exogenous variable to be shocked is t_3, an aggregate variable constructed such that a proportionate change to it represents an across the board proportionate change to the tariffs in the individual ORANI industries. The MACRO variable, however, is not the average tariff rate but the power of the tariff, $1 + t_3$. Since

$$d \log (1+t_3) = \frac{t_3}{1+t_3} d \log t_3$$

it is apparent that the appropriate shock to the power to the tariff is itself dependent upon the average tariff level.

One approach to the determination of the MACRO shock would be to use the average value of t_3 over the MACRO estimation period in the