DM/83/16

INTERNATIONAL MONETARY FUND

Research Department

Real Exchange Rate Adjustment to Exogenous Terms of Trade Shocks*

Prepared by Grant H. Spencer

Approved by Jacques R. Artus

March 3, 1983

Summary

This paper considers the case of a small open economy where an external imbalance arises as the result of a sustained shift in the external terms of trade. Such a shift has a permanent effect on the real value of the aggregate domestic product and a return to external balance requires that real incomes adjust accordingly. If aggregate activity is to be maintained at its original level, then such an adjustment requires a change in the real exchange rate, defined here as the price of foreign output in domestic currency relative to the price of domestic output. With traded goods prices fixed in foreign currency terms, a change in the real exchange rate brings about a shift in the relative price of traded to non-traded goods which in turn leads to the changes in domestic production and absorption patterns required to correct the initial external imbalance.

The purpose of the paper is to investigate the extent to which real exchange rate adjustments may be required to offset the trade balance effects of terms of trade shocks, given a constant level of total output, and employing alternative structural assumptions regarding trade elasticities and traded goods shares. A simple analytical framework is developed and used to generate a comparative static result, which is then quantified using parameter estimates for five small industrial countries: Australia,

* The author wishes to thank Jacques Artus, Michael Hadjimichael, William Hemphill, Michio Ishihara, Malcolm Knight, and Subash Thakur for helpful comments on earlier drafts.

Denmark, Finland, Ireland, and New Zealand. Differences between country outcomes are used to highlight the sensitivity of the numerical results to variations in underlying structural parameters. Summarizing the range of numerical results, the percentage real depreciation required to offset a 1 per cent fall in the terms of trade was found to lie between 0.9 per cent for Ireland and 1.4 per cent for Australia. The larger required adjustments were found to be associated with relatively small import price and income elasticities, and with relatively small shares of traded goods in output and absorption.

I. Introduction

In recent years frequent calls have been made for adjustment on the part of the developing and small industrial countries to correct external and internal imbalances which have persisted since the time of the first oil shock. Furthermore, it has been claimed that in many cases a shift in the real exchange rate, induced by some combination of demand management and exchange rate policies, would be appropriate. This argument is based on the view that the adverse terms of trade changes faced by many small specialized economies during the 1970s should to some extent be regarded as permanent. It follows that the real exchange rate of such countries should not be supported at historical levels in anticipation of corrective (cyclical) terms of trade movements; rather they should be adjusted towards new, more sustainable levels.

While it may be difficult in many countries to achieve even small real exchange rate movements in the direction of a sustainable equilibrium, there would nevertheless appear to be a need for a better understanding of the size of real exchange rate adjustments which may be required to fully offset a given change in the terms of trade. More specifically, our concern here is to consider the size of real exchange rate adjustments, defined in terms of relative GDP deflators, which may be required to offset the trade balance effects of a change in the terms of trade given that aggregate activity is maintained at some initial pre-shock level.

In Section II a simple model is developed of a small open economy facing infinite foreign price elasticities and having a fixed level of total output. A comparative static result is then derived which gives combinations of terms of trade and real exchange rate changes required to maintain a given initial trade balance. This result is quantified in Section III where estimates are obtained of trade elasticities and share parameters for five small industrial countries: Australia, Denmark, Finland, Ireland, and New Zealand. The sensitivity of outcomes is discussed in Section IV, largely within the context of inter-country differences in parameter estimates.

II. The Model

There is now a considerable literature on the macroeconomic implications of price shocks arising from commodity markets, but little of this work has considered the situation where a permanent terms of trade shock is imposed on a small open economy. Models of the open economy have typically included two traded goods, with the home economy facing an infinitely elastic supply of a foreign final good, but facing a relatively inelastic foreign demand for its own domestic final good. In order to analyze the effects of an external shock to the relative price of an imported raw material this framework has been expanded, for example, by Findlay and Rodriguez (1977), Bruno and Sachs (1979), Obstfeld (1980), and Buiter (1978), to include a third importable good which is used as an intermediate input into domestic production, and which has its price set in relation to the foreign final good. The experiment which is typically conducted within such a framework involves a change in the foreign relative price of the intermediate import. As domestic expenditures and production respond to this shift, the impact of the relative price change may then be traced, inter alia, to shifts in both the real exchange rate and the terms of trade.

In moving to a small open economy model the exportable domestic product becomes a perfect substitute for the foreign final good, and consequently both importers and exporters become price takers. Within this framework, an external relative price shock is seen as an exogenous shift in the terms of trade. In order that the overall domestic price level and hence the real exchange rate may respond to such a shock, it becomes necessary to distinguish a non-traded good from the two (importable and exportable) traded goods. If, however, the intention is to conduct an empirical analysis within a macroeconomic framework, this then raised the prospect of a considerable modelling--data collection task and for this reason it is convenient here to adopt a number of simplifying assumptions. First, given that our concern is not with cyclical fluctuations in aggregate production, but with medium-term effects on patterns of production and absorption, it is assumed that total domestic output is fixed. Secondly, it is assumed that production of traded goods is concentrated in exportables and that absorption is concentrated in importables. These latter two assumptions allow substitution possibilities to be characterized by one export supply elasticity and one import demand elasticity.

The four components of supply and demand in the model are given by equations (1)-(4). With supply decisions constrained by a fixed level of total output, the supply of exports is determined as a price sensitive ratio of total output. The supply of non-traded goods is determined residually in equation (2); in that this assumes perfect substitution in production, the home economy may best be seen here as the producer of just one good which is sold both on a protected home market at a monopoly price, and on the export market at a fixed world price. On the demand side the scale variable adopted is nominal output deflated by a domestic expenditure price; absorption is thus affected by changes in purchasing power arising through terms of trade movements. The relative demand price entering the import equation is also deflated by the expenditure price. To maintain internal equilibrium within the model, equation (4) sets the demand for non-tradables equal to supply. It may be noted here that while the home economy's 'non-traded' and export products may be distinguished only as a result of price discrimination between home and export markets, the 'non-traded' product is necessarily an imperfect substitute for the imported good.

(1) $Q_X = Q_X(P_X/P_Q).Q$

(2) $Q_{NT} = Q - Q_X$

(3) $D_M = D_M(P_M/P_D,\ Q.P_Q/P_D)$

(4) $D_{NT} = Q_{NT}$

$D = D_M + D_{NT}$

Notation:

Q_X = Volume of exports.

Q_{NT} = Volume of non-traded goods production.

Q = Fixed volume of total output.

D_M = Volume of imports.

D_{NT} = Real domestic expenditure on non-traded goods.

D = Total real domestic expenditure.

P_X = Export price index, local currency.

P_M = Import price index, local currency.

P_Q = GDP deflator.

P_D = Domestic expenditure deflator.

Price and income elasticities are defined as:

$\alpha = \partial \ell n Q_X / \partial \ell n(P_X/P_Q)$

$\eta = \partial \ell n D_M / \partial \ell n(P_M/P_D)$

$\varepsilon = \partial \ell n D_M / \partial \ell n(Q.P_Q/P_D)$

Both the output and expenditure price indexes can be expressed in terms of the three product prices with weights reflecting the shares of exportables and importables in total output and absorption respectively:

(5) $P_Q = \gamma P_X + (1-\gamma)P_{NT}$

(6) $P_D = \sigma P_M + (1-\sigma)P_{NT}$

The terms of trade and real exchange rate are defined as

(7) $T = P_X/P_M$

and

$R = E.P_Q^*/P_Q$

where E is the nominal exchange rate and * denotes foreign equivalent. Defining θ as the traded goods expenditure price relative to the output price, the assumption of no exportables consumption in the home country implies that:

(8) $\theta = P_M/P_Q$

If δ is taken as the share of foreign traded goods expenditures going on goods which are exportable by the home country, then the foreign equivalent is:

(9) $\theta^* = [(1-\delta)P_M + \delta P_X]/P_Q^*.E$

and the real exchange rate can be expressed as:

(10) $R = [(1-\delta) + \delta T]\ \theta/\theta^*$

The measure of the external balance which we choose to keep fixed is the local currency trade balance as a proportion of GDP:

$B = (P_X Q_X - P_M D_M)/Q.P_Q$

Substituting equations (1), (3), (5), (6), (7), and (8) into this expression and setting the total differential equal to zero, a linear homogenous equation is obtained 1/ in $d\ell nT$ and $d\ell n\theta$ (equation (11)) with arguments W_T and W_θ depending on the two share parameters γ and σ , the elasticities α, η,and ε, and the size of the initial current account balance as a proportion of nominal output ϕ. 2/

1/ See Appendix II for a full derivation of equations (11), (12), and (13).

2/ The initial scale of the current balance, rather than the trade balance, is required in order to determine the scale of total absorption relative to total output.

(11) $W_\theta d\ell n\theta + W_T d\ell nT = 0$

where

(12) $W_\theta = \gamma - (1-\phi)\sigma + \alpha\gamma - \eta\ \sigma(1-\sigma)(1-\phi)/(1-\gamma) + \varepsilon\ \sigma(\sigma-\gamma)(1-\phi)/(1-\gamma)$

and

(13) $W_T = \gamma + \alpha\gamma - \eta\ \sigma(1-\sigma)(1-\phi)\gamma/(1-\gamma) - \varepsilon\ \sigma(1-\sigma)(1-\phi)\gamma/(1-\gamma)$

Condition (11) combined with the real exchange rate expression in (10) implies that:

$$\left.\frac{d\ell nR}{d\ell nT}\right|_{dB=0} = \left.\frac{d\ell n\theta}{d\ell nT}\right|_{dB=0} - \frac{d\ell n\theta^*}{d\ell nT} + \delta$$

$$= -W_T/W_\theta - \frac{d\ell n\theta^*}{d\ell nT} + \delta$$

Thus, provided that the foreign traded goods price ratio θ^* is unaffected by movements in the home country's terms of trade and provided that the home country's exports represent a small proportion of total foreign traded goods expenditures, then we may focus on the quantity $m = -W_T/W_\theta$ as a measure of the adjustment required to maintain a constant trade balance in the face of a terms of trade shift. In the case of a small specialized economy δ will certainly tend to be small and if terms of trade fluctuations emanate primarily from movements in the foreign relative price of the home country's exports then the assumption of a fixed θ^* will also be acceptable. However, if a terms of trade shock is seen to result primarily from a shift in the foreign relative price of the home country's imports then the implied change in θ^* will not be negligible and it will become necessary to make an estimate of this change in order to obtain a proper assessment of the required real exchange rate adjustment. Notwithstanding this caveat, the empirical analysis here does not relate to specific terms of trade shocks and so, by default, it is assumed that the foreign traded goods relative price θ^* remains fixed.

Before going on to derive estimates of m for specific sets of country parameters, it may be of use to discuss briefly the structure of W_θ and W_T as defined in (12) and (13). Each of these expressions comprises four components representing the four channels in the model through which movements in the real exchange rate and the terms of trade affect the trade balance. The four types of effects are:

1) Pure valuation effects. These are caused primarily through terms of trade movements but also through real exchange rate adjustments when there is an initial trade account imbalance. It may be noted here that if the comparative static result is derived on the alternative basis of a

fixed trade balance in foreign currency terms then the only change which is required to the expressions for W_θ and W_T in (12) and (13) is the elimination of the exchange rate valuation effect, i.e., the first two terms in (12).

2) Relative price effects on the volume of exports. These are equal in size between the two expressions with equivalent 1 per cent increases in T and θ both leading to $\gamma\alpha$ per cent increases in export volumes.

3) Relative price effects on import volumes. A terms of trade improvement (T increase) and a real exchange rate depreciation (θ increase) both improve the trade balance through this channel, a real depreciation more so than an equivalent terms of trade improvement. The result that an increase in the terms of trade causes a trade balance improvement through an increase in the relative price of imports, is somewhat counterintuitive. It must be recalled, however, that W_T represents a partial derivative, giving the trade balance effects of a terms of trade change for a fixed real exchange rate level. If the real exchange rate is allowed to appreciate as the terms of trade improve, then the net effect is a decrease in the relative price of imports which tends to worsen the trade balance.

4) Real income effects on import volumes. The trade balance improvement caused by the valuation and substitution effects of a terms of trade improvement are offset to some extent by the income effect which causes import volumes to increase. The impact of income effects resulting from real exchange rate movements depends on the relative proportions of traded goods in production and expenditure, i.e., on the sign of $(\sigma-\gamma)$. If, for example, imports represent a greater proportion of domestic expenditures than exports represent as a proportion of total production, then a real depreciation causes a reduction in real income which tends to improve the trade balance. In the reverse case a real depreciation tends to worsen the trade balance through this channel.

III. Parameter Estimates for Five Small Industrial Countries

The six parameters entering expressions (12) and (13) are estimated here for each of the five small industrial countries: Australia, Denmark, Finland, Ireland, and New Zealand. The three elasticities are estimated using time series regressions while estimates for the three ratios are based on simple historical averages.

1. Regression Estimates

Ideally, we wish to estimate export supply and import demand functions which are essentially of the form described in Section II. Given that the expressions in equations (1) and (3) are simple long-run relationships, however, these are modified somewhat in an attempt to allow for the short-term effects of business cycles, lagged relative price effects, and unusual historical events which would tend to bias elasticity estimates derived from simple static estimating equations. Furthermore, the two equations are disaggregated in order to allow for parameter differences across broad commodity groupings. Both the export and import estimating equations are reduced form equations in that all right hand side variables are predetermined with respect to our model. They are estimated on annual data extending over the 20-year period from 1960 to 1980.

a. Export Supply

Based on equation (1), the general form adopted here for estimating equations is:

$$(15)\quad \ell n(X/PX)_t - \ell nQ_t = \alpha_0 + \alpha_1(L)\ell n(PX/PQ)_t + \alpha_2\ell n(QF/QFT)_t + \alpha_3\ell n(Q/QT)_t + \alpha_4 TD$$

where: 1/

X = Local currency value of merchandise exports f.o.b.

PX = Export unit value.

Q = GDP in constant (1975) prices.

PQ = GDP deflator.

QF = Index of foreign GDP, constant prices.

QT = Exponential trend in output, formed as the exponential of predicted values from the regression of ℓnQ on a constant and trend.

QFT = Exponential trend in QF, formed in the same manner at QT.

TD = Time trend.

L = Lag operator.

$\alpha_1(L)$ = Almon lag polynomial. Note that the estimated long-run relative price elasticity $\hat{\alpha}$ is equal to $\hat{\alpha}_1(1)$ = the sum of the estimated Almon lag coefficients.

1/ Data sources for the regression analysis are given in Appendix I.

Thus, the proportion of output exported is given as a function of: lagged relative prices intended to capture medium-term substitution effects; domestic and foreign cyclical variables intended to pick up the direct demand effects which circumvent the price mechanism in the short term; and a time trend intended to capture secular shifts in output composition. In the actual estimating equations, kinked trend variables are used in cases where significant shifts in trend growth have occurred during the sample period. Dummy variables are also included to allow for specific historical events. It may be noted further from the results presented in Table 1 that the actual estimating equations include lags and first differences rather than current levels of the cyclical variables where these give a better representation of cyclical demand pressures.

In the five countries under consideration, exports are commonly concentrated in a small number of distinct commodity groupings. Consequently, it is considered that the aggregate relative price elasticity estimates may be substantially improved by estimating separate equations of the form (15) for significant export subaggregates falling in one or more of the four categories:

XA = Exports of agricultural goods	SITC 0+1
XR = Exports of raw materials	SITC 2+4
XF = Exports of fuels	SITC 3
XM = Exports of manufactures	SITC 5-8

The intention here is not to focus on relative price movements between these commodity groupings, but rather to allow the magnitudes and lag structures of the same right hand side parameters in (15) to vary between the groups, and to allow the use of group specific dummy variables. Thus, apart from equation specific dummies and variations in the dynamic form of the cyclical variables, the regression set remains as in equation (15) and the overall relative price elasticity is derived by taking a simple weighted average of the disaggregated elasticity estimates. It may be noted from the weights used to construct the aggregate supply elasticities in Table 2, that those export sub-categories taken as exogenous contribute negligibly to country totals.

The estimated aggregate supply price elasticities reported in Table 2 are all of a similar magnitude, lying within the range from 0.5 to 1.5. The size of standard errors given in Table 1 indicate that it is the smallest of these elasticities, for Ireland, which is the most precisely determined. The commodity group elasticities for Ireland have standard errors around 0.15 as compared to an across country median standard error

Table 1. Export Supply Equation Estimates 1/

Country	Australia			Denmark			Finland		Ireland		New Zealand	
Dependent variable	$\ell n(\frac{XA/PX}{Q})$	$\ell n(\frac{XR/PX}{Q})$	$\ell n(\frac{XM/PX}{Q})$	$\ell n(\frac{XA/PX}{Q})$	$\ell n(\frac{XR/PX}{Q})$	$\ell n(\frac{XM/PX}{Q})$	$\ell n(\frac{XR/PX}{Q})$	$\ell n(\frac{XM/PX}{Q})$	$\ell n(\frac{XA/PX}{Q})$	$\ell n(\frac{XM/PX}{Q})$	$\ell n(\frac{(XA+XR)/PX}{Q})$ 5/	$\ell n(\frac{XM/PX}{Q})$
Lag weights on relative price $\ell n(PX/PO)$												
(t)	0.141		0.015		0.327	0.787			0.087	-0.002		0.041
(t-1)	0.255	0.205	0.249	0.150	-0.024				0.103	0.083		0.272
(t-2)	0.298	0.295	0.244	0.292	0.008			0.100	0.106	0.134		0.384
(t-3)	0.270	0.291		0.332	0.255		0.258	0.363	0.098	0.152	0.053	0.376
(t-4)	0.170	0.193		0.271	0.546		0.758	0.434	0.077	0.135	0.229	0.248
(t-5)				0.107	0.713		0.882	0.313	0.045	0.084	0.278	
(t-6)					0.588		0.629				0.202	
Total weight	1.134	0.984	0.507	1.152	2.414	0.787	2.527	1.209	0.515	0.587	0.762	1.321
	(0.279)	(0.485)	(0.715)	(0.540)	(0.683)	(0.424)	(1.063)	(0.438)	(0.116)	(0.169)	(0.568)	(0.816)
$\ell n(O/OT)$ 2/				-2.406	-1.566	-0.901	-0.422(-1)	-0.363			-0.501	-1.209(-1)
				(0.593)	(0.994)	(0.728)	(0.664)	(0.356)			(0.855)	(0.492)
$\Delta\ell n(O/OT)$	-0.818(-1)	-0.511	-1.833						-0.396(-1)	-0.577(-1)		
	(0.709)	(0.747)	(1.200)						(0.579)	(0.331)		
$\ell n(OF/OFT)$		2.571		3.719	5.541	1.565		0.493		4.003 6/		0.120
		(0.910)		(1.130)	(1.625)	(1.101)		(0.935)		(0.718)		(1.201)
$\Delta\ell n(OF/OFT)$	1.640(-2)	2.776	1.192				5.703 6/		0.233		1.193	
	(0.652)	(0.953)	(1.470)				(2.128)		(0.598)		(0.840)	
CNST	-3.781	-3.865	-6.527	-3.418	-7.023	-4.625	-1.786	-4.127	-2.138	-4.480	-2.238	-6.833
	(0.162)	(0.357)	(1.055)	(0.484)	(0.604)	(0.448)	(0.580)	(0.150)	(0.046)	(0.023)	(0.314)	(0.276)
TD	0.022	0.022		0.028	0.097		-0.030		0.133	0.099	0.009	
	(0.006)	(0.013)		(0.017)	(0.021)		(0.017)		(0.002)	(0.001)	(0.009)	
TD1 3/			0.133			0.103		0.113				0.092
			(0.047)			(0.019)		(0.008)				(0.012)
TD2			0.015			0.032						0.221
			(0.009)			(0.009)						(0.033)
DUM1	0.217	0.059					-0.190	-0.125	0.089	0.083	-0.105	
	(0.043)	(0.040)					(0.065)	(0.047)	(0.052)	(0.023)	(0.042)	
DUM2	-0.188	-0.124									-0.190	
	(0.029)	(0.043)									(0.052)	
Rho			0.411		-0.294		0.752		-0.531	-0.640		
			(0.252)		(0.224)		(0.076)		(0.205)	(0.215)		
$\overline{R}^2$	0.826	0.886	0.920	0.794	0.813	0.983	0.759	0.970	0.748	0.998	0.879	0.990
S.E.E.	0.040	0.037	0.062	0.031	0.048	0.037	0.058	0.033	0.044	0.026	0.035	0.064
D.W.	2.67	2.47	1.43	2.11	2.16	1.55	1.43	2.15	2.47	2.55	1.72	2.24
Poly characteristics 4/	(2,2,2.07)	(2,2,2.48)	(2,2,1.45)	(2,0,2.91)	(3,2,4.16)	(0,0,0)	(2,2,4.75)	(2,2,3.79)	(2,2,2.21)	(2,2,3.01)	(2,2,4.82)	(2,2,2.39)
and F test	$F_{3,8}$=0.62	$F_{2,6}$=2.02	$F_{1,9}$=0.44	$F_{2,11}$=0.06	$F_{4,9}$=1.22	..	$F_{2,7}$=1.34	$F_{2,9}$=0.74	$F_{4,8}$=2.10	$F_{4,8}$=14.50**	$F_{2,11}$=0.23	$F_{3,9}$=2.41
t test on unit Q elasticity	t_{10}=1.48	t_7=2.26	t_9=0.51	..	..	..	t_8=1.60	t_{10}=0.63	t_{11}=1.35	t_{11}=0.59	..	t_{11}=0.06
Sample	1963-80	1965-80	1964-80	1961-80	1961-80	1961-80	1964-80	1964-80	1962-80	1961-80	1961-80	1963-80

1/ Standard errors in parentheses. All estimates by OLS.
2/ Lags of cyclical variables are indicated where used.
3/ Country definitions of TD1 and TD2, and of DUM1, DUM2, are given in Appendix I.
4/ First number in parentheses gives degree of polynomial restrictions. The second gives the type of end point restrictions adopted: 0 = none, 1 = near end zero restriction, 2 = far end zero restriction. The third number gives the estimated average length of lag in years. The F statistic provides a test of the polynomial lag structure against an unrestricted distributed lag of the same length.
5/ In the case of New Zealand, raw material exports mainly consist of animal and vegetable products which are closely linked to agricultural production. Accordingly, agricultural and raw material exports are treated here in aggregate.
6/ This weight is spread over both current and lagged levels of the regressor.

* Indicates a significant F test at the 5 per cent level.
** Indicates a significant F test at the 1 per cent level.

of approximately 0.4. The time profile of lagged relative price effects, as revealed in Table 1, is seen to vary widely across commodity groups and countries. The average length of lag, however, is commonly found to lie between two and four years.

Table 2. Derivation of Aggregate Export Supply Price Elasticities 1/

	Australia		Denmark		Finland		Ireland		New Zealand	
	Share	Elast.	Share	Elast.	Share	Elast.	Share	Elast.	Share	Elast.
Agriculture	0.359	1.134	0.395	1.152	0.038	..	0.524	0.515	0.528	0.762
Raw Materials	0.347	0.984	0.075	2.414	0.238	2.527	0.063	..	0.344	
Fuels	0.072	..	0.022	..	0.012	..	0.012	..	0.007	..
Manufactures	0.222	0.507	0.508	0.787	0.712	1.209	0.401	0.587	0.121	1.321
Total		0.861		1.037		1.462		0.505		0.824

1/ The "share" reported is the 20-year average from 1960 to 1980. Elasticity estimates are from Table 1.

In making comparisons with previous elasticity estimates, the numbers obtained here appear to be generally consistent with the small amount of available evidence. Econometric results reported in the OECD Economic Survey (1979) for Denmark include an estimated export volume equation which, while demand based, supports a significant profitability effect with an elasticity in the region of 0.6 to 1.0. In a survey of empirical work on Australia's balance of payments, MacFarlane (1979) finds agreement that a supply based model is appropriate for export volumes but, as a result of difficulties encountered in identifying stable supply functions, he finds that the evidence on export supply price responses is scant and inconclusive. Evidence on export supply responses for Finland is also scarce but in this instance it would seem, for example from work by Aurikko (1975), that the small country assumption has been rejected in favor of a demand based explanation of export volumes. In the case of New Zealand, a number of estimated export supply price elasticities are reported in Deane et al (1982) (ch. 25) and in general these lie within the vicinity of the estimates obtained here. Finally, the available evidence for Ireland is limited, with agricultural supply models having concentrated on overall production rather than exports. Supply price elasticities have been estimated by O'Connell (1977) for manufactured exports, and these lie in a range (2.0 to 3.0) which is considerably higher than the 0.6 estimate reported in Table 1. However, O'Connell's estimating equations do not include an output scale variable and therefore they are not directly comparable with the share supply equations estimated here.

b. Import demand

The demand for import volumes is disaggregated on a simple fuels, non-fuels basis, the main objective being to filter out any spurious effects on aggregate elasticity estimates resulting from the two oil shocks. In order to achieve this it is of course necessary to explain the two import components as functions of their own relative prices, rather than of a single overall relative price as used in the disaggregated export equations. However, given that the demand for fuels is expected to be relatively inelastic, separate cross price effects between fuels and non-fuels are not considered. Estimating equations, based on equation (3), are thus of the form:

$$(16) \quad \ell n(M/PM)_t = \beta_0 + \beta_1 \ell n(Q.PQ/PD)_t + \beta_2(L)\ell n(PM/PD)_t + \beta_3 \ell n(Q/QT)_t + \beta_5 TD$$

where 1/

M = Local currency value of merchandise imports f.o.b.

PM = Import unit value

PD = Domestic expenditure deflator

and all other variables are as defined for equation (15).
Equations of this form are estimated for each of the five countries with M and PM being replaced by MF and PMF for fuel imports, and by MNF and PMNF for non-fuel imports where:

MF = Imports of fuels, local currency, SITC 3

MNF = Imports of non-fuels, local currency, SITC 0-2, 4-8

PMF = Unit value, fuel imports

PMNF = Unit value, non-fuel imports.

1/ Data sources for the regression analysis are given in Appendix I.

Table 3. Import Demand Equation Estimates 1/

Country / Dependent variable	Australia 3/ ℓn(MNF/PMNF)	Denmark ℓn(MNF/PMNF)	Denmark ℓn(MF/PMF)	Finland ℓn(MNF/PMNF)	Finland ℓn(MF/PMF)	Ireland ℓn(MNF/PMNF)	Ireland ℓn(MF/PMF)	New Zealand ℓn(MNF/PMNF)	New Zealand ℓn(MF/PMF)
ℓn(PMNF/PD)	-0.410 (0.130)			-0.952 (0.196)		-0.817 (0.363)			
$ℓn(PMNF/PD)_{-1}$		-0.481 (0.188)						-0.580 (0.381)	
ℓn(PMF/PD)			-0.133 (0.039)		-0.205 (0.087)		-0.344 (0.048)		-0.199 (0.048)
$ℓn(PMF/PD)_{-1}$					-0.196 (0.086)				
ℓn(Q.PQ/PD)	1.034 (0.043)	1.249 (0.138)	0.905 (0.055)	1.242 (0.043)					
$ℓn(Q.PQ/PD)_{-1}$					1.597 (0.221)	1.461 (0.191)	0.879 (0.098)	1.114 (0.147)	0.671 (0.128)
$ℓn(Q/QT)_{-1}$			1.268 (0.354)						
Δℓ(Q/QT)	0.650 (0.612)	0.517 (0.348)			1.267 (0.664)			1.391 (1.026)	
$Δℓn(Q/QT)_{-1}$				1.858 (0.442)		1.903 (0.677)			0.558 (0.747)
CNST	-2.331 (0.170)	-2.827 (0.739)	-2.483 (0.296)	-2.774 (0.187)	-5.591 (1.011)	-4.616 (1.555)	-1.696 (0.805)	-2.870 (1.328)	-0.413 (1.187)
DUM1 2/	0.132 (0.036)	-0.085 (0.023)				0.048 (0.028)		-0.208 (0.076)	
DUM2	0.157 (0.053)							-0.161 (0.085)	
DUM3	-0.175 (0.055)								
Rho					0.429 (0.202)	0.756 (0.155)			
$\bar{R}^2$	0.974	0.987	0.967	0.980	0.814	0.839	0.806	0.927	0.570
S.E.E.	0.050	0.032	0.038	0.049	0.073	0.056	0.073	0.072	0.074
D.W.	1.81	1.66	2.01	1.61	2.13	1.49	1.83	2.12	2.01
Sample	1961-80	1964-80	1961-80	1961-80	1962-80	1961-80	1961-80	1962-80	1961-80

1/ Standard errors are in parentheses. All estimates are by OLS.
2/ Country definitions of DUM1, DUM2, DUM3 are given in Appendix I.
3/ No equation estimates of any accuracy could be obtained for the volume of Australia's fuel imports as a result of significant variations in home production.

As in the export supply equations, cyclical and trend terms are included here in an attempt to account for both direct short-term demand effects and longer-term shifts in tastes and production patterns. In the imports equation, however, only a domestic cyclical variable is included as fluctuations in foreign output are assumed to have no significant direct effect on the supply of imports available to the five countries under consideration. It may be noted from Table 3 that the first difference rather than the level of $\ell n(Q/QT)$ was generally found to give the best representation of domestic cyclical pressures on import volumes. Estimates of the aggregate income and relative price elasticities, ε and η, are derived in Table 4 as simple weighted averages of the β_2 and β_1 estimates respectively.

Table 4. Derivation of Aggregate Import Demand Price and Income Elasticities 1/

	Australia		Denmark		Finland		Ireland		New Zealand	
	Non-Fuels	Fuels	Non-Fuels	Fuels	Non-Fuels	Fuels	Non-Fuels	Fuels	Non-Fuels	Fuels
Shares	0.915	0.085	0.849	0.151	0.826	0.174	0.893	0.107	0.883	0.117
Price elasticities	-0.410	...	-0.428	-0.133	-0.952	-0.401	-0.817	-0.344	-0.580	-0.199
Total price elasticity	-0.375		-0.428		-0.856		-0.766		-0.535	
Income elasticities 2/	1.034	1.0	1.249	0.905	1.242	1.597	1.461	0.879	1.114	0.671
Total income elasticity	1.031		1.197		1.304		1.399		1.062	

1/ Reported shares are 20-year averages over 1960-1980. Elasticity estimates are from Table 3.
2/ Default value for the Australian income elasticity of demand for fuel imports is taken as 1.0.

Within the context of the model described in Section II, the estimating equation (16) is in reduced form but from a statistical viewpoint one may suspect a degree of (negative) reverse causality from import volumes to output and therefore some downward bias in both the income and and relative price elasticity estimates. For this reason the import equations were re-estimated using foreign GDP, the terms of trade and real government expenditure as instrumental variables. The resulting elasticity estimates, however, were very similar to the OLS estimates reported in Tables 3 and 4.

The lag structures on the relative price effects are of a simple form with no more than two price terms entering each equation and with no lags longer than one period. Such specifications were found to be most suitable following initial experiments with longer polynomial distributed lag structures. The estimated relative price elasticities are all of a moderate size, lying between -0.38 and -0.86. In comparison to estimates from previous studies the values derived here for Denmark, Finland, and New Zealand seem to be reasonably consistent. However, the surveys by McAleese (1970) and MacFarlane (1979) for Ireland and Australia, respectively, both report demand price elasticity estimates in the region of -1 to -1.5. This discrepancy may be attributed in part to the use here of domestic cyclical variables which tend to explain variations which might otherwise be picked up by the relative price terms. Furthermore, the studies cited in these surveys were based on data covering earlier historical periods which tend to yield larger elasticity estimates for the two countries concerned.

The estimated income elasticities of demand for imports are all found to be greater than one, lying between 1.03 for Australia and 1.40 for Ireland. Within the context of a steady state growth model, a 'long-run' income elasticity of demand which differs from one will cause the model to be dynamically unstable, but our present concern is to analyze relative price induced income effects within a comparative static framework and within this context a unity restriction is not considered to be appropriate. The income elasticity estimates reported in Table 4 are not inconsistent with comparable estimates derived in previous studies.

2. Ratio estimates

The three parameters of the model which remain to be estimated are:

γ = The share of total domestic output in exports.

σ = The share of total domestic expenditure going on imports.

ϕ = The current account balance as a proportion of nominal output.

The values adopted for these parameters are the average values of the actual ratios over the last five years (1976-1980) of the sample period. 1/

1/ Once ϕ is determined from current account and GDP data then the total domestic demand series used to estimate σ is just the GDP series scaled up by $(1-\phi)$.

These numbers serve to characterize the average structure of the five economies over recent history although it is clear that, in analyzing specific episodes, one may wish to base the parameter estimates on alternative historical periods. Indeed, if the objective is to formulate an appropriate response to a terms of trade shift which has already occurred, it may be of interest to use pre-shock parameter estimates in the expression (13) for W_T and post-shock estimates in the expression (12) for W_θ. The estimates based on 1976-1980 data are given in Table 5.

Table 5. Ratio Parameter Estimates

	ϕ	γ	σ
Australia	-0.021	0.133	0.113
Denmark	-0.044	0.230	0.265
Finland	-0.010	0.260	0.228
Ireland	-0.116	0.432	0.491
New Zealand	-0.038	0.193	0.186

IV. Comparative Static Results

In this section the parameter estimates presented in Tables 2, 4, and 5 are used to quantify the comparative static relationship, derived in Section II (equation (11)), between changes in the real exchange rate and the terms of trade which have offsetting effects on the trade balance. The quantity used to summarize this relationship is:

$$m = \left.\frac{d\ell n\theta}{d\ell nT}\right|_{dB=0} = -W_T/W_\theta$$

For a given foreign relative traded goods price θ^*, this quantity approximates the percentage real depreciation required to offset the effect of a permanent 1 per cent improvement in the terms of trade. 1/ The

1/ Note. A real appreciation occurs when θ falls.

sensitivity of country results is discussed largely within the context of intercountry differences although variations in price elasticities outside of the observed range are also considered. This is seen in Tables 6.1 to 6.5 below where values of m are reported both on the basis of best parameter estimates and also using a range of alternative import and export price elasticities. The ranges of price elasticities considered; 0.0 to 1.5 and 0.0 to -1.0 for exports and imports respectively, correspond roughly to the ranges observed across the five countries and thus enable comparisons to be made between countries with effects due to elasticity differences neutralized.

Briefly considering the tabulated figures corresponding to econometric elasticity estimates (those boxed in the tables), the absolute m values are seen to be considerably smaller for the two countries, Finland and Ireland, which have the largest import price and income elasticities. These countries both have price elasticities in the region of -0.8, income elasticities of 1.3 to 1.4, and m values close to -1. The remaining three countries all have import price elasticities in the region of -0.4 to -0.5, income elasticities between 1.0 and 1.2, and m values near -1.3. There is an indication therefore that one or both of the import elasticities have a significant bearing on the size of m. The relative importance of the import price elasticity vis-à-vis the export price elasticity is supported further by the general pattern of values observed in Tables 6.1 through 6.5 where, at least for non-zero α, the gradient of m by η appears to be steeper than the gradient of m by α. The lesser role of the export price elasticity α is demonstrated in the case of Ireland where relatively high import price and income elasticities dominate a low export price elasticity to give an $|m|$ value less than one. In the three countries with relatively steep tradeoffs, $|m|$ values may be ranked inversely by the size of $|\eta|$; relatively large export price and import income elasticities for Denmark do not significantly affect that country's tradeoff position relative to Australia and New Zealand.

Considering further the relationship between m and the two relative price elasticities, it is readily apparent from the tabulated figures that the extent of reductions in $|m|$ resulting from absolute increases in one of the elasticities, depends inversely on the absolute size of the other. In the situation where elasticities become large, however, the relationship loses symmetry; the gradient of m with respect to η approaches zero as α becomes large, but the gradient of m with respect to α becomes positive for large $|\eta|$ values. Specifically, with α carrying the same weight in both the W_θ and W_T expressions ((12) and (13)), increases in α are found to increase the value of $|m|$ when $|m|$ is smaller than 1. From the tabulated figures, it would appear that this point is reached in every country case, except Ireland, when η reaches a value in the region -0.8 to -1.0. For Ireland, $|m|$ approaches 1 when η equals -0.6. In contrast, the import price elasticity η always

Table 6. Real Exchange Rate, Terms of Trade Tradeoffs

Tabulated m values give the percentage real depreciation required to offset the trade balance effects of a one per cent increase in the terms of trade, for given values of country parameters. 1/

Table 6.1. Australia

Parameters: σ = 0.113 γ = 0.133 ε = 1.031 ϕ = -0.021

α \ η	0.000	-0.200	-0.375	-0.600	-0.800	-1.000
0.000	..	-3.117	-2.075	-1.473	-1.184	-0.997
0.500	-2.253	-1.776	-1.506	-1.266	-1.114	-0.998
0.861	-1.788	-1.532	|-1.366|	-1.202	-1.090	-0.998
1.000	-1.689	-1.475	-1.331	-1.185	-1.083	-0.999
1.500	-1.476	-1.342	-1.246	-1.142	-1.065	-0.999

Table 6.2. Denmark

Parameters: σ = 0.265 γ = 0.230 ε = 1.197 ϕ = -0.044

α \ η	0.000	-0.200	-0.428	-0.600	-0.800	-1.000
0.000	..	-7.989	-2.251	-1.527	-1.146	-0.938
0.500	-3.265	-2.088	-1.519	-1.277	-1.089	-0.958
0.800	-2.240	-1.722	-1.384	-1.215	-1.072	-0.965
1.037	-1.913	-1.571	|-1.318|	-1.183	-1.063	-0.969
1.500	-1.603	-1.405	-1.239	-1.142	-1.050	-0.975

Table 6.3. Finland

Parameters: σ = 0.228 γ = 0.260 ε = 1.304 ϕ = -0.010

α \ η	0.000	-0.200	-0.400	-0.600	-0.856	-1.000
0.000	..	-2.949	-1.804	-1.343	-1.043	-0.938
0.500	-2.103	-1.648	-1.374	-1.190	-1.027	-0.959
0.800	-1.720	-1.463	-1.283	-1.150	-1.022	-0.966
1.000	-1.585	-1.389	-1.243	-1.131	-1.020	-0.969
1.462	-1.408	-1.284	-1.184	-1.102	|-1.016|	-0.975

Table 6. (Concluded) Real Exchange Rate, Terms of Trade Tradeoffs

Table 6.4. Ireland

Parameters: σ = 0.491 γ = 0.432 ε = 1.399 ϕ = -0.116

α \ η	0.000	-0.200	-0.400	-0.600	-0.766	-1.000
0.000	..	-2.871	-1.375	-1.016	-0.876	-0.764
0.505	-1.944	-1.413	-1.159	-1.009	|-0.925|	-0.841
0.800	-1.555	-1.284	-1.119	-1.007	-0.939	-0.866
1.00	-1.434	-1.234	-1.101	-1.006	-0.946	-0.879
1.500	-1.281	-1.163	-1.074	-1.005	-0.957	-0.903

Table 6.5. New Zealand

Parameters: σ = 0.186 γ = 0.193 ε = 1.062 ϕ = -0.038

α \ η	0.000	-0.200	-0.400	-0.535	-0.800	-1.000
0.000	..	-4.329	-2.211	-1.692	-1.190	-0.989
0.500	-2.637	-1.924	-1.534	-1.357	-1.117	-0.992
0.824	-1.986	-1.630	-1.392	|-1.271|	-1.093	-0.994
1.000	-1.811	-1.537	-1.342	-1.240	-1.084	-0.994
1.500	-1.539	-1.378	-1.252	-1.181	-1.066	-0.995

1/ Recalling again the definitions of model parameters,

α = Export supply price elasticity
η = Import demand price elasticity.
σ = Share of merchandise imports in total domestic demand.
γ = Share of merchandise exports in total domestic output.
ε = Income elasticity of demand for imports.
ϕ = Current account balance as a proportion of nominal output.

carries a larger weight in W_θ than in W_T and consequently a larger demand price elasticity almost always 1/ reduces $|m|$.

Briefly considering the behavior of m values when both of the relative price elasticities approach zero, it is apparent from equation (12) that the total real exchange rate effect W_θ comes to be dominated by real income and valuation effects which are small and of uncertain sign. In such a situation the real exchange rate clearly ceases to be a relevant policy variable and m becomes rather meaningless; accordingly m values for $\alpha=0$, $\eta=0$ are not tabulated.

Whilst both the valuation effects and the export and import relative price effects of a terms of trade improvement are positive, the terms of trade income effect operating through import volumes is seen to work in the opposite direction, reducing the need for offsetting real exchange rate adjustments. Income effects resulting directly from real exchange rate adjustments are proportional to $(\sigma-\gamma)$, and stabilize the trade balance when this quantity is positive. Such effects, however, are relatively small compared to terms of trade income effects, and furthermore they are more than offset by the direct valuation effects of real exchange rate adjustments which are destabilizing under an initial deficit position. It follows that the income elasticity of demand for imports ε has its primary influence on m through the terms of trade income effect, and that therefore, $|m|$ varies inversely with ε. The size of real income changes resulting from terms of trade movements depends mainly on the size of the traded goods sector and consequently the influence of ε on $|m|$ is greater in those countries with large traded goods sectors.

Considering the influence on m due to the size of the initial trade balance, a worsened initial position, caused say by a ceteris paribus increase in σ, tends to magnify the stabilizing income and relative price effects of real exchange rate changes. It also increases the degree to which terms of trade movements are self correcting. As mentioned above, however, the real exchange rate valuation effect becomes more destabilizing as the initial balance position worsens. This effect becomes relatively less important as the size of the traded goods sector increases, but even in the case of Ireland it is large enough so that a worsened initial deficit causes $|m|$ to increase. The net influence of the initial trade balance may be demonstrated in a comparison of the tabulated figures for Denmark and Finland where, for similar income elasticities and traded goods shares, $|m|$ values corresponding to like price elasticities are found to be higher for that country, Denmark, which has the larger initial deficit position.

1/ The only requirement here is that $|m|$ be greater than γ.

To see how the size of the traded goods sector may affect m it is necessary to look at the general level of σ and γ rather than their difference. The task may be made easier by assuming that both the trade and current accounts are initially in balance. Substituting $\gamma=\sigma$ and $\phi=0$ into (12) and (13), the expression for m reduces to

$$(17) \quad m' = \frac{-W_T}{W_\theta}\Bigg|_{\substack{\sigma = \gamma \\ \phi = 0}} = \frac{\gamma(\varepsilon+\eta)-(1+\alpha)}{(\alpha-\eta)}$$

and the absolute value of m' is seen to be inversely proportional to γ provided that $(\varepsilon+\eta)$ is positive. Providing some rationale for this condition, an increase in the size of the traded goods sector leads to near proportionate increases in all relative price and valuation effects caused by real exchange rate changes and, similarly, proportionate increases in the export relative price and valuation effects caused by terms of trade changes. However, the terms of trade effects working through relative import prices and real income increase more than proportionately with the traded goods share and so, provided that the net impact of these two effects is negative (stabilizing), an increase in the relative size of the traded sector reduces the real exchange rate adjustment required to offset a given terms of trade change. Given that $(\varepsilon+\eta)$ is indeed found to be positive in each of the five country cases, we may thus expect to see larger traded goods sectors associated with absolutely smaller m values. Unfortunately, intercountry differences in tabulated m values which relate specifically to the size of the traded goods sector are not easily detected as there is no one country which provides a suitable 'control' for any other. However, the Australia table may be recalculated with $\varepsilon = 1.304$ and $\phi = -0.010$, and compared with the Finland table to give an indication of differences in m resulting from a traded goods share of 0.26 for Finland as opposed to 0.13 for Australia. Comparing figures based on the Australian relative price elasticity estimates, the higher traded goods share appears to decrease $|m|$ by approximately 0.06.

Whilst the real exchange rate adjustment to a terms of trade shock may become smaller as the traded goods sector becomes larger it should be recognized that real exchange rate adjustments also become harder to achieve in that larger movements are required in the relative price of non-traded goods. Using the model equations from Section II it can be shown that the relative non-traded goods price adjustment associated with any given m value is:

$$(18) \quad \frac{d\ell n(P_{NT}/P_Q)}{d\ell nT}\Bigg|_{dB=0} = \frac{-\gamma(m+1)}{(1-\gamma)}$$

Considering the simplified definition of m given in (17), this expression indicates that an increase in γ will increase the required adjustment in the relative price of non-traded goods even though $|m|$ will tend to fall. Of course in the extreme case where the non-traded sector becomes small, i.e., γ approaches 1, then m approaches -1 as the real exchange rate becomes more like the inverse of the terms of trade; but trade balance adjustment to a terms of trade shock becomes more nearly impossible as the required change in the non-traded goods price approaches infinity.

V. Conclusion

The aim of the foregoing analysis has been to develop a simple framework which may be used to derive an estimate of the real exchange rate correction required to maintain the trade balance of a small open economy under a permanent exogenous shift in the terms of trade. The framework is based on the assumption of an infinite elasticity of demand for exports, stable export supply and import demand functions and a fixed long-run level of real GDP. Goods are classified as either exportable, importable, or non-traded and the traded goods sector is assumed to be completely specialized in that no importables are produced and no exportables are consumed. Furthermore, it is assumed that the domestic price level is controlled in the long run, independently of terms of trade and real exchange rate movements.

Based on this list of simplifying assumptions an economy which is suitable for analysis within the framework should be specialized and also small in that it exerts little influence on world traded goods prices. In order to justify the concentration on the trade balance, it should also have a balance on invisibles account which is relatively stable under terms of trade and real exchange rate shocks. A number of both developing and small industrial countries fit this description reasonably well although the empirical application here was concerned solely with countries from the latter group; Australia, Denmark, Finland, Ireland, and New Zealand.

The relationship between terms of trade changes and 'offsetting' real exchange rate changes is summarized by the quantity m which gives the percentage real depreciation required to neutralize the trade balance effects of a one per cent increase in the terms of trade. Based on empirical estimates of six model parameters for each of the five countries under consideration, this quantity was found to range between -0.92 for Ireland and -1.37 for Australia.

Of the underlying model parameters, emphasis was placed on the estimation of trade price and income elasticities. Econometric time series estimates of export supply and import demand equations yielded export supply price elasticities between 0.5 and 1.5, and import demand price elasticities between -0.4 and -0.9. The latter estimates, while spanning a relatively narrow range, were nevertheless found to have a dominant influence on the relative size of m values. Increases in export supply price elasticities were seen to significantly reduce the absolute size of m for small import price elasticities but also increase the aboslute size of m for import price elasticities large enough to reduce $|m|$ below 1. As already indicated, however, the estimated import price elasticities were not so high as to trigger this somewhat perverse relationship.

Income effects, felt in the model through the demand for import volumes, are generated both by terms of trade movements and also by real exchange rate adjustments. The real exchange rate income effect is stabilizing when the share of traded goods in domestic demand is greater than the traded goods share in production, but this is usually dominated by the terms of trade income effect which is always stabilizing. Both types of income effect are directly influenced by the size of the traded goods sector (σ,γ), and by the income elasticity of demand for imports ε. The traded goods share parameters were found to range between 0.11 and 0.49 while the income elasticities of import demand fell between 1.03 and 1.40. In both cases the largest estimates obtained were for Ireland which indicates that the proportion of adjustment to be achieved through income effects is significantly greater for Ireland than for the remaining countries.

Whilst a larger traded goods sector tends to reduce $|m|$ through larger stabilizing real income effects, there is also an opposite influence resulting from an increase in the terms of trade effect on the relative import price. The net influence of the traded goods share on the size of $|m|$ nevertheless remains negative provided that the sum of the income and price elasticities of demand for imports is positive. This condition was met in all five country cases, but it was noted that when an increase in the traded goods share reduces the size of the required adjustment to a terms of trade shock, it also makes it more difficult to achieve.

Data Sources and Definitions for Regression Analysis

All non-dummy variables are derived from IFS data unless otherwise stated.

Country codes: 193 : Australia
128 : Denmark
172 : Finland
178 : Ireland
196 : New Zealand

XD = Value of merchandise exports f.o.b., US$.
= line 77AAD for 178, 196.
= (line 77AAD)/1000 for 193, 128, 172.

MD = Value of merchandise imports f.o.b., US$.
= line 77ABD for 178, 196.
= (line 77ABD)/1000 for 193, 128, 172.

ER = Exchange rate, US$ per local curr. unit, period average.
= line ..RH. for 193, 178, 196.
= 1/(line ..RF.) for 128, 172.

X = Local currency value of merchandise exports f.o.b.
= XD/ER

XA = Local currency value of agricultural exports, SITC 0+1, source DRI.

XR = Local currency value of raw material exports, SITC 2+4, source DRI.

XF = Local currency value of fuel exports, SITC 3, source DRI.

XM = Local currency value of manufactured exports, SITC 5-8, source DRI.

M = Local currency value of merchandise imports f.o.b.
= MD/ER

PX = Export price index.
= line 76... for 193.
= line 74... for 128, 172, 178, 196.

PM = Import price index.
= line 76.X. for 193.
= line 75... for 128, 172, 178, 196.

QNOM = Gross Domestic Product, current prices.
= line 99B..

Q = Gross Domestic Product, 1975 prices.
= line 99B.R for 193.
= line 99B.P for 128, 172, 178, 196.

PQ = GDP deflator, 1975 = 100
= 100 . QNOM/Q

PD = Domestic expenditure deflator, proxied by consumer price index.
= line 64...

QF = Index of foreign GDP, 1975 prices.

$$= \sum_{j=1}^{n} W_j . Q_j(t)/Q_j\ (1975)$$

where $Q_j(t)$ equals Q for country j at time t, W_j equals that proportion of exports going to j,

$\sum_j W_j = 1$, and n equals the number of countries required to cover approx. 80 per cent of exports in 1970.

Dummy variable definitions

Before defining variables on a country by country basis, the following examples demonstrate the naming convention adopted.

D71 takes the value 1 in 1971, zero elsewhere.

D7172 takes the value 1 in 1971, 1 in 1972, zero elsewhere.

DD71 takes the value 1 in 1971, -1 in 1972, zero elsewhere.

TD70 takes the values of a linear trend from 1960 to 1970 and the value of TD70, at 1970, from 1971 to 1980.

TD7180 takes the values of a linear trend from 1971 to 1980, zero elsewhere.

Variable definitions by country, by equation, are as follows:

Australia

Agricultural exports:

DUM1 = D7172 Unusually high growth in agricultural exports in 1971, 1972 was associated with a large increase in subsidies on agricultural production and a substantial temporary relaxation of U.S. beef quotas at a time, in 1972, when beef livestock levels were high.

DUM2 = D666878 Droughts caused significant reductions in agricultural exports relative to total GDP in 1966, 1968, and 1978. The effects are assumed to be of the same magnitude to save degrees of freedom.

Raw Material Exports:

DUM1 = D70

DUM2 = D78 In 1970 and 1978 Japanese steel production was, respectively, well above and well below the average Australian foreign cycle; a large proportion of Australia's raw material exports are in the form of coal and iron ore exports to Japan.

Manufactured Exports:

TD1 = TD70

TD2 = TD7180 These two variables allow for the significant reduction in the trend growth of manufactured exports following a period of rapid expansion through the 1960s.

Non-Fuel Imports:

DUM1 = DD74 An across the board tariff cut of 25 per cent in mid-1974 was followed in late 1974, early 1975, by tariff increases and the imposition of quotas on a range of imported goods.

DUM2 = D65 Unusually high levels of imports in 1965 were associated with large defense expenditures brought on by the Vietnam war and the development of a number of large capital projects, on top of a generally high level of domestic demand.

DUM3 = D72 Low import levels in 1972 resulted from a strong downturn in business fixed and inventory investment, and the effects of U.S. dock strikes.

Denmark

Manufactured Exports:

TD1 = TD70

TD2 = TD7180 As in the case of Australia, these variables allow for the significant reduction in the trend growth of manufactured exports which occurred following a period of rapid expansion through the 1960s.

Non-Fuel Imports:

DUM1 = DD72 Investment expenditures, and hence imports were held back in 1972, pending a decision on Denmark's memberships of the EEC. Furthermore, stocks were held at low levels pending the phasing out of a temporary surcharge.

Finland

Raw Material Exports:

DUM1 = D75 As a result of high inventories in 1975, the world demand for forest products remained low while overall foreign demand expanded.

Manufactured Exports:

DUM1 = D75 As in the case of forest based raw materials, the demand for forest based manufactures in 1975 was low relative to the overall foreign cycle.

TD1 = TD70 This variable allows for the high trend growth of manufactured exports through the 1960s.

Ireland

Agricultural Exports:

DUM1 = D67 Unusually high levels of beef exports were experienced in 1967 when abnormally high cattle stock levels coincided with the implementation of the Anglo-Irish Free Trade Agreement.

Manufactured Exports:

DUM1 = D6566 In 1965-1966 there was a temporary surcharge on imports into the U.K., Ireland's major export market.

Non-Fuel Imports:

DUM1 = DD74 An excessive build up of inventories resulted in high import volumes in 1974, followed by low import volumes in 1975 as inventory levels were adjusted downwards.

New Zealand

Agricultural and Raw Material Exports:

DUM1 = D65

DUM2 = D7475 These two variables allow for the detrimental effects of severe droughts in 1964 and 1973.

TD1 = 1, 2, 3, ...7 from 1960 to 1966.
= 7, 7, 7, 7 from 1967 to 1970,
= 8, 9, 10, ...17 from 1971 to 1980.

TD2 = 1, 2, 3, 4 from 1967 to 1970,
= 4, 4, ...4 from 1971 to 1980,
= zero elsewhere.

These two variables allow trend growth to increase over the years 1966 to 1970 when the New Zealand-Australia Free Trade Agreement (NAFTA) was brought into effect.

Non-Fuel Imports

DUM1 = D72 Imports were very low in 1972 relative to total GNP as growth in that year was solely in the export sector. Tight monetary and fiscal policies restricted domestic demand at that time.

DUM2 = D6768 Tariffs and quantitative import controls became temporarily more restrictive over the 1967-68 period.

Derivation of equations (11), (12), (13) as given in Section II

Model equations required to derive the comparative static result are as follows:

(1) $Q_X = Q_X(P_X/P_Q) \cdot Q$

(2) $D_M = D_M(P_M/P_D,\ Q \cdot P_Q/P_D)$

(3) $P_Q = \gamma P_X + (1-\gamma)P_{NT}$

(4) $P_D = \sigma P_M + (1-\sigma)P_{NT}$

(5) $T = P_X/P_M$

(6) $\theta = P_M/P_Q$

(7) $B = (P_X \cdot Q_X - P_M D_M)/P_Q \cdot Q$

Firstly obtaining the relevant price ratios, equations (3), (4), (5), and (6) may be used to give:

(8) $P_X/P_Q = \theta T$

(9) $P_{NT}/P_Q = (1-\gamma\theta T)/(1-\gamma)$

(10) $P_Q/P_D = (1-\gamma)/[\sigma\theta(1-\gamma) + (1-\sigma)(1-\gamma\theta T)]$

(11) $P_M/P_D = \theta(1-\gamma)/[\sigma\theta(1-\gamma) + (1-\sigma)(1-\gamma\theta T)]$

Now setting dB=0 and taking initial values of Q_X/Q and D_M/Q as γ and $\sigma(1-\phi)$ respectively, 1/ we have:

(12) $$\gamma d\ell n\left(\frac{P_X \cdot Q_X}{P_Q \cdot Q}\right) = \sigma(1-\phi) d\ell n\left(\frac{P_M \cdot D_M}{P_Q \cdot Q}\right)$$

Expanding the total differentials on each side of (12) and substituting in the elasticity definitions from Section II;

1/ Recalling that ϕ is the initial current account deficit as a proportion of GNP, then $(1-\phi)Q$ approximates the scale of total domestic demand and $\sigma(1-\phi)Q$ approximates the scale of total imports.

$$(13) \quad \gamma[d\ln(\frac{P_X}{P_Q}) + \alpha d\ln(\frac{P_X}{P_Q})]$$

$$= \sigma(1-\phi)[d\ln(\frac{P_M}{P_Q}) + \eta d\ln(\frac{P_M}{P_D}) + \varepsilon d\ln(\frac{Q.P_Q}{P_D})]$$

Making use of equations (8) to (11) above, and defining all price ratios to have an initial scale of one, (13) can be expressed just in terms of $d\ln\theta$ and $d\ln T$:

$$(14) \quad \gamma(\alpha+1)(d\ln\theta + d\ln T)$$

$$= \sigma(1-\phi)[(1+\eta)d\ln\theta + (\varepsilon+\eta)\frac{(\gamma-\sigma)}{(1-\gamma)}d\ln\theta + (\varepsilon+\eta)\frac{(1-\sigma)\gamma}{(1-\gamma)}d\ln T]$$

Finally, collecting terms and moving everything to the left hand side we have:

$$W_\theta d\ln\theta + W_T d\ln T = 0$$

where

$$W_\theta = \gamma - (1-\phi)\sigma + \alpha\gamma - \eta\sigma(1-\sigma)(1-\phi)/(1-\gamma) + \varepsilon\sigma(\sigma-\gamma)(1-\phi)/(1-\gamma)$$

and

$$W_T = \gamma + \alpha\gamma - \eta\sigma(1-\sigma)(1-\phi)\,\gamma/(1-\gamma) - \varepsilon\sigma(1-\sigma)(1-\phi)\,\gamma/(1-\gamma)$$

The partial derivatives W_θ and W_T are expressed here, as in Section II, with separate additive terms representing valuation effects, export relative price effects, import relative price effects and import income effects in that order.

References

Aurikko, E., "A Structural Model of Finnish Foreign Trade," Scandinavian Journal of Economics, Vol. 77 (1975), pp. 165-78.

Bruno, M. and J. Sachs, "Macro-economic Adjustment with Import Price Shocks: Real and Monetary Aspects," NBER Working Paper No. 340 (April 1979).

Buiter, W., "Short-run and Long-run Effects of External Disturbances Under a Floating Exchange Rate," Economica, Vol. 45 (1978), pp. 251-72.

Deane, R.S., P.W.E. Nicholl, and M.J. Walsh, External Economic Structure and Policy, (Wellington: Reserve Bank of New Zealand, 1981), Chapter 25.

Findlay, R., and C.R. Rodrigues, "Intermediate Imports and Macroeconomic Policies Under Flexible Exchange Rates," Canadian Journal of Economics, Vol. 10 (May 1977), pp. 208-17.

Macfarlane, I.J., "The Balance of Payments in the 1970s," Conference in Applied Economic Research, (Reserve Bank of Australia, Dec. 1979), pp. 2-28.

McAleese, D., A Study of Demand Elasticities for Irish Imports, (The Economic and Social Research Institute, March 1970), Paper No. 53.

Obstfeld, M., "Intermediate Imports, The Terms of Trade, and the Dynamics of the Exchange Rate and Current Account," NBER Working Paper No. 540, (Sept. 1980).

O'Connell, T., "Demand and Supply Functions for Irish Exports of Manufactures," The Economic and Social Review, Vol. 8 (Dublin, July 1977), pp. 257-78.

Organization for Economic Cooperation and Development, Economic Surveys Denmark (July 1979), pp. 53-57.