CHAPTER 6

Developing the MONASH closures

45. Introduction

In Chapter 1 we described four closures of the MONASH model: decomposition, historical, forecast and policy. The application of these closures was illustrated in Chapter 2. Here we provide a detailed discussion of the closures built around comprehensive lists (Table 45.1) of their exogenous variables. We set out the processes by which the historical and forecast closures were developed from the decomposition closure and the policy closure was developed from the forecast closure.

The details of the decomposition closure are presented in section 46. As described in general terms in Chapter 1, this is a standard, one-period long-run closure. It can be deduced from the names of the MONASH equations. As mentioned in subsection 17.8, the endogenous variables in the decomposition closure are those for which there are named equations and the exogenous variables are those for which there are no named equations. At the end of section 46 we describe modifications to the decomposition closure required for conducting a homogeneity test.

In section 47 we develop the historical closure by a series of swap statements using the decomposition closure as a starting point. Swap statements alter an existing closure by swapping variables between the endogenous and the exogenous categories (see section 15). As described in Chapter 1, the historical closure is used in simulations designed to generate estimates of changes in consumer preferences, in production technologies and in other unobservable variables.

The forecast closure is developed in section 48, again using a series of swap statements applied to the decomposition closure. As illustrated in Chapter 2, the forecast closure is used in generating disaggregated forecasts incorporating expert views on macroeconomic variables, on commodity exports, on world prices, on technology and preference changes, and on tariff and tax changes.

In developing the policy closure it is convenient to use the forecast closure as a starting point. The swaps that convert the forecast closure into the policy closure are described in section 49. In Chapter 2 we saw that the policy closure is used in generating policy-induced deviations from explicit forecasts.

Concluding remarks on closure issues are given in section 50.

46. The decomposition closure (third column of Table 45.1)

In preparation for this section it will be useful for readers to review Figure 5.1 and the associated explanation in subsection 5.3(b). The variables and connections in Figure 5.1 are a schematic representation of the decomposition closure. The aim of this section is to fill in the details.

Table 45.1. Exogenous variables in four closures of the MONASH model

Policy		Forecast		Decomposition		Historical
1 Technology, import/domestic preferences and consumer tastes						
a0ccom		a0ccom		a0ccom		a0ccom
a0ci		a0ci		a0ci	9 →	x0ci_obs
a0com		a0com		a0com		a0com
a0ind		a0ind		a0ind		a0ind
del_f_a1		del_f_a1	← 1	a1	11 →	del_f_a1
a1cap		a1cap		a1cap		a1cap
a1csi		a1csi		a1csi		a1csi
a1lab		a1lab		a1lab		a1lab
a1labgen		a1labgen		a1labgen		a1labgen
a1laboi		a1laboi		a1laboi		a1laboi
a1land		a1land		a1land		a1land
a1oct		a1oct		a1oct		a1oct
capprod 104		capprod 104	← 1	a1prim	6 →	flabprod
a1prim 1-103 105-113		a1prim 1-103 105-113				
a1primgen	← 2	phi	← 2	a1primgen	5 →	phi
a2csi		a2csi		a2csi		a2csi
del_f_a2		del_f_a2	← 1	a2ind	11 →	del_f_a2
a3com		a3com		a3com	2 →	a3shift 1-21 23-24 27 31-39 41-113 115
					2 →	x3_obs 29-30
					2,11 →	x0dom_absobs 19 22 23 25 33 99
a3cs		a3cs		a3cs		a3cs
a3ncom		a3ncom		a3ncom	2 →	x3ncom_obs 1 3-4 6-38
						a3ncom 2
					2,11 →	x0dom_absobs 34

.... continued

Table 45.1 continued

Policy		Forecast		Decomposition		Historical
ac		ac		ac	11 →	ffac
					9 →	avea0ci_jp 2 4-9
						ac 1 3
aq		aq		aq	11 →	x0dom_absobs 10 12-18 20-21 24 29-32 35-92 97-98 101-104 aq 1-9 11 19 22-23 25-28 33-34 93-96 99-100
d_f_tw_hist	← 2	d_f_tw_forc	← 4	d_f_tw_hist		d_f_tw_hist
f1_commun	← 2	f1_commun_a		f1_commun_a		f1_commun_a
f1_commun_u		f1_commun_u		f1_commun_u	3 →	x0imp_obs 100
f1_trans	← 2	f1_trans_a		f1_trans_a		f1_trans_a
f1_trans_u		f1_trans_u		f1_trans_u		f1_trans_u
fa1c		fa1c		fa1c		fa1c
fa1ci		fa1ci		fa1ci		fa1ci
fa1marg		fa1marg		fa1marg		fa1marg
fa1margc		fa1margc		fa1margc		fa1margc
fa2c		fa2c		fa2c		fa2c
fa2ci		fa2ci		fa2ci		fa2ci
fa2marg		fa2marg		fa2marg		fa2marg
fa2margc		fa2margc		fa2margc		fa2margc
fa3marg		fa3marg		fa3marg		fa3marg
fa3margc		fa3margc		fa3margc		fa3margc
fa4marg		fa4marg		fa4marg		fa4marg
fa4margc		fa4margc		fa4margc		fa4margc
fa5marg		fa5marg		fa5marg		fa5marg
fa5margc		fa5margc		fa5margc		fa5margc
ff_twistlk		ff_twistlk		ff_twistlk	7 →	cap_at_t 68
						ff_twistlk 1-67 69-113
twist_eff	← 2	ftwist_eff		ftwist_eff		ftwist_eff
ftwist_src	← 2	impftwist	← 4	ftwist_src	3 →	x0imp_obs 1-96 98 101-114 ftwist_src 97 99-100 115

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Table 45.1 continued

Policy		Forecast		Decomposition		Historical
f_twistlk	← 2	real_wage_c	← 5	f_twistlk		f_twistlk
twistlk_s		twistlk_s		twistlk_s	7 →	cap_at_t_s 1-24
						twistlk_s 25-26
twist_src_bar	← 2	impvol	← 2	twist_src_bar		twist_src_bar
2 Employment and wages						
del_f_wage_pt	← 5	emp_hours		emp_hours	6 →	a1primgen
fwagei		fwagei		fwagei		fwagei
fwageo		fwageo		fwageo		fwageo
fwageoi		fwageoi		fwageoi		fwageoi
fwage_s		fwage_s		fwage_s	8 →	wagebill_s
labprod_d		labprod_d		labprod_d	6 →	labind_d
d_emp_sh		d_emp_sh		d_emp_sh		d_emp_sh
d_empadj		d_empadj		d_empadj		d_empadj
d_f_labsup	← 5	labsup		labsup		labsup
3 Capital, investment and rates of return						
del_r		del_r		del_r		del_r
del_r_tot		del_r_tot		del_r_tot		del_r_tot
del_f_ac_p_y		del_f_ac_p_y	← 1	del_ff_rate		del_ff_rate
del_ff_rate_s		del_ff_rate_s		del_ff_rate_s	8 →	p_va_s 1-10 12-18
						del_ff_rate_s 11 19-20
d_f_eeqror_j 10 15 104-109 113	← 4	y 10 15 105-109 113	← 1	r_inv_cap	4 →	f_r_inv_cap 1-95 97-113
d_f_eeqror_j 1-9 11-14 16-103 110-112		d_f_eeqror_j 1-9 11-14 16-104 110-112	← 1		4 →	y 96
r_inv_cap_s		r_inv_cap_s		r_inv_cap_s	4 →	y_s 1-24
						r_inv_cap_s 25-26
r_inv_cap_u		r_inv_cap_u		r_inv_cap_u		r_inv_cap_u
d_rint		d_rint		d_rint		d_rint
d_ff		d_ff		d_ff		d_ff
d_f_pi_l		d_f_pi_l	← 1	pi_l		pi_l
d_f_rint_l		d_f_rint_l	← 1	d_rint_l		d_rint_l

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Table 45.1 continued

Policy		Forecast		Decomposition		Historical
f_1octss		f_1octss		f_1octss	8 →	ff_p_va_s 1-10 12-18 f_1octss 11 19-20
d_diseq	← 4	d_f_diseq		d_f_diseq		d_f_diseq
d_f_eeqror	← 4	irtrue	← 2	d_f_eeqror		d_f_eeqror
		4 Public and private consumption and inventories				
apc	← 3	cr	← 2	apc_gnp	2 →	ave_a3com
othreal		othreal	← 2	r_cr_othreal	1 →	f5gen
d_x6cs 1 3-5	← 1	x0dom 1 3-5	← 5	d_x6cs	9 →	peobs 1 3
d_x6cs 2 6-230		d_x6cs 2 6-230				d_x6cs 2 4-230
		5 Exports				
fep	← 2	x4_abare (TRADEXP)	← 3	fep	5 →	x4_obs(TRADEXP)
fep_ntrad		fep_ntrad		fep_ntrad		fep_ntrad
fep_ntradi		fep_ntradi		fep_ntradi	5 →	x4_obs(NTRADEXP)
fep_tour	← 2	agg_tour	← 3	fep_tour		fep_tour
fep_touri		fep_touri		fep_touri	5 →	x4_obs(TOURISM)
feq		feq		feq		feq
hs_ntrad	← 2	expvol	← 2	feq_general		feq_general
feq_ntrad		feq_ntrad		feq_ntrad		feq_ntrad
feq_tour		feq_tour		feq_tour		feq_tour
feq_general		feq_general	← 3	fhist_cont		fhist_cont
fx4_abare_mi		fx4_abare_mi		fx4_abare_mi		fx4_abare_mi
fx4_abare_ru		fx4_abare_ru		fx4_abare_ru		fx4_abare_ru
fx4_commun		fx4_commun		fx4_commun	5 →	x4_obs (COMMUNICAT)
fx4_transerv		fx4_transerv		fx4_transerv	5 →	x4_obs (TRANSERV)
fx4_wattran		fx4_wattran		fx4_wattran	5 →	x4_obs (WATERTRAN)
f_forc		f_forc	← 3	f_hist		f_hist

.... continued

Table 45.1 continued

Policy		Forecast		Decomposition		Historical
hist_cont 1 53	←2	x4_abare (NTABARE)	←3	f_ntrad		f_ntrad
x4_abare 11						
hist_cont 2-7 9-52 54-95		hist_cont 2-7 9-52 54-95	←3			
f_pe_u	←2	toft	←3	f_pe_u	10→	expvalf
f_pe_u_nt		f_pe_u_nt		f_pe_u_nt		f_pe_u_nt
f_tour		f_tour		f_tour		f_tour
			6 Import prices			
f_pm		f_pm		f_pm	10→	impvalf
pmrel		pmrel	←4	pm	10→	pmobs 1-85 98-115
					10→	fpdm 86-97
pm_f		pm_f	←4	pm_ff		pm_ff
			7 Tax rates, transfer payments and the structure of public expenditure			
d_f_othcapgov		d_f_othcapgov		d_f_othcapgov		d_f_othcapgov
eligsh		eligsh		eligsh		eligsh
f5dom		f5dom		f5dom	1→	x5cs_obs 1-115
f5imp		f5imp		f5imp	1→	x5cs_obs 116-230
ffpowtaxm		ffpowtaxm		ffpowtaxm		ffpowtaxm
agginv_rg		agginv_rg	←2	ff_y_g		ff_y_g
fpowtax1gg		fpowtax1gg		fpowtax1gg		fpowtax1gg
fpowtax1phph		fpowtax1phph		fpowtax1phph		fpowtax1phph
fpowtax2gg		fpowtax2gg		fpowtax2gg		fpowtax2gg
fpowtax2phph		fpowtax2phph		fpowtax2phph		fpowtax2phph
r_cpi_elec		r_cpi_elec	←5	fpowtax3g	12→	taxrev3gc 30
fpowtax3g 1-85 87-200 202-230		fpowtax3g 1-85 87-200 202-230				fpowtax3g 1-144 146-230
fpowtax0g		fpowtax0g		fpowtax0g		fpowtax0g
d_add_rev	←1	fpowtax3gu		fpowtax3gu		fpowtax3gu
fpowtax3ph		fpowtax3ph		fpowtax3ph		fpowtax3ph
fpowtax5g		fpowtax5g		fpowtax5g		fpowtax5g
fpowtax5ph		fpowtax5ph		fpowtax5ph		fpowtax5ph
fpowtaxm		fpowtaxm		fpowtaxm		fpowtaxm

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Table 45.1 continued

Policy		Forecast		Decomposition		Historical
powtaxmo	← 1	fpowtaxmo		fpowtaxmo		fpowtaxmo
ftax_fgn_gov		ftax_fgn_gov		ftax_fgn_gov		ftax_fgn_gov
f_age_ben		f_age_ben		f_age_ben		f_age_ben
f_g		f_g		f_g		f_g
f_grants		f_grants		f_grants		f_grants
f_oth_ben		f_oth_ben		f_oth_ben		f_oth_ben
f_oth_g_rev		f_oth_g_rev		f_oth_g_rev		f_oth_g_rev
f_tax_r		f_tax_r		f_tax_r		f_tax_r
f_unempben		f_unempben		f_unempben		f_unempben
f_y_g		f_y_g		f_y_g		f_y_g
iacrate		iacrate		iacrate		iacrate
p3_adj		p3_adj		p3_adj	12 →	pow_phph3_ave
powpayroll		powpayroll		powpayroll		powpayroll
powtax0ph		powtax0ph		powtax0ph	9 →	avea0ci_j
						powtax0ph 8-113
powtax3vg		powtax3vg		powtax3vg	12 →	taxrev3gc 29 31 58
						powtax3vg 1-28 30 32-57 59-115
powtax4g		powtax4g		powtax4g		powtax4g
powtax4ph (PCOSTD)	← 2	peobs(PCOSTD)	← 3	powtax4ph	10 →	peobs 10-13 17-31 33-65 67-85 97-103 105-114
powtax4ph (COM\PCOSTD)		powtax4ph (COM\PCOSTD)				powtax4ph 1-9 14-16 32 66 86-96 104 115
powtax4sph (PWORLDD)	← 2	peobs(PWORLDD)	← 3	powtax4sph	10 →	peobs 14-16 32 66
powtax4sph (COM \PWORLDD)		powtax4sph (COM\PWORLDD)				powtax4sph 1-13 17-31 33-65 67-115
powtaxgg		powtaxgg		powtaxgg		powtaxgg

.... *continued*

Table 45.1 continued

Policy	Forecast		Decomposition		Historical
powtaxphph	powtaxphph		powtaxphph	12 →	p3_obs 13 20-31 37 39-41 45 55-56 58 76 93 112-114 powtaxphph 1-12 14-19 32-36 38 42-44 46-54 57 59-75 77-92 94-111 115-230
d_f_rint_psd	d_f_rint_psd		d_f_rint_psd		d_f_rint_psd
t2_star	t2_star		t2_star		t2_star
tax_l_r	tax_l_r		tax_l_r		tax_l_r
8 Foreign assets and liabilities and the balance of payments					
ff_shfeat	ff_shfeat	← 1	d_f_netfltf		d_f_netfltf
d_r_balgdp	d_r_balgdp		d_r_balgdp		d_r_balgdp
d_f_fea_t_j	d_f_fea_t_j	← 1	shfeat_j		shfeat_j
fgnshd	fgnshd		fgnshd		fgnshd
fgnshd_j	fgnshd_j		fgnshd_j		fgnshd_j
ftrnoth_fgn	ftrnoth_fgn		ftrnoth_fgn		ftrnoth_fgn
ftrn_fgn_hh	ftrn_fgn_hh		ftrn_fgn_hh		ftrn_fgn_hh
d_f_aef_t	d_f_aef_t	← 1	f_fat		f_fat
f_fat1	f_fat1		f_fat1		f_fat1
f_shfeat1_j	f_shfeat1_j		f_shfeat1_j		f_shfeat1_j
f_xiworld	f_xiworld		f_xiworld		f_xiworld
rodiv_aef	rodiv_aef		rodiv_aef		rodiv_aef
roi_fcdc	roi_fcdc		roi_fcdc		roi_fcdc
roi_fcfc	roi_fcfc		roi_fcfc		roi_fcfc
roi_fddc	roi_fddc		roi_fddc		roi_fddc
roi_fdfc	roi_fdfc		roi_fdfc		roi_fdfc
sht1fcdc	sht1fcdc		sht1fcdc		sht1fcdc
sht1fcfc	sht1fcfc		sht1fcfc		sht1fcfc
sht1fddc	sht1fddc		sht1fddc		sht1fddc
sht1fdfc	sht1fdfc		sht1fdfc		sht1fdfc
d_f_fcdc_t	d_f_fcdc_t	← 1	shtfcdc		shtfcdc
d_f_fcfc_t	d_f_fcfc_t	← 1	shtfcfc		shtfcfc
d_f_fddc_t	d_f_fddc_t	← 1	shtfddc		shtfddc

.... *continued*

Table 45.1 continued

Policy		Forecast		Decomposition		Historical
d_f_fdfc_t		d_f_fdfc_t	← 1	shtfdfc		shtfdfc
world_gdp		world_gdp		world_gdp		world_gdp
		9 Adjustments to conflicting data				
adj_abs		adj_abs		adj_abs	11 →	x0dom_absobs 26-28 94-96 adj_abs 1-25 29-93 97-104
f_x0ci		f_x0ci		f_x0ci	9 →	x0dom_absobs 1-9
fvas		fvas		fvas	8 →	fwage
		10 Treatment of relations between start-, mid- and end-of-year variables				
d_f_excht		d_f_excht	← 1	d_ff_excht		d_ff_excht
d_f_pcapatt		d_f_pcapatt	← 1	d_ff_pcapatt		d_ff_pcapatt
d_f_xiwldt		d_f_xiwldt	← 1	d_ff_xiwldt		d_ff_xiwldt
d_ff_excht1		d_ff_excht1	← 1	d_f_excht1		d_f_excht1
d_ff_pcapatt1		d_ff_pcapatt1	← 1	d_f_pcapatt1		d_f_pcapatt1
d_f_psd_t1		d_f_psd_t1		d_f_psd_t1		d_f_psd_t1
d_ff_xiwldt1		d_ff_xiwldt1	← 1	d_f_xiwldt1		d_f_xiwldt1
d_f_psd_t		d_f_psd_t	← 1	d_psd_t		d_psd_t
		11 Transfer of forecast results to policy simulations				
tax_l_r_o	← 1	ftax_l_r_o		ftax_l_r_o		ftax_l_r_o
b3sh_o	← 1	f_b3sh_o		f_b3sh_o		f_b3sh_o
emp_hours_o	← 1	f_emp_o		f_emp_o		f_emp_o
labsup_o	← 1	f_labsup_o		f_labsup_o		f_labsup_o
real_wage_c_o	← 1	f_rwage_o		f_rwage_o		f_rwage_o
real_wage_pt_o	← 1	f_rwage_pt_o		f_rwage_pt_o		f_rwage_pt_o
x3cs_o	← 1	f_x3cs_o		f_x3cs_o		f_x3cs_o
del_ror_se_o	← 1	d_f_ror_se_o		d_f_ror_se_o		d_f_ror_se_o
d_eror_o	← 1	d_f_eror_o		d_f_eror_o		d_f_eror_o

.... continued

Table 45.1 continued

Policy	Forecast		Decomposition	Historical
		12 Miscellaneous variables		
del_ff1oct	del_ff1oct		del_ff1oct	del_ff1oct
del_unity	del_unity		del_unity	del_unity
del_wealth	del_wealth		del_wealth	del_wealth
gdpreal_true	gdpreal_true		gdpreal_true	gdpreal_true
n	n		n	n
pop	pop		pop	pop
pop_aged	pop_aged		pop_aged	pop_aged
q	q		q	q
xi3	xi3		xi3	xi3
d_f_xi3_2l	d_f_xi3_2l	$\xleftarrow{1}$	xi3_2l	xi3_2l
d_f_xi3_l	d_f_xi3_l	$\xleftarrow{1}$	xi3_l	xi3_l

For organizing the presentation of the decomposition closure, we partition the MONASH variables into twelve groups starting with technology and preference variables.

Technology, import/domestic preferences and consumer tastes

In the decomposition closure, changes in technology, import/domestic preferences and consumer tastes are exogenous. The only technology/preference/taste variables not included in the third column of Table 45.1 are derived from varaibles that are included. For example, a1ci is not included: instead, column 3 includes ac, fa1c and fa1ci which determine a1ci via E_a1ci in subsection 18.8o. Similarly, ave_a3com is not included: instead, column 3 includes a3com which determines ave_a3com via E_ave_a3com in subsection 18.8e.

Four variables which may seem out of place in column 3, part 1 of Table 45.1 are f1_commun_a, f1_commun_u, f1_trans_a and f1_trans_u. In the decomposition closure we adopt the specification of industry demands for imported transport services and imported communication services given by E_f1_commun and E_f1_trans, see subsections 18.8b and 20.3. With this specification, nonzero shocks to the four variables impose technical changes, affecting the use by industries of the two services.

Employment and wages

Aggregate hours of employment is exogenized in the decomposition closure by the inclusion in Table 45.1 (column 3) of emp_hours. With emp_hours being exogenous, the cost-weighted measure of aggregate employment (emp_c_wgts) is endogenous. The relative wages of workers in different industry and occupation categories are exogenized (fwagei, fwageo, fwageoi and fwage_s appearing in E_wlaboi, subsection 18.8c, are in the third column of Table 45.1). To accommodate the exogenous determination of aggregate employment, the overall wage rate must be endogenous. Thus fwage is not in the third column of Table 45.1.

The final four variables in column 3, part 2 of Table 45.1 are unimportant. The variable labprod_d occurs only in E_flabprod (subsection 18.8o) and plays no role in decomposition simulations because this equation is turned off by endogenization of the shift variable flabprod. Similarly, d_empadj and d_emp_sh appear only in equations (E_d_f_empadj and E_d_ff_empadj, subsection 18.8p) which are turned off in decomposition closures. The variable labsup plays a minor role through its influence on unemployment benefits (see E_unemp_ben in subsection 18.8q)

Capital, investment and rates of return

Reflecting their long-run focus, decomposition simulations generate results for capital available in year t [cap_at_t(j)] mainly on the basis of assumptions concerning movements in rates of return [del_ror_se(j)]. Movements in rates of return are determined in decomposition simulations largely by exogenously specified movements in the variables del_r, del_r_tot, del_ff_rate and del_ff_rate_s (see E_del_ror_se and E_del_f_rate in subsection 18.8n). All of these variables are listed in column 3, part 3 of Table 45.1.

With the inclusion of the variables r_inv_cap, r_inv_cap_s and r_inv_cap_u in column 3, investment in decomposition simulations is determined by exogenously imposed assumptions concerning movements in investment/capital ratios (see E_y and E_f_r_inv_cap in subsections 18.8m & n).

MONASH does not have an explanation of movements in real rates of interest. Consequently d_rint is a natural inclusion in Table 45.1 (column 3). With movements in rates of return being largely exogenous, shocks to d_rint in decomposition simulations affect capital and investment by affecting rental rates [p1cap(j)] via E_d_int, E_d_rint_pt_se and E_p1cap in subsection 18.8n.

With d_ff exogenized, we are assuming that expectations of rates of return are determined statically (see E_d_eror in subsection 18.8n). Forward-looking expectations are not applicable because the decomposition closure is used in one-period simulations.

The variables pi_l and d_rint_l influence lagged actual rates of return (see E_d_ror_act_l and E_d_int_l in subsection 18.8n). However, under static expectations lagged actual rates of return have no role.

We include f_1octss among the capital/investment variables in column 3 of Table 45.1 only because it plays a role in the determination of results for capital and investment by industry in historical simulations (see the explanation in section 31 of E_del_f1oct). In decomposition simulations f_1octss is simply a shifter affecting the price of other cost tickets and is usually set at zero.

The remaining variables (d_f_diseq and d_f_eeqror) in column 3, part 3 of Table 45.1 are irrelevant in decomposition simulations. They appear in equations (subsection 18.8m) or groups of equations that are turned off by endogenous shifters.

Public and private consumption and inventories

In the decomposition closure aggregate public and private consumption is tied to GNP by exogenization of apc_gnp (see E_cr in subsection 18.8r). The split of consumption between public and private is determined exogenously by the setting of r_cr_othreal (see E_othreal in subsection 18.8l).

As explained in section 24, MONASH does not currently explain inventory changes. Consequently, in decomposition simulations, d_x6cs is treated exogenously.

Exports

In the decomposition closure we put in place the four sets of demand schedules discussed in section 23 by exogenizing all of their shift variables. Apart from export-demand shifters the only other export-related variables in column 3, part 5 of Table 45.1 are fhist_cont, fx4_abare_mi, fx4_abare_ru, f_hist, f_pe_u and f_pe_u_nt. All of these variables are irrelevant in decomposition simulations because they appear only in equations or groups of equations which have been turned off by endogenization of shift variables.

Import prices

In the decomposition closure we treat Australia as a small importing country. Consequently we exogenize the c.i.f. foreign-currency prices of imports [pm(i)]. The only other variables in column 3, part 6 of Table 45.1 are irrelevant, appearing only in equations that are turned off in decomposition simulations.

Tax rates, transfer payments and the structure of public expenditure

In the decomposition closure, changes in tax and benefit rates are exogenous. The only tax/benefit variables excluded from column 3, part 7 of Table 45.1 are functions of those that are included. For example, powtax1 is excluded because it is determined in E_powtax1 (see subsection 18.8k) as a function of powtaxgg, fpowtax1gg, powtax4sph, powtaxphph and fpowtax1phph, all of which are included in column 3 of Table 45.1.

Movements in the real rate of interest on public sector debt (d_rint_psd) are linked in the decomposition closure to movements in the real rate of interest applicable to business borrowing (d_rint) by exogenization of d_f_rint_psd (E_rint_psd, subsection 18.8q).

Changes in the structure of public consumption and in the ratios of public to total investment in each industry are exogenous in the decomposition closure. Thus, column 3, part 7 of Table 45.1 includes expenditure shift variables: f5dom, f5imp, ff_y_g, f_g and f_y_g (see E_x5cs, E_y_g and E_f_gj in subsections 18.8g & q). We also exogenize the ratio of government asset sales to GDP by including d_f_othcapgov in column 3 of Table 45.1 (E_d_othcapgov, subsection 18.8q).

The change in the public sector deficit (d_gov_def) is endogenous in the decomposition closure. This reflects the exogeneity of tax and benefit rates and the linking of aggregate public consumption to GNP. Alternatively, we could hit a target for d_gov_def by allowing an adjustment in tax rates or a break in the public expenditure/GNP link.

Foreign assets and liabilities and the balance of payments

Closure options for foreign asset, liability and balance of payments variables were discussed in sections 34 and 35. With regard to these variables, the main features of the decomposition closure are as follows. First, the movement in net foreign liabilities (d_netfltf) is determined by the mechanisms discussed in section 34, that is d_netfltf is determined mainly by growth in capital compared with growth in GNP (which determines growth in domestic saving). Consequently, in column 3, part 8 of Table 45.1 we find that E_d_netfltf in subsection 18.8ris turned on by the exogeneity of d_f_netfltf. Second, with f_fat appearing in the third column of Table 45.1, the movement in Australia's start-of-year foreign assets (fat) is determined by the movement in GDP, leaving the movement in start-of-year foreign liabilities (flt) to be determined as a residual. Third, with f_fat1 exogenous, the movement in Australia's end-of-year foreign assets (fat1) is also determined by the movement in GDP. Movements through the year in Australia's foreign liabilities are then determined by fat, fat1 and the current account deficit. Fourth, in the decomposition closure, the start- and end-of-year shares of foreign assets and liabilities accounted for by foreign- and domestic-currency debt and credit are given exogenously, and the equity shares are therefore a residual. Thus, sht1fcdc, ..., shtfdfc all appear in the third column of Table 45.1. Fifth, the overall start- and end-of-year shares of industry capital stocks owned by foreigners are determined endogenously (ff_shfeat and ff_shfeat1 are endogenous) but shifts in the relative foreign-ownership shares across industries [shfeat_j(j) and f_shfeat1_j(j)] are exogenous. Sixth, in common with other closures, movements in rates of dividend and interest [rodiv_aef, ..., roi_fdfc] applying to Australia's foreign assets and debt are exogenous. MONASH contains no explaining mechanisms for these variables. Similarly, MONASH contains no explaining mechanisms for shift variables associated with: the balancing item in the balance of payments (d_r_balgdp); the ratio of dividend payments to profit on foreign-owned equity in Australian industry (fgnshd, fgnshd_j); transfer items in the current account (ftrnoth_fgn, ftrn_fgn_hh); and world inflation and economic growth (f_xiworld, world_gdp). Hence all these shift variables appear in column 3, part 8 of Table 45.1.

Adjustments to conflicting data

As discussed in section 31, the variables listed in column 3, part 9 of Table 45.1 are used endogenously in historical simulations to adjust conflicting data. In decomposition simulations there are no data adjustments and consequently these variables are exogenous.

Treatment of relations between start-, mid- and end-of-year variables

In simulations spanning more than one year, MONASH does not explain the start-of-year public sector debt. Consequently, as indicated in column 3, part 10 of Table 45.1, in the decomposition closure, d_psd_t is exogenous. On the other hand, E_d_psd_t1 in subsection 18.8q provides an adequate explanation in decomposition simulations of the end-of-year public sector debt. Thus this equation is turned on by exogenizing its shift variable (d_f_psd_t1). Exogenization of the remaining variables in column 3, part 10 of Table 45.1 turns on the appropriate equations for determining in decomposition simulations the movements in the start- and end-of-year values of: the exchange rate; asset prices; and world prices (see the discussion in section 35).

Transfer of forecast results to policy simulations

The variables listed in column 3, part 11 of Table 45.1 (the shifters fx_o) are irrelevant in decomposition simulations. Their exogenously set values influence results only for x_o variables. In decomposition simulations, x_o variables have no influence on other results. As discussed in section 32 [see (32.7)], equations involving the fx_o shifters (see subsection 18.8p) play an active role only in policy simulations.

Miscellaneous variables

In decomposition simulations the consumer price index is the numeraire. We do not explain either its movements or the movements in its lagged values. Thus xi3, xi3_2l and xi3_l appear in column 3 of Table 45.1, in part 12.

MONASH does not explain demographic variables [pop, pop_aged and q], the availability of agricultural land (n), extraneous forecasts for GDP [gdpreal_true, see the discussion of E_f_gdpreal in section 31] or the homotopy variables [del_unity and del_wealth] . Consequently these variables are included in column 3, part 12, of Table 45.1.

The only remaining variable in part 12 of column 3 is a vector, del_ff1oct, of shifts in the prices of other costs. In decomposition simulations we move these prices with the CPI by setting del_ff1oct, together with f_1octss appearing in part 3 of column 3, exogenously at zero (see E_del_f1oct and E_del_p1oct in subsections 18.8o & b).

Homogeneity test

It is useful to test the coding and data of a general equilibrium model by conducting homogeneity simulations. Several such simulations are discussed in Dixon *et al*. (1992, Chapter 4). The essence of these simulations is that the solution has a simple structure which is known, without computation, from the theory of the model. For example, a commonly applied homogeneity test is to shock all exogenous nominal variables by 1 per cent and to check that there is a 1 per cent increase in all endogenous nominal variables and no effect on real variables.

The smooth growth assumptions built into the decomposition closure through variables in part 10 of Table 45.1 make this closure unsuitable for homogeneity testing. Under smooth growth, a 1 per cent increase in a mid-year price (e.g. pi(j) = 1) is not normally compatible with a 1 per cent increase in the start-of-year price (that is, pcapatt(j) ≠ 1, see E_pcapatt in subsection 18.8s). Thus, it is hard to design a decomposition simulation which provides a comprehensive test of the code and for which the solution is known simply from theory.

By turning off the smooth growth assumptions, we can modify the decomposition closure to form a closure (the homogeneity closure) suitable for homogeneity testing. The smooth growth assumptions are turned off by endogenizing the first six variables listed in column 1 of Table 46.1 and exogenizing the corresponding six variables in column 2. Then with the shocks given in column 3, a one-step simulation should produce a 1 per cent increase in the levels of all endogenous nominal variables and no change in the levels of other variables. In an n-step homogeneity test (n large), the shocks to excht and excht1 should be –0.99009900… . This recognizes that the effects on international competitiveness of a 1 per cent increase in the domestic price level are offset by a devaluation of 1/1.01 per cent.

Table 46.1. Closures and shocks for testing homogeneity

Decomposition	Homogeneity	Shock
d_ff_excht	excht	-1
d_f_excht1	excht1	-1
d_ff_pcapatt	pcapatt	uniform 1
d_f_pcapatt1	pcapatt1	uniform 1
d_ff_xiwldt	xiworld_t	0
d_f_xiwldt1	xiworld_t1	0
d_psd_t		0.01*PSDATT
pi_l		1
xi3		1
xi3_2l		1
xi3_l		1

Notes.

(1) The first two columns show selected exogenous variables in the decomposition and homogeneity closures. Apart from the first six variables, the two closures are identical.

(2) d_psd_t is an exogenous nominal change variable. In the homogeneity test its shock must be a $ amount (0.01*PSDATT) which represents a 1 per cent increase in its level.

(3) As explained in the text, shocks of –1 for excht and excht1 are suitable only for 1-step homogeneity tests.

47. Developing the historical closure (fourth column of Table 45.1)

Figure 47.1 is a schematic version of the historical closure. The centre of attention in this closure is the estimation of technology variables. These include growth rates in total-factor productivity and biases in technical change favouring the use of some inputs relative to others. As indicated in the figure, technology variables are deduced from data on movements between years t and t+τ (e.g., 1987 and 1994) in outputs, inputs and real wage rates (ΔGDP, ΔL, ΔK and ΔW/P). Movements in rates of return are computed endogenously in historical simulations, largely reflecting data on real wage rates and results for technology variables.

Movements in investment, exports and imports are set exogenously (indicated in Figure 47.1 by the rectangles for ΔI and ΔBOT) using data for years t and t+τ. With ΔGDP also exogenous, the change in consumption (ΔC) between years t and t+τ is deduced as a residual.

The relationships in the centre of Figure 47.1 connecting net foreign liabilities, GNP, momentum and accumulated investment and savings (ΔNFL, ΔGNP, ΔU, $I_{87/94}$ and $S_{87/94}$) are treated the same way in historical simulations as in decomposition simulations. To date we have not used data on net foreign liabilities as an input to historical simulations. We have simply checked the endogenously determined results for ΔNFL against the actual outcome.

In explaining the details of the historical closure, we show how it is developed from the decomposition closure in a series of 12 steps, indicated in Table 45.1 by the arrows connecting columns 3 and 4. For example, in the first step we endogenize r_cr_othreal and exogenize f5gen [Table 45.1, part 4] and we endogenize f5dom and f5imp and exogenize x5cs_obs 1-115 and x5cs_obs 116-230 [Table 45.1, part 7]. The arrow going from a3com in column 3 (part 1) to x0dom_absobs in column 4 carries two step numbers, 2 and 11. This indicates that two steps were involved in the exogenization of 6 components of x0dom_absobs (components 19, 22, 23, 25, 33 and 99). As we will see in the discussion of steps 2 and 11, these 6 components of x0dom_absobs were exogenized in step 11 by endogenizing 6 components of a3shift. The 6 components of a3shift were exogenized in step 2 by endogenizing 6 components of a3com. Similarly as can be seen from part 1 of Table 45.1, two steps were involved in the exogenization of component 34 of x0dom_absobs. In step 11 this component was exogenized by endogenizing component 5 of x3ncom_obs which had been exogenized in step 2 by endogenizing a component of a3ncom.

In the 12 steps we cumulatively exogenize the naturally endogenous variables for which we have data. The steps are designed so that at the end of each step we have a valid closure.[1] Thus, at the end of each step we are able to perform an historical simulation. Comparison of results for successive simulations show the effects of the additional data introduced at each step. Results from this step-by-step approach applied for 1987 to 1994 are shown in Table 47.1. Each column was generated with a single-step Johansen computation.

Column 0 of Table 47.1 shows the effects, calculated using the decomposition closure, of shocks to all the variables that are exogenous in both the historical and decomposition closures. Column 1 shows the effects of these shocks plus the effects of shocks to the newly exogenous variables in step 1 (f5gen, x5cs_obs 1-115 and x5cs_obs 116-230). The results in column 1 are computed with the closure arrived at by implementing the 1-arrows connecting columns 3 and 4 in Table 45.1. The final column in Table 47.1 shows results for the full historical simulation. These differ from the results presented in the final columns of Tables 5.4 and 5.5 only because Table 47.1 is generated by computations using 1987 to provide the base solution. The earlier tables used a mid-point base solution (see footnote 11 in Chapter 1 and subsection 34.2).

Figure 47.1. Macro connections in the historical simulation for 1987 to 1994

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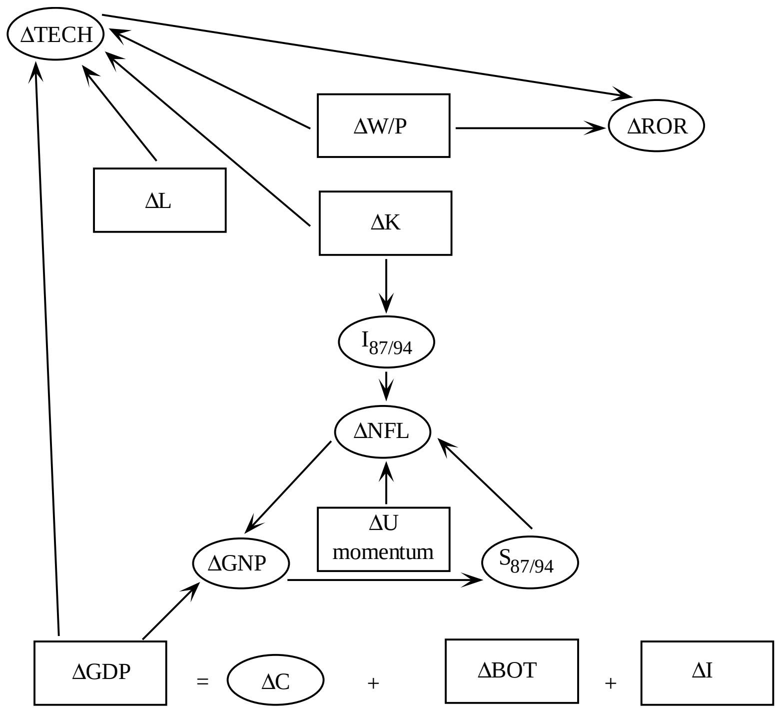
[1] As will be explained in our discussions of steps 5 and 6, the need to maintain a valid closure caused us to endogenize a1primgen in step 5 and exogenize it in step 6. This is the only example in which an endogenization is reversed.


ΔTECH
ΔW/P
ΔROR
ΔL
ΔK
I87/94
ΔNFL
ΔU
momentum
ΔGNP
S87/94
ΔGDP
=
ΔC
+
ΔBOT
+
ΔI

As will be apparent, the historical closure is complicated and unusual. Without a cautious step-by-step approach, it is impossible to find a satisfactory historical closure which allows us to use all the available data. With the step-by-step approach it is relatively easy to locate sources of unsatisfactory results and to make corrections.

In interpreting the results from step to step we refer to the stylized model in Table 47.2. This is useful for understanding the broad features of the results. For understanding the finer features it is necessary to consider aspects of the MONASH data and micro theory.

Table 47.2. Stylized model

$Y = C + I + G + X - M$	(47.1)
$Y = (1/A) * F(K, L)$	(47.2)
$C + G = APC * Y$	(47.3)
$C / G = \Gamma$	(47.4)
$M = H(Y, TOT, T)$	(47.5)
$TOT = J(X, V)$	(47.6)
$I/K = \Psi$	(47.7)
$K/L = N(ROR, A, TOT)$	(47.8)

In the stylized model, (47.1) is the GDP identity in constant-price terms. Equation (47.2) is the production function relating real GDP to inputs of capital and labour and to a technology shift term (1/A). Equation (47.3) relates the sum of public and private consumption to GDP via the average propensity to consume (APC). Equation (47.4) defines the ratio (Γ) of private to public consumption. Equation (47.5) relates imports positively to GDP, the terms of trade (TOT) and an import/domestic preference variable (T).[2] Here we simplify MONASH by assuming that there is a single imported good and a single domestically produced good which is both absorbed domestically and exported. Ignoring tariffs, it is then legitimate to represent the import-determining relative price as TOT, that is the price of the domestic good (and export) relative to the price of the import. Equation (47.6) relates TOT to the volume of exports (X) and to a demand-shift variable V. This is consistent with MONASH where we assume that Australia is a small country with respect to imports but faces downward-sloping demand curves

[2] T is a stylized version of the import-domestic twist variables discussed in subsection 20.3.

for its exports. Movements in V correspond to movements in these demand curves. Equation (47.7) defines the investment/capital ratio (Ψ). Finally, (47.8) relates the capital/labour ratio to the rate of return on capital (ROR), the terms of trade (TOT) and technology (A). In deriving (47.8) we assume that the value of the marginal product of capital equals the rental on capital (Q). This gives:

$$\frac{\partial F}{\partial K} = A * \frac{Q}{P_d} \quad , \tag{47.9}$$

or equivalently $$\frac{\partial F}{\partial K} = A * \frac{Q}{P_i} * \frac{P_i}{P_d} \quad , \tag{47.10}$$

where P_i and P_d are the price indexes for capital goods and for domestic goods. In (47.10), Q/P_i is the rental price of capital divided by the asset price. This can be interpreted as ROR. P_i/P_d can be interpreted as a decreasing function of TOT: P_i includes import prices but not export prices whereas P_d includes export prices but not import prices. Recognizing that $\partial F/\partial K$ is a monotonically decreasing function of K/L, we arrive at (47.8) where the partial derivatives of N with respect to A and ROR are negative and the partial derivative with respect to TOT is positive.

In terms of the stylized model, the endogenous variables in the decomposition closure are: Y, C, I, G, X, M, K and TOT. The exogenous variables are: L, ROR, A, APC, Γ, Ψ, V and T. As we describe the movements between the MONASH decomposition and historical closures, we will trace the corresponding moves in the stylized model.

Step 0: homotopy and other naturally exogenous variables

In this step we retain the decomposition closure and apply the 1987/1994 shocks: to the homotopy variables (del_unity, del_r and del_wealth); to tariff rates (iacrate); to the price level (xi3 and xi3_l); and to the number of households (q). These are the variables which are formally[3] exogenous and shocked in both the decomposition and historical simulations. The effects (step 0 in Table 47.1) of this rather arbitrary set of shocks are of no particular interest. As in the first column of Table 5.4, we find that in the absence of employment growth and technical change, capital growth would have been very slow (5.59 per cent over seven years). In these circumstances investment requirements would have been more than met by domestic saving with a resulting sharp decline in net foreign liabilities.

[3] The c.i.f. foreign-currency prices of imports (pm) are exogenous in decomposition simulations but endogenous in historical simulations. As we will see, endogeneity of pm is achieved in a trivial way via exogeneity of pmobs. Similar comments could be made regarding the endogeneity in historical simulations of public consumption and various tax rates.

Step 1: public consumption

This step is implemented by the following swap statements (see section 15):

```
swap f5dom = x5cs_obs 1-115;
swap f5imp = x5cs_obs 116-230;
swap r_cr_othreal = f5gen;
```

Each of the variables on the left of these swaps is replaced in the exogenous list of the existing closure (the decomposition closure) with the variable on the right.

Through these swaps, we exogenize the structure and overall quantity of public consumption (G in the stylized model). This requires turning off E_x5cs and freeing the link between public and private consumption (endogenizing Γ). With this modified closure, step 1 in Table 47.1 shows the effects of the shocks from step 0 plus the 1987/1994 shocks to public consumption applied to x5cs_obs. In terms of the stylized model, as we move from step 0 to step 1 we have applied an extra shock to G of 14.95 per cent[4], while holding constant L, A, ROR, APC, Ψ, V and T. On the basis of the stylized model we would expect this additional shock to G to leave Y, C+G, X, M, K, I and TOT unchanged, while generating a decrease in C (and Γ). In accordance with this expectation, as we go from step 0 to step 1 of Table 47.1, there is a decrease in C approximately offsetting the increase in G (private consumption is about 3 times the size of public consumption). However, there is a decrease in K which causes a decrease in Y via equation (47.2) and a decrease in I via (47.7). The decrease in K arises because public consumption expenditure is highly labour-intensive relative to private consumption expenditure. Another characteristic of public consumption is that it has a low import content relative to C and I. Thus imports in step 1 contract relative to Y. The result for X-M depends mainly on the relative sizes of the changes in Y and I. With I being about 1/5th of Y, the decrease in Y outweighs the decrease in I. Thus X-M decreases, and with M falling X must fall by even more. The reduction in X generates an improvement in the terms of trade, see (47.6).

Step 2: private consumption

In this step the swaps applied to the existing closure (that reached in step 1) are:

```
swap a3ncom 1 3-38= x3ncom_obs 1 3-38;
swap a3com 1-28 31-115 = a3shift 1-28 31-115;
swap a3com 29-30 = x3_obs 29-30;
swap apc_gnp = ave_a3com;
```

---

[4] As indicated in column 1 of Table 47.1, the increase in public consumption between 1987 and 1994 was 20.25 per cent. In column 0, where public consumption was linked to GNP, the increase was 5.30 per cent. Thus, as we go from column 0 to column 1, public consumption increases by 14.95 per cent.

Here we impose the change over the period 1987 to 1994 in the commodity structure and overall quantity of consumption. In terms of the stylized model we endogenize APC and impose an additional increase in C of 24.11 per cent (from -0.17 per cent in step 1 to 23.94 per cent in step 2). In the absence of terms-of-trade effects (i.e., if $\partial J/\partial X$ were zero) we would expect the additional increase in C (holding constant L, ROR, A, Ψ, G, V and T) to have relatively minor effects on Y, K, I and M and a major effect on X. Consistent with this, we see a 67.47 per cent decrease in X (from -19.68 to -87.15). However $\partial J/\partial X$ is negative, export demand elasticities in MONASH average about -3. Thus the decrease in X produces a significant increase in TOT and associated increases in M via (47.5) and K via (47.8). The increase in K is accentuated because private consumption expenditure (which has a large component of housing) is capital intensive relative to exports. With an increase in K there are increases in Y via (47.2) and I via (47.7). The ratio of net foreign liabilities to GDP increases sharply because the improvement in TOT is easily outweighed by the decline in X-M.

Our consumption data for 1987 to 1994 consists of growth rates in the 38 National Accounts (NA) categories and in two MONASH categories [commodities 29 and 30 which disaggregate NA category 2 (alcoholic drinks)]. We use these data by applying shocks to x3ncom_obs(na), na = 1, 3-38 and x3_obs(i), i= 29-30. Before we can do this, these variables must be exogenized.

For each exogenized x3ncom_obs(na), we endogenize the shift variable a3ncom(na). Via E_x3_m_na and E_x3ncom in subsection 18.8o, this allows the x3_m_na(i,na) to add over i to the exogenously given value for x3ncom_obs(na).[5] To connect the NA consumption data with the determination of the movements in consumption (x3) in MONASH categories, we exogenize a3shift(i) for all i except 29 and 30 so that apart from these two exceptions x3(i) is determined via E_x3_m_na and E_a3shift. For the two exceptions we determine x3(i) simply by exogenizing x3_obs(i).[6]

With the x3 vector (and consequently its total) now determined from our consumption data, we must turn off the equation, E_x3 in subsection 18.8e, that determined the structure of consumption in decomposition simulations. We must also break the link (imposed in decomposition simulations) between total consumption and GNP. We turn off the structure of consumption generated in E_x3 by N-1 endogenizations: the a3com(i)s are endogenized and ave_a3com is exogenized. We break the consumption-GNP link by endogenizing apc_gnp.

Step 3: imports

---

[5] The adj(i)s are currently exogenous and unshocked. Thus, in setting values for x3ncom_obs(na), we are setting the same values for x3ncom(na), see E_x3ncom_obs in subsection 18.8o.

[6] With the adj(i)s exogenous and unshocked, by setting values for x3_obs(i) we are setting the same values for x3(i), see E_x3_obs in subsection 18.8o.

```
swap  ftwist_src 1-96 98 101-114=x0imp_obs 1-96 98 101-114;
swap f1_commun_u = x0imp_obs 100;
```

In this step we introduce information on the movements in import volumes in most MONASH commodity categories. For these categories we exogenize x0imp_obs. With the exception of communications (MONASH commodity 100) we accommodate the import observations by endogenizing the import/domestic twist variable, ftwist_src. For communications, the dominant use of imports is as an intermediate input. In E_f1_commun we adopt a special treatment of these imported inputs (see the discussion in subsection 20.3). With this treatment in place, we accommodate the data on imports of communication services by allowing a uniform shift (f1_commun_u) in industry usage. In terms of the stylized model, the import observations are accommodated by endogenization of T in (47.5).

Application of the shocks for x0imp_obs increases aggregate imports by 41.17 per cent (from 17.72 in step 2 to 58.89 in step 3). As would be expected from our stylized model, an increase in M via import-favouring twists has little effect on Y, K and I. With C and G exogenously fixed, the main effect [see (47.1)] of the increase in M is an increase in X.[7] The increase in X is accompanied by a decrease in the terms of trade which reduces the purchasing power of GNP. However C and G cannot fall. Thus there is an increase in the average propensity to consume and an associated increase in the ratio of net foreign liabilities to GDP.

Step 4: investment

```
swap r_inv_cap = f_r_inv_cap;
swap r_inv_cap_s 1-24= y_s 1-24;
swap f_r_inv_cap 96 = y 96;
```

In the decomposition closure, investment by industry is tied down by exogenizing the industry I/K ratios (r_inv_cap). For 1987 to 1994 we have information on investment for 24 out of 26 sectors, and for MONASH industry 96 (air transport). We generate a closure in which we can use this information by three swaps. In the first, the I/K ratios become formally endogenous (see E_f_r_inv_cap in subsection 18.8n) and the shift variable (f_r_inv_cap) is exogenized. Via the second swap statement, we produce a closure in which shocks to investment [y_s(j), j = 1, 2, ..., 24] in the first 24 sectors are accommodated by uniform movements [r_inv_cap_s(j), j = 1, 2, ..., 24] in the I/K ratios of industries in the same sector. The I/K ratios of industries in the last two sectors remain fixed provided there are no shocks to r_inv_cap_s(s) for s = 25, 26 or to f_r_inv_cap(j) for j in sectors 25 or 26. The third swap accommodates investment information for industry 96 by allowing its I/K ratio to move independently of the I/K ratio of the sector to which

[7] In MONASH the increase in X is facilitated by real devaluation.

this industry belongs. In terms of the stylized model, we have exogenized I and endogenized Ψ.

The introduction of the investment shocks in step 4 reduces aggregate investment (from 8.53 in step 3 to 5.08 in step 4). With L, A and ROR fixed, there is little change in Y and K. With C and G fixed and M almost fixed, the decrease in I is accommodated in (47.1) mainly by an increase in X. This leads to a small deterioration in the terms of trade. As in step 3, this requires an increase in the APC and generates an increase in the ratio of net foreign liabilities to GDP.

Step 5: exports

```
swap  fep(TRADEXP) =x4_obs(TRADEXP) ;
swap fep_ntradi(NTRADEXP) = x4_obs(NTRADEXP);
swap fep_touri(TOURISM)= x4_obs(TOURISM);
swap  fx4_wattran =x4_obs(WATERTRAN);
swap fx4_transerv =x4_obs(TRANSERV);
swap fx4_commun=x4_obs(COMMUNICAT) ;
swap a1primgen = phi;
```

In this step we introduce information on exports for almost all MONASH commodities by first exogenizing and then shocking x4_obs(TRADEXP), …, x4_obs(COMMUNICAT).

For working out a macro strategy for exogenizing exports it is useful to look at the stylized model. In that model we can write the supply and demand functions for exports as:

$$X = Y(A, L, TOT, ROR) - (C + I + G - M) \tag{47.11}$$

and $$TOT = J(X, V) \quad . \tag{47.12}$$

Equation (47.11) is derived by substituting from (47.8) into (47.2) and then into (47.1) and equation (47.12) is a reproduction of (47.6). In the previous step A, L, ROR, C, I, G, M and V were exogenous and (47.11) and (47.12) can be thought of as determining X and TOT. In this step, we exogenize X.

In light of (47.11) and (47.12) there are two obvious strategies for exogenizing X: we could allow movements in export supply by endogenizing technological change (A in the stylized model and a1primgen in MONASH) or we could allow movements in export demand by endogenizing export demand shifts (V in the stylized model and fep(TRADEXP), …, fx4_commun in MONASH). Other potential candidates for endogenization are L and ROR. However, at this stage, these should remain exogenous because in later steps we will introduce information directly relevant to both employment and rates of return.

As can be seen from Table 47.1, step 5 involves a 94.44 per cent increase in exports (from -31.77 to 62.67). Accommodating such a large increase purely by endogenization of export demand shifts produced an unrealistically large terms-of-trade improvement through a sharp increase in foreign-currency export prices (pe in MONASH) with foreign-currency import prices (pm) held constant. This led to an enormous increase in the exchange rate (phi). The role of phi is not obvious from the stylized model. In MONASH, with the domestic price level tied down through the exogenization of the consumer price index (xi3), phi plays the role of the real exchange rate, that is, phi influences the ratio of domestic prices of traded goods to those of non-traded goods. When we generate a large terms-of-trade improvement in MONASH via increases in foreign-currency export prices, a large appreciation is necessary to produce a ratio of traded to non-traded prices compatible with the allocation of resources between production of traded and non-traded goods required by the exogenization of C, I, G, X and M.

The alternative approach of accommodating the 94.44 per cent increase in exports purely by endogenization of technological change produced opposite results: a large terms-of-trade deterioration through a sharp reduction in foreign-currency export prices accompanied by an enormous decrease in phi.

As a compromise between the two extremes, we exogenized exports in step 5 with movements in both the demand and supply curves. We allowed MONASH to determine the split between demand and supply movements by exogenizing phi at its observed change from 1987 and 1994 (-4.29 per cent). On comparing the results in Table 47.1 for step 5 with those for step 4, we find that the 94.44 per cent increase in exports is accommodated by both a substantial demand shift reflected in a terms-of-trade improvement of 29.09 per cent (from 10.43 to 39.52) and a substantial supply shift reflected in primary-factor-saving technical change of 12.53 per cent.

The primary-factor technical change of 12.53 per cent contributes an increase to GDP of approximately the same percentage. The other contributor to the increase of 14.46 per cent in GDP (from 4.15 per cent to 18.61 per cent) is capital growth induced by both the improvements in the terms of trade and in technology. That GDP must increase by about 14.46 per cent in response to the 94.44 per cent increase in exports as we go from step 4 to 5 is dictated by the approximate fixity of C, I, G and M and by our data for 1987 which shows that exports were about 15 per cent of GDP .

With an increase in GDP, an improvement in the terms of trade and fixed domestic absorption (C+I+G), step 5 produces a large reduction in net foreign liabilities (from 9 per cent of GDP in step 4 to -58 per cent in step 5).

Step 6: employment

swap a1prim= labind;

swap emp_hours = a1primgen;

swap labind = flabprod;

swap labprod_d = labind_d;

Here we introduce information on employment. This raises no macro closure issues. In terms of the stylized model, L is already exogenous and we are merely giving it a shock to reflect aggregate employment growth between 1987 and 1994. However, in MONASH our employment information comes at a disaggregated level and we need several endogenous/exogenous swaps before we can use it.

The first swap exogenizes employment by industry (labind), and allows shocks to labind to be accommodated by shifts at the industry level in primary-factor-saving technical change (a1prim). The second swap recognizes that exogeneity of labind requires endogeneity of total employment (emp_hours). The corresponding exogeneity in this swap is a1primgen. This is a shift in overall primary-factor-saving technical change and was endogenized in step 5. Now, in this step, when we endogenize primary-factor-saving technical change in each industry (a1prim), a1primgen must be exogenized. If both a1prim and a1primgen are endogenous, there is an indeterminacy. For example, if in a MONASH solution, a1primgen equaled 6 then we could generate another solution with a1primgen equal to 4 and all of the a1prim values raised by 2.

For the 1987/1994 historical simulation we do not have information on employment by MONASH industry. Instead we have employment for 87 groups of MONASH industries (labind_d). In the third and fourth swaps we re-endogenize employment by industry (labind) and exogenize labind_d. In effect we lose 113 pieces of information (the number of MONASH industries) and gain 87 pieces. This leaves a gap of 26 pieces of information. We fill this gap by reducing the number of degrees of freedom in the determination of labour productivity by industry from 113 (flabprod) to 87 (labprod_d). As can be seen from E_flabprod (subsection 18.8o), if flabprod is unshocked, then we are assuming that the movement in labour productivity is the same for all industries in the same labour group.[8]

Comparison of steps 5 and 6 in Table 47.1 shows that the imposition of the labour shocks raises employment by 10.15 per cent. With C, I, G, X and M approximately fixed, the increase in L can have little effect on Y. Assuming, temporarily, no change in the terms of trade and recalling that ROR is fixed, we

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[8] Intuitively, our assumption of equal productivity movements within sectors introduces 26 pieces of information, one for each industry which is not the first industry in its labour group.

see that (47.8) and (47.2) together imply that A must rise and K/L must fall.[9] Looking at steps 5 and 6, we can see both a rise in A (from -12.53 in column 5 to -5.65 in column 6) and a fall in K/L (a slight fall in K and a sharp increase in L).

Contrary to our temporary assumption of no change in TOT, there is a considerable reduction (from 39.52 per cent in step 5 to 26.71 per cent in step 6). The explanation is to be found in the industrial structure of the change in employment. Employment in both the major export sectors (agriculture and mining) declines sharply in step 6 relative to step 5. Because exports are unchanged between steps 5 and 6, the outputs of agriculture and mining are largely unchanged. Thus, these sectors have significantly more primary-factor-saving technical change in step 6 than in step 5. Consequently, in step 6, there is a reduction in the outward movement of export-demand curves required to explain the observed increases in agricultural and mineral exports. This reduces the terms of trade. The reduction in the terms of trade reinforces the decline in K/L and causes an increase in net foreign liabilities as a share of GDP (from -58 per cent in step 5 to -53 per cent in step 6).

Step 7: capital

```
swap twistlk_s 1-24= cap_at_t_s 1-24;
swap ff_twistlk 68 = cap_at_t 68;
```

For the period 1987 to 1994 we have data on capital growth for 24 (out of 26) sectors, covering nearly all the MONASH industries. Before we can introduce these data into the historical simulation, we need to exogenize capital growth for these sectors [cap_at_t_s(s), s = 1, 2, ..., 24]. As explained in section 31 in our discussion of E_twistlk, we accommodate the sectoral capital data by allowing equal capital-labour technology twists (twistlk_s 1-24) for industries within the same sector.

MONASH industry 68 (Motor vehicles), which is part of sector 8 (transport equipment), was the focus of a special study (see Chapter 2). In that study we obtained an estimate of the industry's capital growth [cap_at_t(68)] for the period 1987 to 1994. So that we could use this estimate, we exogenized cap_at_t(68) and endogenized the industry-specific capital-labour twist, ff_twistlk(68). With both ff_twist(68) and twistlk_s(8) endogenous, the MONASH historical simulation was able to hit both the industry and sectoral targets [cap_at_t(68) and cap_at_t_s(8)].

Steps 6 and 7 in Table 47.1 show that the application of the capital shocks increased aggregate capital growth by 11.72 per cent (from 17.25 in step 6 to 28.97 in step 7). With Y and L fixed, (47.2) in the stylized model implies that an

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[9] Assume that A falls. Then with an increase in L and with Y constant, (47.2) implies that K must fall. Thus K/L falls. But with ROR and TOT fixed and with N being a decreasing function of A, the fall in K/L is contradicted by (47.8). Hence A must rise, and via (47.8) K/L must fall.

increase in K must produce an increase in A. This is reflected in the MONASH results (ave_aprim increases from -5.65 in step 6 to -2.21 in step 7). Unlike the employment data in step 6, the capital data in this step do not cause sharp differences in rates of primary-factor-saving technical change between export and non-export industries. Consequently, the achievement of the exogenously given export quantities (X) requires little change in the export-demand shifts (V) from their values in step 6. Thus, consistent with (47.6) there is little change in TOT. With ROR fixed, A increasing and little change in TOT, (47.8) implies a decrease in K/L. However, in this step, K/L is forced to increase. In effect, MONASH equations such as (47.8) are turned off by the endogenizing of capital-labour twists.

The ratio of net foreign liabilities to GDP increases sharply in step 7 relative to step 6 (from -53 per cent to -3 per cent). As we go from step 6 to step 7, there is a significant increase in capital but little change in national saving.

Step 8: prices of value added and wagebills

```
swap del_ff_rate_s 1-10 12-18 = p_va_s 1-10 12-18;
swap fvas = fwage;
swap f_1octss 1-10 12-18 = ff_p_va_s 1-10 12-18;
swap fwage_s = wagebill_s;
```

The swaps in this step allow us to use data on the prices of value added and wagebills. As mentioned in section 31, these data tie down rental prices on capital and industry rates of return.

The first swap exogenizes the prices of value added (p_va_s) for seventeen sectors and allows shocks for these variables to be absorbed by shifts in sectoral rates of return (del_ff_rate_s). As can be seen from E_del_f_rate and E_del_ror_se in subsection 18.8n, movements in del_ff_rate_s impart equal changes to the rates of return of industries belonging to the same sector. Adjustments in rates of return allow sectoral value-added prices to hit their targets by causing adjustments in rental prices of capital (p1cap).

However, with only this first swap in place MONASH gives unsatisfactory results. There are two problems. First, in aggregate, our sectoral value-added prices imply a movement in the domestic price level (the price of GDP). But this movement is already almost tied down by the exogeneity of the consumer price index. Thus our system of equations is almost singular. Second, with rates of return, wage rates and capital/labour twists (twistlk_s) endogenous, MONASH has little basis for splitting movements in value-added prices between movements in wage rates and movements in rentals on capital. Both of these problems are solved by the second swap. With this swap, rental-wage indeterminacy is removed by exogenizing the real wage rate (fwage, see E_wlaboi in subsection 18.8c). Incompatibility between alternative determinations of the domestic price level is resolved by the use of an endogenous wedge (fvas, see E_p_va_s in subsection 18.8o) between the data on sectoral value-added prices and the endogenously-determined industry value-added prices (p_va). Effectively, we no longer require the industry value-added prices to add to the sectoral value-added prices.

As explained in section 31, the role of the third swap is to damp the movements in the p1cap(j)s. With this swap, some of the adjustments required to absorb the data on value-added prices are spread to the prices of other cost tickets.

With the first three swaps in place, we assume that the movement in the real wage rate in all industries is the same, fwage. We can add more detail to the wage movements by using sectoral data on wagebills. Such data are accommodated by exogenizing wagebill_s (see E_wagebill_s in subsection 18.8c) and endogenizing movements in sectoral real wage rates (fwage+fwage_s). Although real wage rates have now been formally re-endogenized, there is no return of rental-wage indeterminacy. Real wage rates are tied down by the data on wagebills and employment.

The effect on the variables in Table 47.1 of applying the 1987/1994 shocks to sectoral value-added prices and wagebills is minor. Most of these variables are already tied down. The main effect is on the terms of trade (a reduction from 25.18 in step 7 to 14.12 in step 8). Our data on value-added prices and wages generates a sharp reduction in rates of return in mining, Australia's main export sector. With a reduction in rates of return, the growth in mineral exports is explained with less outward movement in export-demand curves. Reduction in the terms of trade causes: an increase in net foreign liabilities; an increase in the APC required to maintain the given levels of public and private consumption; and a decrease in the price deflator for GDP.

Step 9: agricultural outputs by commodity and industry and export prices of agricultural commodities

```
swap a0ci = x0ci_obs;
swap f_x0ci = x0dom_absobs 1-9;
swap d_x6cs 1 3 = peobs 1 3;
swap ac 2 4-9 = peobs 2 4-9;
swap powtax0ph 1-7 = avea0ci_j;
```

The main aim of these swaps is to allow the historical simulation to absorb two sets of slightly incompatible agricultural output data: data on changes in the outputs of MONASH's nine agricultural products in each of the model's seven agricultural industries; and data on changes in the overall outputs of MONASH's nine agricultural products. Most of the swaps in earlier steps could be considered one at a time. However in this step, the five swaps are strongly inter-related and must be considered simultaneously.

In the first two swaps we exogenize the 63 observations on commodity outputs by industry (x0ci_obs) and the nine observations on total outputs of agricultural commodities (x0dom_absobs, 1 - 9). Incompatibilities are resolved by endogenizing the shift variable f_x0ci. Via E_x0ci_obs in subsection 18.8o, a movement in f_x0ci(i) makes a uniform percentage adjustment across agricultural industries to the growth rates [x0ci(i,j)] adopted by MONASH for industry outputs of commodity i. Via E_x0dom_JP, E_x0dom_abs and E_x0dom_absobs in subsections 18.8a and 18.8o, these adjustments allow the weighted addition of x0ci(i,j) over agricultural industries j to equal the exogenous value, x0dom_absobs(i), for output of agricultural commodity i.

With total outputs of agricultural commodities exogenized, we must provide some demand-side freedom. We do this in the third and fourth swaps by endogenizing inventory movements (d_x6cs) for commodities 1 and 3 and input-using technical change (ac) for commodities 2 and 4 - 9. Commodities 1 and 3 are wool and wheat, produced in Australia primarily for export. Over the period 1987 to 1994 both these commodities were exported through government marketing boards which attempted to maximize Australia's export revenue by accumulating inventories when world prices were low and running them down when prices were high. For the remaining agricultural products, adjustment via intermediate usage is a suitable approach. These products are used substantially as intermediate inputs and are not held to a significant extent as inventories.

Next, we must consider the supply side: the reconciliation of the observed mix of commodity outputs within each agricultural industry with the profit maximizing behavior built into MONASH. To allow MONASH to reproduce the required mix within agricultural industry j [x0ci(i,j) for i = 1, 2, ..., 9], we free j's *relative* rates of commodity-expanding technical change. We do this by endogenizing a0ci(i,j) for i = 1, 2, ..., 9 in the first swap and exogenizing avea0ci_j(j) in the fifth swap. Because a major component of input-saving technical change [a1prim(j)] is already endogenous (see step 6) we cannot endogenize the absolute rates of commodity-expanding technical change. If we failed to control the average of the a0ci(i,j) for i = 1, 2, ..., 9, then there would be an indeterminacy between this average and a1prim(j) in reconciling j's observed inputs and overall output.

Once we have endogenized relative rates of commodity-expanding technical change, an indeterminacy arises between these rates and the basic prices of commodities [p0dom(i), i = 1, 2, ..., 9]. To understand this indeterminacy, we start by considering the determination of the agricultural p0dom(i)s in step 8, that is before the introduction of data on commodity outputs by agricultural industries. In step 8, the a0ci(i,j)s were exogenous and the determination of the x0ci(i,j)s was unrestricted by observations. Exports and most other components of demand for agricultural products were exogenous. In these circumstances, we can think of the p0dom(i)s as being determined by the need to induce the agricultural sector as a whole to satisfy exogenous demands. Now, in the current step, with the a0ci(i,j)s endogenous, we must introduce some new information to tie down the p0dom(i)s. Otherwise, there may be a variety of relative price and relative technology movements which would reconcile the commodity mix of exogenous demands with profit maximizing behavior. For example, strong growth in the output of wool might be explained either by high wool prices or by wool-expanding technological change.

As can be seen from the third and fourth swaps, we chose observations on export prices to tie down the p0dom(i)s. This was a suitable choice for two reasons: (a) we had such observations; and (b) there are significant exports of all of the agricultural products and it is reasonable to assume that the determination of domestic prices for these products is dominated by movements in export prices.

With the p0dom(i)s tied down by export prices (via E_pe in subsection 18.8j) and with outputs exogenous, revenue in each agricultural industry is determined. To a large extent, costs in each agricultural industry are tied down by exogenous input quantities and by input prices from outside the agricultural sector. With revenue and costs determined in these ways, we need a new degree of freedom to satisfy the zero-pure-profit condition (E_z in subsection 18.8j). As can be seen from the fifth swap, we use phantom production taxes [powtax0ph(j), j = 1, 2, ..., 7].

In our historical simulation for 1987 to 1994, we found that the endogenously determined values for the phantom production taxes were mainly negative and quite large. This alerted us to a potential inconsistency between our data on the movement in the price of value added (p_va_s) for the agricultural sector and our data on export prices for agricultural products. We found that negative phantom production taxes (i.e. subsidies) were necessary because the observed growth rates in export prices were implausibly low relative to the observed growth rate in the sectoral price of value added. Because we found no basis for preferring one set of data (the value added price) to the other set (the export prices) we left the potential inconsistency between them unresolved.

A comparison of steps 8 and 9 in Table 47.1 shows that the introduction of detailed agricultural data has little impact on the macro results from our historical simulation. At this stage the macro variables are largely exogenous. The biggest difference between steps 8 and 9 is in the terms of trade (14.12 in step 8 and 10.83 in step 9). The export prices imposed for agricultural products in step 9 are lower than those generated in step 8. This is consistent with the generation in step 9 of negative phantom taxes.

Overall technical change (measured by the negative of ave_aprim) and real GDP growth are slightly larger in step 9 than in step 8. These variables are not affected by the movements in ac(i)s that we use to accommodate the exogenous output levels for commodities 2 and 4 to 9. However they are affected by the movements in inventories that we use to accommodate the exogenous output levels for commodities 1 and 3 (wool and wheat). The imposed level for wheat output in step 9 is considerably higher than the generated level in step 8, leading in step 9 to a significant accumulation of wheat inventories. For wool, the imposed level of output in step 9 is slightly lower than the generated level in step 8. Thus in step 9 we find a slight rundown of wool inventories. Together the changes in wheat and wool inventories explain the increase in real GDP. With exogenous capital and labour inputs, the increase in GDP explains the improvement in overall technology.

Step 10: import and non-agricultural export prices

```
swap  powtax4ph 10-13 17-31 33-65 67-85 97-103 105-114 =
      peobs 10-13 17-31 33-65 67-85 97-103 105-114;
swap  powtax4sph 14-16 32 66 = peobs 14-16 32 66;
swap pm 1-85 98-115= pmobs 1- 85 98-115;
swap pm 86-97 =fpdm 86-97;
swap f_pe_u = expvalf;
swap f_pm = impvalf;
```

In step 9 we introduced information on the export prices of commodities 1 to 9. The first two swaps in this group allow us to introduce our remaining information on export prices. This covers all other commodities except 86-96 104 115. The exceptions are mainly non-exportable services.

MONASH requires: that basic prices (p0dom) reflect the exchange rate, export prices and associated export taxes (see E_pe in subsection 18.8j); that industry output prices (p0ind) reflect basic prices (see E_p0ind in subsection 18.8j); and that unit production costs equal industry output prices (see E_z in subsection 18.8j). Thus each industry's unit production cost must reflect the exchange rate and the export prices of the commodities produced by the industry together with associated export taxes. The exchange rate was set in step 5 and unit production costs were largely tied down when we introduced information on factor inputs, prices of value added and commodity demands. Up to this step, export taxes have been exogenous. Thus to accommodate given export prices for non-agricultural products, we must now either untie unit production costs or allow shifts in export sales taxes.

For agricultural industries we accommodated given export prices of agricultural products by using endogenous phantom production taxes to untie unit production costs. The alternative approach via export taxes is inconvenient for agricultural industries because there is not a unique export tax associated with each industry. For example, it would have been unclear whether to use the export tax on wool or wheat or some other agricultural commodity to reconcile given export prices with unit costs in the Wheat/sheep zone (MONASH industry 2) because this industry produces all these commodities. If we had used the export tax on wool, say, for the Wheat/sheep zone, then it is not clear how we would have reconciled the given export prices with unit costs in, for example, the Pastoral zone (industry 1) which is dominated by wool production.

For non-agricultural industries the non-uniqueness problem does not arise. Each of these industries produces a single commodity and is the only producer of that commodity. Thus for these industries, the use of phantom export taxs is feasible and, as can be seen from the first and second swaps, this was the approach we used.

An advantage of using phantom export taxes is that it we can allow some domestic purchasers' prices to be dominated by unit costs, independently of export prices. As discussed in subsection 28.1, this approach is implemented by endogenizing the non-spreading phantom export taxes (powtax4ph). It is appropriate for commodities such as fish (MONASH commodity 13) in which the export variety is quite different from the variety sold domestically. From the first swap statement, it can be seen that we implemented the non-spreading approach for commodities 10 - 13, 17-31, etc. For other commodities such as iron ore it is appropriate to assume that export prices dominate domestic prices. For these commodities we could use phantom production taxes for the relevant industries. Equivalently, as discussed in subsection 28.1 and implemented in the second swap, we can use spreading phantom export taxes (powtax4sph).

The third and fourth swaps are concerned with import prices. We absorb information on these prices for commodities 1-85 and 98-115 via shocks to pmobs. Consequently for these commodities we exogenize pmobs and endogenize pm (see E_pmobs in subsection 18.8o). For commodities 86 to 97 (electricity, gas etc) there is no information on foreign-currency import prices. Imports of these commodities are minor. They are mainly services generated by foreigners in Australia. By exogenizing fpdm(i), i = 86 to 97, and applying zero shocks, we assume that the cost of these imported services reflect costs of equivalent domestically produced services (see E_fpdm in subsection 18.8j).

The fifth and sixth swaps introduce some fine-tuning of our data on export and import prices. Via the fifth swap we make a uniform adjustment (f_pe_u, see E_peobs in subsection 18.8o) to all foreign-currency export prices to ensure that the growth in the foreign-currency value of exports implied by the MONASH historical simulation is consistent with data (expvalf). Similarly, via the sixth swap we make a uniform adjustment (f_pm, see E_pmobs in subsection 18.8o) to foreign-currency import prices, ensuring that the implied growth in the foreign-currency value of imports is consistent with the observed growth (impvalf).

Potentially the introduction of information on export and import values could have had a significant effect on the terms of trade. In fact the movement in this variable is small (from 10.83 in step 9 of Table 47.1 to 9.33 in step 10). With little change between steps 9 and 10 in the terms of trade, there is little change in any other variable.

The variable showing the largest percentage change is real devaluation. The export and import prices (xi4 and xim) in step 10 are higher than those emerging from step 9, with little change in the GDP deflator (xigdp)[10]. This explains the greater real devaluation (= xim – xigdp, see E_realdev in subsection 18.8l) in step 10 relative to step 9 (from –30.03 per cent in step 9 to –23.90 per cent in step 10). In light of the argument in step 5, we should explain how the increased ratio of traded to non-traded prices in step 10 is reconciled with the split of production between traded and non-traded goods which has been largely fixed since step 5. To achieve reconciliation, MONASH generates an increase in total phantom export taxes. Fortunately this is quite small indicating that there are not serious conflicts, at least at the aggregate level, between the domestic price, cost and exchange rate data introduced in earlier steps and the export and import values introduced in this step.

Step 11: outputs of non-agricultural commodities

```
swap ac(COM_UP)= ffac;
swap aq 10 12-18 20-21 24 29-32 35-92 97-98 101-104
        = x0dom_absobs 10 12-18 20-21 24 29-32 35-92 97-98 101-104;
swap a1 = del_f_a1;
swap a2ind = del_f_a2;
swap a3shift 22 25 26 28 40 114 = x0dom_absobs 19 22 23 25 33 99;
swap adj_abs 26-28 94-96 = x0dom_absobs 26-28 94-96;
swap x3ncom_obs 5= x0dom_absobs 34;
```

In step 9, MONASH was set up to absorb data on movements in outputs of agricultural commodities (x0dom_absobs 1-9). The aim of the swaps here is to allow MONASH to absorb output data for non-agricultural commodities.

The model has 106 non-agricultural commodities (commodities 10-115). For these commodities, data are available for 95 ABS groups (x0dom_absobs 10-104). In most cases these data are for individual commodities (that is most of the ABS groups contain only one MONASH commodity) but in a few cases the data are for an aggregate of two or three MONASH commodities. For the 1987/1994 historical simulation, we decided that data for three of the ABS groups (x0dom_absobs 11 93 100) were unreliable. Thus on the RHSs of the swaps in this step, x0dom_absobs appears for only 92 groups: 10 to 104 excluding 11, 93 and 100.

The first swap is a preliminary move. It turns on E_ffac in subsection 18.8o. With ffac exogenous, this equation determines ac(i) for all i in COM_UP (that is for non-agricultural products). In historical simulations, we leave ffac(i)

---

[10] Because the information introduced in step 10 gives a terms-of-trade result close to that in step 9, and because there is no change between the two steps in the price deflator for consumption (the major component of domestic absorption), there can be little change between the two steps in the price deflator for GDP.

unshocked. Then, as can be seen from E_ffac, the ac(i)s have the same value [aq(abs)] for all i in the same ABS group, abs.

The next three swaps allow MONASH to absorb exogenously given output changes in most non-agricultural ABS groups (10, 12-18, etc.) by taste changes and by cost-neutral commodity-using changes in technology. For these ABS groups, a shock to x0dom_absobs(abs) is absorbed by an equal endogenously determined movement [aq(abs)] in ac(i) for all i in the ABS group abs. From E_a1ci, E_a2ci, E_a1marg, ..., E_a5marg and E_x3_m_na in subsection 18.8o, we see that movements in ac(i) cause commodity-i-saving technical changes in production, capital creation and margin usage, and possibly[11] a commodity-i-saving change in consumer preferences. As explained in section 31 (see the discussion of E_del_f_a1 and E_del_f_a2), we neutralize the effects of the ac(i) movements on industry production and capital costs by exogenizing del_f_a1 and del_f_a2 and endogenizing a1 and a2ind.

For ABS groups in which intermediate, capital and margin usage are only a minor part of demand, the technology/taste approach [that is absorption of output shocks via the ac(i)s] can generate unrealistically large commodity-i-saving technical changes. The problem is that discrepancies between data on output movements and model-implied demand movements are resolved by alterations in too small a component of demand.

Section 31 (see the discussion of E_adj,..., E_x3ncom_obs) describes three alternatives to the technology/taste approach. We used the first of these (endogenous inventories) for absorbing output information on wool and wheat (see step 9). We use the second (additional shift in consumer preferences) for ABS groups containing commodities with the following two characteristics: (1) households account for more than 70 per cent of demand and (2) household demand is only a small fraction the relevant National Accounts categories. Characteristic (2) means that consumption is not tightly tied down by the introduction of National Accounts consumption data in step 2. ABS groups 19, 22, 23, 25, 33 and 99 possess these two characteristics. It also happens that these groups each contain a single MONASH commodity: commodities 22 25 26 28 40 and 114. As can be seen from the fifth swap, we allow MONASH to absorb information on output movements for ABS groups 19, 22, etc. by altering the consumption of MONASH commodities through endogenous movements in the taste change variables a3shift(i) for i = 22, 25, etc. Now, for example, if our data indicate strong growth in the output of MONASH commodity 22, then a3shift(22) will be positive causing increases in x3_m_na(22,na) and x3(22) [see E_x3_m_na and E_a3shift in subsection 18.8o]. The increase in x3_m_na(22,na) will require

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[11] If consumption of i is completely tied down by our data for x3ncom_obs(na), then movements in ac(i) alter a3ncom(na), but do not influence our ultimate indicator of i-affecting taste change, a3com(i).

offsetting decreases in x3_m_na(i,na) for i ≠ 22 and MM(i,na) ≠ 0 [see E_x3ncom in subsection 18.8o]. These offsets are achieved through movements in a3ncom(na).

The third alternative described in section 31 to the technology/taste approach involves reconciling supply and demand data by reducing (increasing) outputs and imports and by increasing (reducing) exports and consumption. We adopted this alternative for ABS groups 26-28 and 94-96, groups for which data are available on output, imports and all major elements of demand. For these groups, we allowed MONASH to absorb output information by endogenous movements in adj_abs. If, for example, x0dom_absobs(26) is high relative to our information on demand less imports for commodities in ABS group 26, then adj_abs(26) will be negative. As can be seen from E_x0dom_absobs (subsection 18.8o), a negative value for adj_abs(26) reduces the output movement [x0dom_abs(26)] entering the rest of MONASH. Via E_adj, the negative movement in adj_abs(26) generates equal negative movements in adj(i) for all i in ABS group 26. These movements in adj(i) reduce imports [x0imp(i), see E_x0imp_obs], increase exports [x4(i), see E_x4_obs], increase public consumption [x5cs(i,s), see E_x5cs_obs] and increase private consumption [x3(i) or x3ncom(na), see E_x3_obs and E_x3ncom_obs]. The variable adj(i) acts directly on x3(i) when x3_obs(i) is exogenous. This is the case for MONASH commodities 29 and 30 (see step 2). When x3ncom_obs(na) is exogenous, then adj(i) influences x3(i) via its effects on x3ncom(na).

Finally, for ABS group 34 which corresponds to National Accounts category 5 (footwear), we adopted an alternative to the technology/taste approach not mentioned in section 31. As for ABS groups 26-28 and 94-96, for ABS group 34 we have data on supplies and all major components of demand. However, in light of the data on footwear imports, footwear output and aggregate consumption, we judged the National Accounts consumption data on footwear to be unrealistic. Consequently, we abandoned the consumption data [by endogenizing x3ncom_abs(5)] in favour of the output data [by exogenizing x0dom_absobs(34)].

A comparison between steps 10 and 11 in Table 47.1 shows a small increase in GDP arising from: small increases in public and private consumption and in exports; a small reduction in imports; and no change in investment. The changes in these expenditure aggregates reflect the outcomes for the adj_abs(abs)s, which were on average negative. Despite the increase in GDP and the lack of movement in K and L, there is an increase in ave_aprim (from -2.29 in column 10 to -0.02 in column 11). We traced this to margins industries. Step 11 implied considerable retail- and wholesale-saving technical changes, i.e., reductions in these services per unit of flow of goods from producers to users. Unlike other technical changes generated in step 11, margin-saving technical changes were not cost-nuetralized. Saving of resources in the margins industries in step 11 thus allowed the economy to produce a higher level of GDP than in step 10 with approximately the same input of primary factors and with less primary-factor-saving trechnical change.

Step 12: consumer prices and taxes

swap powtaxphph 13 20-31 37 39-41 45 55-56 58 76 93 112-114 =

p3_obs 13 20-31 37 39-41 45 55-56 58 76 93 112-114;

swap p3_adj = pow_phph3_ave;

swap powtax3vg 29 31 58 = taxrev3gc 29 31 58;

swap fpowtax3g 145 = taxrev3gc 30;

The ABS publishes detailed data on movements in consumer prices for major consumer goods. We introduced this information to the historical simulation by shocks to p3_obs. This requires exogenization of p3_obs for the relevant commodities (13, 20-31 etc.). For each of these commodities we must allow MONASH to reconcile the exogenous consumer price with the cost of supplying the commodity to consumers (see E_p3cs, E_p3 and E_p3_obs in subsections 18.8j, 18.8e and 18.8o). For the reconciling variables we chose domestic components of powtaxphph[12]. As can be seen from E_powtax3 in subsection 18.8k, movements in powtaxphph(i,dom) affect the cost of supplying i to consumers via powtax3(i,dom).

Our decision to use powtaxphph(i,dom) as the reconciling variable for p3_obs(i) has two implications. First, it means that our shock to p3_obs(i) is used to inform MONASH about the consumer price of *domestic* good i. We judged that our information on import prices (pmobs, introduced in step 10) provides sufficient guidance on movements in the prices of imported consumption goods. Second, by using powtaxphph, we allowed the data on consumer prices of major consumer goods to dominate the determination of the prices of these goods to all domestic purchasers (see E_powtax1, E_powtax2, E_powtax3 and E_powtax5 in subsection 18.8k). Thus, for example, we assumed a sharp upward movement in the price to households of domestic clothing to be evidence of a sharp upward movement in the price to industries of domestic clothing.

In step zero we introduced data on the overall increase in consumer prices (xi3). To avoid conflicts between xi3 and the p3_obs, we confined the role of the p3_obs to the determination of *relative* consumer prices. This was achieved by endogenizing p3_adj (see E_p3_obs, subsection 18.8o) and by exogenizing at zero the movement in the average power of the phantom taxes applying to consumption (pow_phph3_ave). Endogenous movements in p3_adj affect p3 only when p3_obs is exogenous. Consequently, our procedure amounts to adjusting the movements in the consumer prices for which we have observations so that these movements, together with the model-determined movements in other consumer prices, are

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[12] These are components 1-115. The imported components are 116-230.

compatible with xi3 without requiring overall phantom consumer taxation or subsidization.

The third swap allows us to use data on the collection of indirect taxes on beer, tobacco and petrol [taxrev3gc(i) for i = 29, 31 and 58] to determine the shifts in the powers of the genuine consumption taxes [powtax3vg(i) for i = 29, 31 and 58] applying to domestic and imported varieties of these products. The final swap allows us to use data on the collection of indirect taxes on other alcoholic drinks [taxrev3gc(30)] to determine the shift in the power of the genuine consumption tax applying to the *imported* variety of this product [fpowtax3g(30,imp)[13], see E_powtax3 in subsection 18.8k]. The imported variety is mainly spirits whereas the domestic variety is mainly wine. Other information suggested that there was a shift in the power of the tax on spirits but not wine.

The main role of the of consumer price and tax data in the historical simulation is to improve the estimation of changes in consumer tastes (a3com). With more accurate price data, MONASH is able to distinguish better between price-induced and taste-change-induced movements in consumption. Introduction of the consumer price and tax data has little effect at the macro level. This can be seen by comparing steps 11 and 12 in Table 47.1. What small differences there are between these two steps arise almost entirely from the tax data. On average, the shocks to taxrev3gc increased consumer prices of the directly affected commodities. With xi3 fixed, there must be an offsetting downward adjustment in the consumer prices of other commodities. This is achieved by a downward movement in fvas which reduces value-added prices (see step 8). The reduction in value-added prices has minor effects on the price deflators for investment and GDP (xi2 and xigdp) and on other variables in Table 47.1.

48. Developing the forecast closure (second column of Table 45.1)

Forecast simulations are performed as a sequence of annual solutions: the base solution for the year-t computation is the solution for year t-1. In annual solutions investment and saving accumulated over a number of years ($I_{87/94}$ and $S_{87/94}$ in Figures 5.1 and 47.1) play no role and are therefore omitted from Figure 48.1, our diagram for the forecast closure.

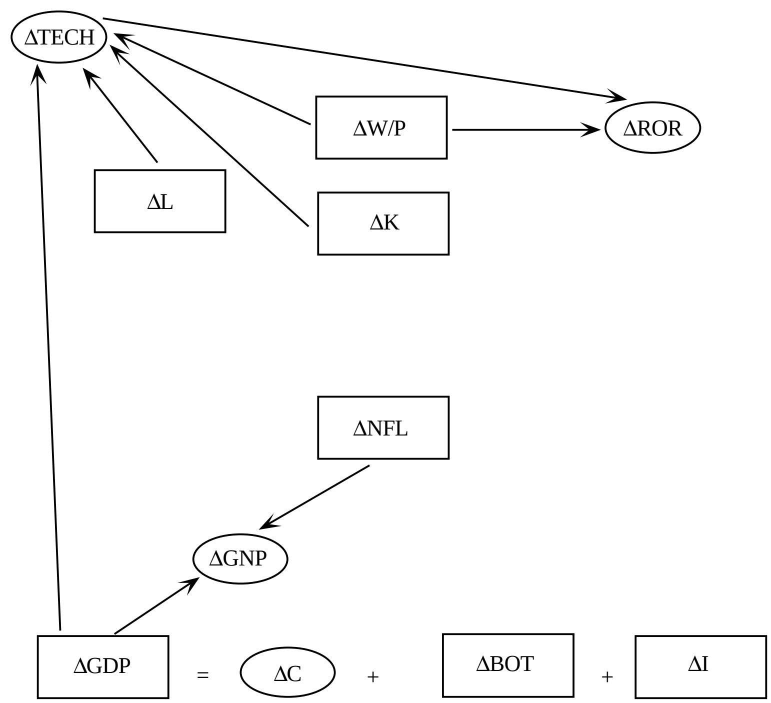
Because we are dealing with annual solutions, start-of-year stock variables for year t are completely determined by end-of-year stock variables in the base solution. We indicate this in Figure 48.1 by showing the changes in start-of-year capital (ΔK) and in start-of-year net foreign liabilities (ΔNFL) as exogenous. While these variables can be thought of as exogenous in the computation for any year t, they should be thought of as endogenous for the sequence of annual solutions which make up a forecast simulation. Although not indicated in Figure

[13] This is the 145th element of fpowtax3g.

48.1, ΔI together with ΔK in year t determine end-of-year capital stocks for year t which then determine start-of-year capital stocks for the next year, t+1. Similarly, ΔBOT and ΔNFL determine end-of-year net foreign liabilities which then determine the start-of-year net foreign liabilities for the next year.

As in historical simulations, in forecast simulations most macro variables are exogenous, allowing them to take shocks from macro forecasters. This requires endogenization of technical change ($\Delta TECH$). However in forecast simulations there are comparatively few exogenized industry and commodity variables. Consequently, the endogenous technical changes in forecast simulations are confined to a few broad variables such as a1primgen and f_twistlk. These impose equal percentage changes across industries in primary-factor-saving technological progress and in capital/labour technological bias.

Figure 48.1. Macro connections in the forecast closure



In developing the forecast closure we follow a similar approach to that in the previous section. We apply a series of swaps to the decomposition closure. These are indicated by the arrows from the third column of Table 45.1 to the second column.

The 24 swaps listed above convert the decomposition closure (a closure for solutions spanning a multi-year period) into one that is suitable for year-to-year simulations. The swaps configure MONASH for simulations in which the base solution for the year-t computation is generated from the final solution for year t-1.[14]

The 11 swaps in the left column turn on equations for determining start-of-year values for variables in year t from the base solution on the assumption that this solution is for year t-1. For example, the first swap exogenizes the shift variable in

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[14] For year 1 the base solution is generated from data for year 0. For convenience we refer to the data for year zero as if it were the final solution for year 0.

Step 1: swapping from a one-period long-run closure to a year-to-year short-run closure

```
swap d_ff_excht = d_f_excht;
swap del_ff_rate = del_f_ac_p_y;
swap d_ff_pcapatt = d_f_pcapatt;
swap shtfdfc = d_f_fdfc_t;
swap shtfddc = d_f_fddc_t;
swap shfeat_j = d_f_fea_t_j;
swap shtfcfc = d_f_fcfc_t;
swap shtfcdc = d_f_fcdc_t;
swap f_fat = d_f_aef_t;
swap d_psd_t = d_f_psd_t;

swap d_ff_xiwldt = d_f_xiwldt;
```

```
swap xi3_l = d_f_xi3_l;
swap xi3_2l = d_f_xi3_2l;
swap d_rint_l = d_f_rint_l;
swap pi_l = d_f_pi_l;
swap d_f_pcapatt1 = d_ff_pcapatt1;
swap d_f_excht1 = d_ff_excht1;
swap d_f_xiwldt1 = d_ff_xiwldt1;
swap d_f_netfltf = ff_shfeat;
swap r_inv_cap = d_f_eeqror_j ;
swap d_f_eeqror_j 10 15 105-109 113
                  = y 10 15 105-109 113;
swap a1 = del_f_a1;
swap a2ind = del_f_a2;
swap a1prim 104 = capprod 104;
```

E_d_f_excht (subsection 18.8s). With its shift variable exogenous and unshocked, E_d_f_excht equates the start-of-year exchange rate for year t to the end-of-year exchange rate in the base solution. This is appropriate when the base solution for year t is the final solution for year t-1. Similarly, via the second swap we can ensure in forecast simulations that start-of-year capital stocks in year t equal end-of-year capital stocks in year t-1 (see E_del_f_ac_p_y, subsection 18.8m).

On the assumption that the initial solution for year t is the final solution for year t-1, the first four swaps in the right column allow MONASH to evaluate correctly lagged variables in year t. For example, when the shift variables in E_d_f_xi3_l and E_d_f_xi3_2l (see subsection 18.8n) are exogenized and unshocked, then as discussed in subsection 30.2, the lagged and double-lagged movements in the CPI are equated to the movements in the CPI between years t-2 and t-1 and between years t-3 and t-2.

Again on the assumption that the initial solution for year t is the final solution for year t-1, the next three swaps in the right column allow end-of-year levels of variables in year t to be determined by adding six months growth to these variables' mid-year levels with the growth rates being determined from mid-year t-1 to mid-year t. For example, the first of these swaps turns on E_d_ff_pcapatt1 (see subsection 18.8s). As explained in section 35, if the shift variables in this equation are exogenous and unshocked, then we are assuming that the rates of growth in industry asset prices from the middle to the end of year t are the same as those from the middle of year t-1 to the middle of year t.

The eighth swap in the right column is concerned with the change in start-of-year net foreign liabilities (d_netfltf). In decomposition simulations this variable is determined by E_d_netfltf (see subsection 18.8r and subsection 34.1). As explained in section 35, in year-to-year simulations, d_netfltf is determined by movements in foreign liabilities (fdfc_t, fddc_t, fea_t_j), foreign assets (fcfc_t, fcdc_t, aef_t) and the exchange rate in year t-1. These movements are deduced via homotopy equations from the base solution (that is the final solution for year t-1). As we move from decomposition simulations to year-to-year simulations we turn off E_d_netfltf by endogenizing its shift variable (d_f_netfltf). With shfeat_j having been endogenized to allow fea_t_j to be determined via the homotopy equation E_d_f_fea_t_j, we avoid indeterminacy in E_fea_t_j by exogenizing ff_shfeat.

The ninth swap in the right column turns on the inverse-logistic determination of investment by industry (E_d_f_eeqror_j, subsection 18.8m) described in subsection 30.1 and frees investment/capital ratios. The tenth swap turns off the inverse-logistic determination of investment in Forestry (10), Oil and gas (15), government-related industries (105-109) and the dummy industry (113).[15] For these industries we prefer to use direct forecasts of their investment rather than rely on endogenous determination.

The next two swaps allow us to neutralize the cost effects of input-saving technical change (scenarios for the variable ac, see the discussion in step 11 of section 47).

The final swap in the right column concerns Ownership of dwellings (industry 104). The output of this industry is the services provided by its capital, the housing stock. In most MONASH simulations we wish to assume that output of 104 is proportional to capital in 104. Because industry 104 uses no labour or land, its price-substitution and twist terms in the capital-demand equation, E_cap_at_t, are zero. Thus, in the absence of technical change, E_cap_at_t produces a fixed capital/output ratio for industry 104 [cap_at_t(104) = z(104)]. However, with a1(104) moving to neutralize cost effects of input-saving technical change, E_cap_at_t generates changes in the capital/output ratio for industry 104. We solve this problem by exogenizing the industry's capital productivity [capprod(104)] and turning off its capital-demand equation by endogenizing a1prim(104).

To check the legitimacy of the closure produced in this step, we shocked a selection of its exogenous variables with their forecast changes from 1997 to 1998. The selected variables are those that are exogenous in this closure and are also

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[15] The dummy industry produces a negligible quantity of non-competing imports.

exogenous and shocked in the ultimate forecast closure. This meant that the shocks were applied: to a variety of technology and preference variables; to employment and demographic variables; to the structure of public consumption; to tariff rates; to world GDP; to the CPI; to investment for selected industries; to interest rates; and to homotopy variables. The results for a one-step computation are in step 1 in Table 48.1.

The main significance of these results is that they are interpretable, indicating no closure problem. They show growth in real GDP of 2.46 per cent, in line with improvements in primary factor productivity (ave_aprim = -0.87) and growth in primary factor inputs (exogenously set at 1.20 per cent for labour and pre-determined at 1.72 per cent for capital). Real wage growth is low (-0.01 per cent) relative to primary-factor-productivity growth because the forecasts involve a twist in technology against labour (predominantly negative values for twistlk_s). Relatively low wage growth produces increases in rates of return. Despite this, investment declines by 1.25 per cent: investment in the database for 1997 is high relative to rates of return, producing investment-damping positive values for d_diseq (see subsection 30.1) in our forecasts for 1998. Weak investment generates real devaluation (2.99 per cent) with associated strong export growth (7.96 per cent) and terms-of-trade decline (2.22 per cent). Because of the decline in the terms of trade, real public and private consumption (which are locked together) grow at a slower rate than real GDP (2.10 per cent compared with 2.46 per cent).

Step 2: introducing the macro forecasts

```
swap apc_gnp = cr;
swap r_cr_othreal = othreal;
swap d_f_eeqror = irtrue;
swap ff_y_g = agginv_rg;
swap twist_src_bar = impvol;
swap feq_general = expvol ;
swap a1primgen = phi;
```

These swaps configure MONASH to accept extraneous forecasts for real private and public consumption and investment (cr, othreal, irtrue, agginv_rg), aggregate exports and imports (expvol, impvol) and the exchange rate (phi). In typical MONASH applications, these extraneous forecasts are taken from organizations such as the Treasury which specialize in short-run macro forecasting.

In exogenizing cr and othreal, we endogenize the link between these two variables (r_cr_othreal) and the link between total public and private consumption and GNP (apc_gnp).

In exogenizing irtrue we endogenize the scalar shift variable (d_f_eeqror) in the inverse-logistic equation E_d_f_eeqror_j. In step 1 we turned this equation on by exogenizing d_f_eeqror_j. Here we give MONASH the freedom to accommodate exogenously specified movements in aggregate investment by a uniform vertical

Table 48.1. Step-wise development of the forecast closure from the decomposition closure: forecasts for 1998

Description (MONASH variable)	step 1	step 2	step 3	step 4	step 5
	percentage changes between 1997 and 1998				
real GDP (gdpreal)	2.46	4.04	4.04	4.04	3.94
real private consumption (cr)	2.10	4.60	4.60	4.60	4.60
real investment (irtrue)	-1.25	8.20	8.20	8.20	8.20
real public consumption (othreal)	2.10	4.10	4.10	4.10	4.10
real exports (expvol)	7.96	3.80	3.80	3.80	3.80
volumes of traditional exports (tradexpvol)	8.18	4.24	4.68	4.68	4.68
volumes of non-traditional exports (ntradexpvol)	7.55	3.10	5.20	5.23	5.19
aggregate tourism (agg_tour)	9.42	1.95	-6.20	-6.20	-6.20
real imports (impvol)	2.71	9.60	9.60	9.60	9.60
uniform primary-factor-sav. technical change (a1primgen)	0.00	-1.57	-1.59	-1.59	-1.48
average primary-factor-sav. technical change (ave_aprim)	-0.87	-2.28	-2.30	-2.30	-2.20
aggregate employment (emp_hours)	1.20	1.20	1.20	1.20	1.20
aggregate capital (k_r_wgts)	1.72	1.72	1.72	1.72	1.72
real devaluation (realdev)	2.99	2.86	2.12	5.04	4.91
terms of trade (toft)	-2.22	-4.22	-0.20	-0.20	-0.20
nominal exchange rate (phi)	-2.63	-1.90	-1.90	-1.90	-1.90
average propensity to consume out of GNP (apc_gnp)	0.00	1.19	0.33	0.20	0.29
price deflator for GDP (xigdp)	-0.36	-0.96	-0.22	-0.24	-0.11
price deflator for investment (xi2)	0.59	0.31	0.35	0.81	1.01
price deflator for consumption (xi3)	0.00	0.00	0.00	0.00	0.00
average nominal wage rate (ave_wage)	-0.01	1.19	0.49	-0.54	0.75
	100 times the change between 1997 and 1998				
ratio of net foreign laibilities to GDP (100*d_nfl_gdp)	-2.52	-3.08	-3.51	-3.50	-3.52

shift applied to the inverse-logistic curve of each industry (see Figure 30.1). If irtrue is set at a high (low) number then the inverse-logistic curves shift down (up).

To accommodate an exogenous value for real public sector investment (agginv_rg), we allow a uniform endogenous shift (ff_y_g) in the ratio of public to total investment in each industry (see E_y_g in subsection 18.8q).

Exogenous settings for aggregate exports and imports (expvol and impvol) are handled by a uniform horizontal shift in all export demand curves (feq_general) and an overall twist in import/domestic preferences (twist_src_bar).

The final swap accommodates exchange rate (phi) forecasts and solves two problems. First, it eliminates a potential over-determination of GDP. With the exogenization of C, I, G, X, and M, GDP is tied down. If technological change were entirely exogenous, then GDP would also be tied down by the exogenous setting for aggregate employment and the pre-determined setting for capital. To allow GDP from the supply side to adjust to equal GDP from the expenditure side, we endogenize overall primary-factor-saving technical change (a1primgren). The second problem solved by the final swap in this step is the elimination of a potential indeterminacy between the exchange rate (phi) and the general shift in the export-demand curves (feq_general): if both were endogenous, then the export target could be achieved with a high value for feq_general combined with a high value for phi or a low value for feq_general combined with a low value for phi.

In step 2 of Table 48.1 we have adopted the closure generated by the swaps in steps 1 and 2 and computed a forecast for 1998 using all of the shocks from step 1 plus shocks to the variables made exogenous in step 2. By comparing the results in steps 1 and 2, we see the effects of the swaps and shocks introduced in step 2. We see that GDP has increased (from 2.46 to 4.04) reflecting exogenously imposed increases in private and public consumption (from 2.10 to 4.60 and from 2.10 to 4.10) and in investment (from -1.25 to 8.20). These expenditure increases outweigh the imposed reduction in exports (from 7.96 to 3.80) and the imposed increase in imports (from 2.71 to 9.60). With capital and labour fixed, the increase in GDP requires an increased rate of total-factor-productivity growth (ave_aprim moves from -0.87 to -2.28).

Step 3: disaggregated export quantities and prices

```
swap f_ntrad(NTABARE) =                    swap f_ntrad 2-7 9-52 54-95 =
              x4_abare(NTABARE);                   hist_cont 2-7 9-52 54-95;
swap fep = x4_abare(TRADEXP);              swap fhist_cont = feq_general;
swap fep_tour = agg_tour;                  swap powtax4sph(PWORLDD) =
                                                        peobs(PWORLDD);
swap f_hist = f_forc;                      swap powtax4ph(PCOSTD) =
                                                        peobs(PCOSTD);
                                           swap f_pe_u = toft;
```

These swaps allow MONASH to absorb extraneous forecasts of movements in all export prices and in export quantities for agriculture, mining and tourism. With the total export quantity exogenized in step 2, MONASH determines non-traditional (manufacturing) export quantities as a residual.

The first two swaps are concerned with quantities of agricultural and mineral exports, commodities in the sets NTABARE and TRADEXP. Exports of these commodities are forecast regularly by the Australian Bureau of Agricultural and Resource Economics (ABARE)[16]. To allow MONASH to incorporate these

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[16] See *Agriculture and Resources Quarterly*, periodic publication of the Australian Bureau of Agricultural and Resource Economics, Department of Primary Industries and Environment, Canberra, Australia.

forecasts we exogenize x4_abare(i) for i in NTABARE and TRADEXP [17] and we endogenize shifters in the foreign demand curves for the relevant commodities.

The third swap allows MONASH to accommodate forecasts of tourism export growth (agg_tour) via endogenous shifts (fep_tour) in the tourism demand curve (see E_x4_TOURISM, subsection 18.8f). Tourism forecasts are made by the Bureau of Tourism Research (BTR) and the Tourism Forecasting Council.[18]

The role of the next three swaps is to allow for the introduction of historically-based structure to MONASH's forecasts of non-traditional exports. As explained in section 31 (see the discussion of E_hist_cont and E_f_forc), in forecasting simulations we activate E_f_forc (subsection 18.8o) by exogenizing f_forc and we turn off E_hist_cont by endogenizing f_hist. Then for most non-traditional export commodities,[19] we determine exports in E_f_forc with hist_cont set exogenously. This requires turning off the determination of non-traditional exports in E_x4_NTRADEXP (subsection 18.8f) by endogenization of the shift variable f_ntrad. Because aggregate non-traditional exports satisfies E_ntradexpvol (subsection 18.8f), we must introduce a scalar degree of freedom in E_f_forc. At the same time, we must remove the scalar degree of freedom from E_x4_NTRADEXP. Otherwise there is an indeterminacy between the now endogenous f_ntrad and the scalar degree of freedom feq_general. Consequently, we endogenize fhist_cont and exogenize feq_general.

The last three swaps in this group allow for the introduction of extraneous forecasts for export prices and the terms of trade via shocks to peobs(i) and toft. With the shift variables (f_pe_u_nt and f_pe_u) in E_peobs (subsection 18.8o) exogenous and unshocked, the movement in the export price for commodity i [pe(i)] equals peobs(i). However, we endogenize the scalar shift variable f_pe_u to allow the pe(i)s to be adjusted to achieve the terms-of-trade forecast, toft. With export prices determined in this way, we must endogenize an export tax or subsidy. This is necessary to reconcile extraneously given export prices with the costs of exporting (production costs, margins and taxes). For some commodities, those in the set PWORLDD, we use powtax4sph as the reconciling variable and for others, those in the set PCOSTD, we use powtax4ph. As explained in the discussions of E_powtax1, ..., E_powtax0 in subsection 28.1 and of step 10 in section 47, we use powtax4sph for commodities (e.g. iron ore) for which the export price dominates

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[17] With fx4_abare_ru and fx4_abare_mi exogenous and unshocked, the movement in exports of i [x4(i)] equals x4_abare(i), see E_x4_abare_RUR and E_x4_abare_MIN in subsection 18.8o.

[18] See *Forecast,* periodic publication of the Tourism Forecasting Council, Sport and Tourism Division, Commonwealth Department of Industry, Science and Resources, Canberra, Australia.

[19] The exceptions are the non-traditional export commodities for which we have ABARE forecasts. These commodities are Meat cattle, Oil and gas and Iron and steel, which are non-traditional export commodities 1, 8 and 53.

the determination of purchasers' prices in Australia. We use powtax4ph for commodities (e.g. fish) for which the export price has little effect on domestic purchasers' prices.

As can be seen by comparing steps 2 and 3 of Table 48.1, the main effects on our 1998 forecasts of introducing detailed forecasts for export prices and quantities are to change the composition of exports away from tourism (reflecting the Asian financial crisis of 1998) and to increase the terms of trade. With the price deflator for consumption (xi3) being exogenous and unchanged between steps 2 and 3, the improvement in the terms of trade generates an increase in the price deflator for GDP (xigdp).[20] Because the exchange rate and foreign-currency import prices are fixed, the increase in the price deflator for GDP is matched by an increase in the real exchange rate (see E_realdev and E_xim in subsection 18.8l), that is a negative movement in realdev. The final noteworthy change between steps 2 and 3 is the decline in the real wage rate (from 1.19 to 0.49). This is associated with an increase in indirect taxes. Positive phantom taxes are necessary to accommodate the extraneous forecasts for export prices.

Step 4: import twists and prices

swap ftwist_src = impftwist;	swap pm_ff=pm_f;
swap d_f_tw_hist = d_f_tw_forc;	swap pm=pmrel;

The first two swaps allow MONASH import forecasts to be informed by historical trends in import/domestic preferences via shocks to impftwist. As explained in section 31 (see the discussion of E_twist_src, E_twist_eff, E_impftwist and E_d_f_tw_forc), this requires us to exogenize impftwist and endogenize ftwist_src. Then shocks to impftwist drive import/domestic preferences by causing movements in ftwist_src. As also explained in section 31, problems in extrapolating the impftwists caused by rapidly declining import shares are avoided by exogenizing d_f_tw_forc and endogenizing d_f_tw_hist.

Extraneous macro forecasts generally include only an overall price change for imports. One possibility is to assume that this overall change applies to all imported commodities, that is to assume that pm(i) is the same for all i. However, the third and fourth swaps in this step provide a convenient mechanism for introducing historically informed non-uniform forecasts for the pm(i)s. As explained in section 31 (see the discussion of E_pm_f and E_pmrel), non-uniform forecasts can be generated by (a) shocking pm_f with the forecast for the overall change in foreign-currency import prices and (b) shocking pmrel(i) with the historical trend in the price of import i relative to the overall price of imports.

---

[20] An improvement in the terms of trade increases the price deflator for GDP (which includes exports but not imports) relative to the price deflator for GNE (which includes imports but not exports). Consumption is a major component of GNE. Thus improvements in the terms of trade usually generate an increase in the price deflator for GDP relative to the price deflator for consumption.

With pm_f and the pmrel(i)s exogenous, it is clear from E_pmrel (subsection 18.8o) that the pm(i)s must be endogenous. The scalar variable pm_ff must also be endogenous to ensure that the pm(i)s determined in E_pmrel can add to pm_f (see E_pm_f and E_xim, subsections 18.8o & l).

The information on import twists and import prices introduced in this step has little effect on our 1998 forecasts for the variables shown in Table 48.1. This can be seen by comparing steps 3 and 4. The only significant effects are for the real exchange rate (additional real devaluation of 2.92 per cent) and for the real wage rate (a decline of 1.03 per cent). With the nominal exchange rate, the terms of trade and the consumer price index all fixed, our shock to pm_f, which imposes an overall 2.9 per cent increase in foreign-currency import prices, must generate additional real devaluation of about 2.9 per cent. With the terms of trade fixed, the increase in import prices must be matched by an increase in export prices. The required increase in export prices is brought about by additional phantom export taxes leading to a reduction in the real wage rate.

Step 5: miscellaneous

```
swap fpowtax3g(CELECSET,SOURCE) = r_elec_cpi ;
swap d_x6cs(WOOLGRAIN, dom) = x0dom(WOOLGRAIN) ;
swap f_twistlk = real_wage_c ;
```

As explained in section 31 (see the discussion of E_r_elec_cpi), the first of these swaps fixes the relationship between consumer prices for domestic and imported electricity and the CPI, allowing our forecasts to reflect government pricing policies for electricity.

The role of the second swap is to allow MONASH to absorb ABARE forecasts for outputs of wool and grains (commodities in the set WOOLGRAIN). The ABARE output forecasts are accommodated by inventory changes (d_x6cs). Output forecasts are available only for the early years in forecasting simulations. In later years the forecasts for outputs of wool and grains are driven in the MONASH model mainly by export forecasts. Consequently, in computations for these later years, the second swap in this step is not made.

Via the third swap, we can introduce forecasts for changes in the overall real wage rate. These are accommodated by twists in capital/labour-using technology (see E_labind, E_cap_at_t and E_twistlk in subsections 18.8c & o and the associated discussions in sections 20 and 31).

Apart from an imposed change in the real wage rate (from -0.54 to 0.75), the forecasts and closure changes introduced in this step leave the variables in Table 48.1 almost unchanged. There is a slight reduction in GDP as we go from step 4 to step 5 reflecting an endogenous run-down in wool and grain stocks. With employment and capital fixed there is a corresponding reduction in primary-factor productivity.

49. Developing the policy closure (first column of Table 45.1)

Like forecast simulations, policy simulations are performed as a sequence of annual solutions. Thus in describing the policy closure we can use a diagram (Figure 49.1) similar to that used for the forecast closure (Figure 48.1).

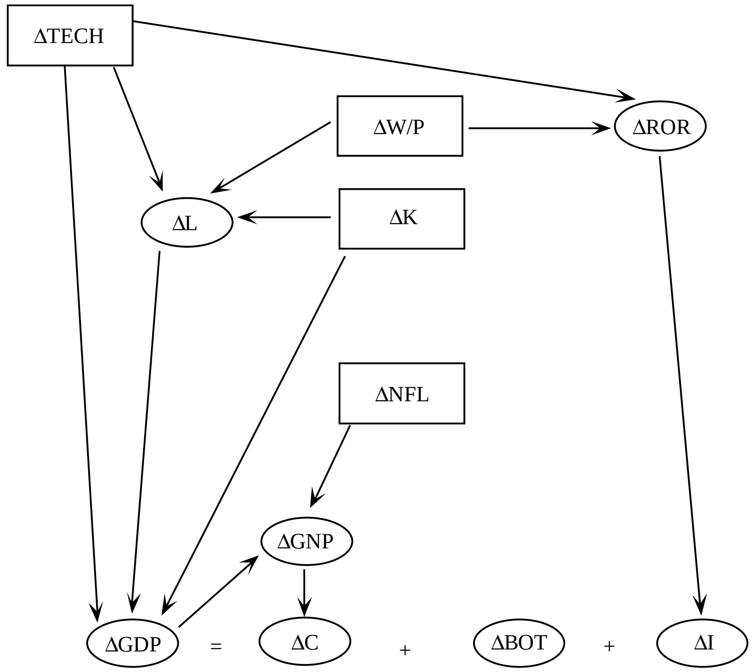
The policy closure is more orthodox than the forecast closure. Whereas in the forecast closure most macro expenditure variables are exogenous, in the policy closure these variables are endogenized so that they can be affected by policy shocks. Consumption is endogenized via a consumption function indicated in Figure 49.1 by an arrow linking ΔGNP to ΔC; investment is endogenized via investment functions indicated in Figure 49.1 by an arrow linking ΔROR to ΔI; GDP is endogenized via production functions indicated in Figure 49.1 by arrows linking factor inputs (ΔL, ΔK) and technology (ΔTECH) to ΔGDP; and the balance of trade is endogenized as the residual in the GDP identity.

Technology is exogenous in policy simulations and we have also indicated in Figure 49.1 that the real wage rate (ΔW/P) is exogenous. In fact, in most policy simulations we allow a sticky response by real wages to changes in employment. This could have been indicated by a two-way arrow connecting ΔL and ΔW/P. However, for a general understanding of the policy closure it is reasonable to think of ΔW/P as being exogenous or pre-determined. Together, technology and the real wage rate determine the rate of return on capital via the factor-price frontier. [As mentioned in subsection 5.3(b), the factor-price frontier is the relationship between the marginal product of labour, which is tied down by the real wage rate, and the marginal product of capital, which determines the rate of return.] With labour being paid according to its marginal product, employment (ΔL) is determined by ΔW/P, ΔK and ΔTECH via the marginal-product function for labour.

In developing the policy closure it is convenient to apply a series of swaps to the forecast closure. These are indicated by the arrows from the second column of Table 45.1 to the first. We test the policy closure as it develops by simulating a cut in the tariff on motor vehicles (commodity 70).

As explained in section 32 [see the discussion following (32.7)], the first ten swaps enable MONASH to carry forecast results into the policy simulation. The eleventh swap allows MONASH to generate a change (fpowtax3gu) in consumption taxes to compensate for the loss in tariff revenue associated with a cut in motor vehicle tariffs (see E_d_add_rev in subsection 18.8p and the discussion in section 32). The final swap allows the output of wool and grains to adjust to policy shocks and exogenizes the changes in their inventories.

Figure 49.1. Macro connections in the Policy Closure



Step 1: preliminary setup

swap ftax_l_r_o = tax_l_r_o;
swap f_b3sh_o = b3sh_o;
swap f_emp_o = emp_hours_o;
swap f_labsup_o = labsup_o;
swap f_rwage_o = real_wage_c_o;
swap f_rwage_pt_o = real_wage_pt_o;
swap f_x3cs_o = x3cs_o;
swap d_f_ror_se_o = del_ror_se_o;
swap d_f_eror_o = d_eror_o;
swap fpowtaxmo = powtaxmo;
swap fpowtax3gu = d_add_rev;
swap x0dom(WOOLGRAIN) =
d_x6cs(WOOLGRAIN, dom);

The first step in Table 49.1 shows the effects (deviations from forecasts) of a cut in the power of the tariff on motor vehicles computed with the closure reached after the twelve swaps listed above. The simulation was made in a one-step computation with a policy shock[21] of -6.6 per cent to fpowtaxm(70). This is a tariff

[21] A policy shock is additional to the forecast shocks applied to variables that are exogenous in policy and have non-zero movements, either endogenously or exogenously, in forecast.

cut of about the same size as that analysed in section 7. Here, however, we impose the tariff cut in one year, 1998, rather than over the four years 2002 to 2005, and we look at the results only for 1998.

With C, I, G, X and M still fixed at their forecast values, the tariff cut in this step cannot affect real GDP. Aggregate inputs of capital and labour are also fixed at their forecast values. Nevertheless there is a small deterioration in technology (ave_aprim = 0.020). The cut in tariffs switches consumer spending towards motor vehicles [x3(70) = 1.638 whereas cr =0.0], enhancing GDP because motor vehicles are subject to high indirect taxes (tariffs and sales taxes). An offsetting technological deterioration is required to keep real GDP unchanged.

Motor vehicles are a higher proportion of investment than of consumption. Thus the cut in motor vehicle tariffs lowers the investment price index relative the consumer price index. This effect is reinforced by the replacement tax which falls only on consumption. With the consumer price index fixed at its forecast level, there is a decline in the investment price index (xi2 = -0.186).

The final result in step 1 requiring comment is for the average propensity to consume (apc = 0.020). Although the reduction in tariff payments is balanced by the increase in consumer taxes, there is a reduction in household disposable income deflated by the consumer price index. This reflects the increase in consumer prices relative to investment prices. Thus to maintain the forecast level of real consumption, there must be an increase in the average propensity to consume.

Step 2: technology and the balance of trade

swap x4_abare 1-5 7-10 12-14 16 = fep;	swap impvol = twist_src_bar;
swap x4_abare 6 15 = hist_cont 1 53;	swap ftwist_eff = twist_eff;
swap agg_tour = fep_tour;	swap impftwist = ftwist_src;
swap expvol = hs_ntrad;	swap d_f_tw_forc = d_f_tw_hist;
swap peobs(PCOSTD) = powtax4ph(PCOSTD);	swap phi = a1primgen;
swap peobs(PWORLDD) = powtax4sph(PWORLDD);	swap real_wage_c = f_twistlk;
swap toft = f_pe_u;	swap f1_commun_a = f1_commun;
	swap f1_trans_a = f1_trans;

The first four swaps endogenize export volumes and exogenize demand-shift variables. These shifts were endogenous in the forecast closure to allow MONASH to absorb extraneous forecasts for exports of agricultural and mineral products, exports of tourism and exports in total.

Table 49.1. Step-wise development of the forecast closure from the decomposition closure: effects of a tariff cut in 1998

Description (MONASH variable)	step 1	step 2	step 3	step 4	Step 5
	policy-induced percentage changes				
real GDP (gdpreal)	0.000	0.026	0.024	0.024	0.008
real private consumption (cr)	0.000	0.000	-0.042	-0.040	-0.041
real investment (irtrue)	0.000	0.000	0.000	0.020	-0.006
real public consumption (othreal)	0.000	0.000	0.000	0.000	0.000
real exports (expvol)	0.000	0.560	0.660	0.640	0.579
real imports (impvol)	0.000	0.403	0.388	0.395	0.383
uniform primary-factor-sav. technical change (a1primgen)	0.022	0.000	0.000	0.000	0.000
average primary-factor-sav. technical change (ave_aprim)	0.020	0.000	0.000	0.000	0.000
aggregate employment (emp_hours)	0.000	0.000	0.000	0.000	-0.025
aggregate capital (k_r_wgts)	0.000	0.000	0.000	0.000	0.000
terms of trade (toft)	0.000	-0.162	-0.193	-0.187	-0.169
nominal exchange rate (phi)	0.000	-0.204	-0.269	-0.260	-0.233
average propensity to consume (apc)	0.020	0.043	0.000	0.000	0.000
uniform shift in power of consumption tax (fpowtax3gu)	0.229	0.229	0.229	0.229	0.229
price deflator for GDP (xigdp)	-0.044	-0.081	-0.079	-0.078	-0.072
price deflator for investment (xi2)	-0.186	-0.168	-0.141	-0.141	-0.143
price deflator for consumption (xi3)	0.000	0.000	0.000	0.000	0.000
average nominal wage rate (ave_wage)	0.000	-0.049	-0.042	-0.039	-0.012
household consumption of motor vehicles (x3(70))	1.638	1.616	1.547	1.551	1.556
price deflator for GNE (xigne)	-0.044	-0.048	-0.040	-0.039	-0.037
	100 times the policy-induced change				
ratio of trade balance to GDP (del_bt_gdp)	0.000	-0.006	0.012	0.007	0.001

As explained in step 3 of section 48, in forecasting we exogenize the terms of trade (toft) and the structure of export prices (peobs). To do this we endogenize a scalar shifter on export prices (f_pe_u) and phantom export taxes (powtax4ph and powtax4sph). For policy analysis the situation is reversed. In the last three swaps in the left-hand column of the list above, we endogenize the structure of export prices and the terms of trade by exogenizing phantom export taxes and the scalar shifter on export prices. Together, all the swaps in the left-hand column mean that in policy simulations changes in export prices and volumes are determined by changes in genuine costs of exporting in combination with exogenously specified changes in export-demand curves.

The first entry in the right-hand column of the list of swaps for this step endogenizes the aggregate volume of imports. This undoes the forecasting treatment in which aggregate imports were exogenized by endogenizing the scalar shifter, twist_src_bar, appearing in E_twist_src (subsection 18.8o). The other shifters [twist_eff(i) and ftwist_src(i)] in E_twist_src are exogenized in the next two swaps. With all three shifters taking their forecast values in policy simulations, we ensure that the import/domestic twist [twist_src(i)] for each good is the same in policy simulations as in forecast. As can be seen from E_twist_eff, exogenization of twist_eff requires endogenization of ftwist_eff. As explained in section 31, in forecasting d_f_tw_forc is exogenous and ftwist_src is determined in E_d_f_tw_forc via exogenous values for impftwist. To exogenize ftwist_src(i) we endogenized impftwist. With impftwist endogenous, singularity caused by zero values for DUM_TW(i) is avoided by switching on E_impftwist (exogenizing d_f_tw_hist) and switching off E_d_f_tw_forc (endogenizing d_f_tw_forc).

The fifth swap in the right-hand column concerns the exchange rate and overall technology. With the earlier swaps making exports and imports endogenous, GDP is no longer tied down by the expenditure identity. Thus, at this stage we exogenize technology (a1primgen), thereby tying down GDP from the supply side. With GDP determined this way, the balance of trade is determined as a residual, the difference between GDP and the still exogenous values for C, I and G. To allow the model the flexibility to achieve the residually determined balance of trade, we endogenize the exchange rate (phi).

The next swap exogenizes the capital/labour biases in primary-factor-saving technical change. These biases were endogenized in the forecast closure to accommodate exogenous wage forecasts (see step 5 in section 48). With the biases exogenized, the real wage rate (real_wage_c) is endogenized. At this stage we have created a closure in which wages adjust fully to achieve a given level of employment. Later, in step 5, we will make further swaps so that wage adjustment becomes sticky, allowing employment to be determined endogenously.

The final two swaps are of minor importance. They turn off the special treatments of industry demands for imported communication and transport services, and turn on the standard treatments (see E_x1csi, E_f1_trans and E_f1_commun in subsection 18.8b and the related discussion in subsection 20.3). While it is reasonable to retain the special treatments in policy applications we have usually turned them off to simplify the interpretation of results. As explained in subsection 20.3, the special treatments imply technological shifts which sometimes complicate the interpretation of results for economic welfare.

The effects of the 6.6 per cent reduction in the power of the motor vehicle tariff computed in the closure we have now reached are shown in step 2 in Table 49.1. Having been endogenized, imports are stimulated by the tariff cut (impvol = 0.403). With C, I and G still fixed at their forecast levels and GDP approximately fixed at its forecast level by the exogenization of employment, capital stock and technology, we would expect the increase in imports to be matched by an increase in exports facilitated by a reduction in the exchange rate. Step 2 shows a reduction in the exchange rate of 0.204 per cent and an increase in the volume of exports (0.560 per cent) that exceeds the increase in the volume of imports. With a greater expansion in exports than in imports, there is an increase in real GDP of 0.026 per cent. As explained in the discussion of step 1, the cut in motor vehicle tariffs causes a GDP-stimulating switch in consumer spending towards motor vehicles which are heavily taxed. In step 1 this was offset by an endogenous technological deterioration, which no longer applies in step 2. Despite the increase in export volumes relative to import volumes, there is a decline in the balance of trade reflecting a fall in the terms of trade.

The fall in the terms of trade reduces the GDP deflator (which includes export prices but not import prices) relative to the GNE deflator (which includes import prices but not export prices). With consumer prices increasing relative to prices of other components of GNE, there is a marked reduction in the GDP deflator relative to the CPI. To maintain the exogenously given level of employment, there is a reduction in the real wage rate (ave_wage = -0.049 and xi3 = 0.0).

Step 3: consumption

```
swap cr = apc;
```

In this step we exogenize the average propensity to consume (apc), thereby endogenizing real private consumption (cr) by linking it to household disposable income.

In step 1, there was a decline in real household disposable income because consumption prices increased relative to investment prices. This was accentuated in step 2 when exports were endogenized allowing a terms-of-trade decline. Now in step 3 of Table 49.1, the decline in real household disposable income generates a reduction in real household consumption (cr = -0.042).

The reduction in consumption has little effect on real GDP. Thus, compared with step 2, in step 3 we see an expansion in exports relative to imports with an associated improvement in the balance of trade and declines in the exchange rate and the terms of trade.

Step 4: investment

```
swap irtrue = d_f_eeqror;
swap y 10 15 105-109 113 = d_f_eeqror_j 10 15 105-109 113;
swap d_f_diseq = d_diseq;
```

The first swap frees aggregate investment (irtrue) to respond to the policy shock and exogenizes the scalar shifter (d_f_eeqror) in E_d_f_eeqror_j (subsection 18.8m). The second swap frees investment in particular industries to respond to the policy shock and exogenizes corresponding industry shifters in E_d_f_eeqror_j. The particular industries are those for which we imposed investment forecasts in the forecast simulation (see step 1 in section 48).

Investment in the remaining industries was endogenous in the forecast closure and remains endogenous in the policy closure. The third swap ensures that disequilibrium in investment (discussed in subsection 30.1) is eliminated in the policy simulation at the same rate as in the forecast simulation.

As can be seen from step 4 in Table 49.1, investment responds positively to the cut in motor vehicle tariffs (irtrue = 0.020). This reflects the shift in indirect taxes away from capital goods towards consumption goods (discussed in step 1). The increase in investment has little effect on real GDP and consumption. Thus, compared with step 3, in step 4 there is a decline in exports relative to imports with an associated deterioration in the balance of trade and increases in the exchange rate and the terms of trade.

Step 5: employment

swap emp_hours = del_f_wage_pt;

swap labsup = d_f_labsup;

The first swap endogenizes aggregate employment and turns on MONASH's sticky wage specification. With del_f_wage_pt exogenous, real post-tax wage rates in policy simulations deviate from their forecast path in response to deviations in aggregate employment, see E_del_f_wage_pt in subsection 18.8p and the discussion in section 32. The second swap allows deviations in employment to generate deviations in labour supply, see E_d_f_labsup in subsection 18.8q and the discussion in section 33.

In step 2 we saw that the tariff cut requires a reduction in the real wage rate to allow employment to remain at its forecast level. In this step, with sticky wage adjustment, employment falls (emp_hours = -0.025). This reduces the GDP deviation from 0.024 in step 4 to 0.008 in step 5. Despite the reductions in employment and GDP, there is little change in private consumption as we move from step 4 to step 5. This is because household disposable income is bolstered in step 5 relative to step 4 by higher real wage rates and higher levels of social security payments associated with increased unemployment (see E_unemp_ben discussed in section 33). Higher real wage rates in step 5 reduce rates of return on capital causing a decline in investment (from 0.020 to -0.006).

50. MONASH closures: concluding remarks

Two ideas about choosing exogenous variables (i.e. choosing a closure) emerge from this chapter. The first applies in policy and decomposition simulations. In those simulations we include a variable on the exogenous list only if we think that it is reasonable to assume that its value is determined independently of the value of any other variable. The second idea applies in historical and forecast simulations. In those simulations, we include a variable on the exogenous list if we know its value, irrespective of how we think that value is determined.

The first idea was prominent in the earliest CGE literature where its application was the subject of heated debate.[22] Decisions about which variables to treat independently in the savings/investment nexus were particularly controversial because of their strong influence on results for employment, wage rates and the distribution of income between capital and labour. In looking at the effects of policy shocks, some CGE modellers (the neoclassicals) assumed independent determination of savings propensities and endogenous adjustment of investment while others (the Johansen school) assumed the opposite. Two other groups (the General-Theory-Keynesians and the neo-Keynesians) assumed independent determination both of investment and of savings propensities. For General-Theory-Keyensians, the savings-investment equality was achieved through adjustments in employment which lead to adjustments in income and savings. For neo-Keynesians, employment was fixed. They assumed that savings is brought into line with investment though adjustments in the gap between the value of the marginal product of labour and the real wage rate. Adjustments in this gap cause adjustments in savings by shifting income between profits (high propensity to save) and wages (low propensity to save).

In its treatment of savings and investment, the standard MONASH policy closure described in section 49 is close to that of the Johansen school. We assume independent determination of investment (or more accurately, exogenous shift variables in functions relating investment to rates of return) and an adjusting saving propensity, mainly through changes in the ratio of foreign savings (the trade deficit) to GDP. Similarly, in the decomposition closure (section 46) we allow adjustments in the domestic use of foreign savings and we assume independent determination of investment (through exogenous I/K ratios and rate-of-return shifts). By contrast with MONASH, Johansen (1960) assumed that the main savings adjustments are in domestic rather than foreign savings. In his model, exports are exogenous and imports are linked by fixed coefficients to industry outputs and consumption, leaving little scope for adjustments of foreign savings. Thus, Johansen allowed the domestic savings propensity to adjust, perhaps through implicit endogenization of either the household savings propensity or of a tax rate.

In addition to decisions about which variables are independent in the determination of investment, savings and the trade accounts, other important independence decisions which must be embedded in policy and decomposition closures concern employment and wage rates, capital and rates of return, and public finance.

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[22] This debate is beautifully synthesised by Rattsø (1982).

In year-to-year policy simulations, we usually assume sticky post-tax real wage rates (via independent determination of shift variables in wage equations) and endogenous adjustment in aggregate employment. Reflecting its long-run focus, in the decomposition closure we assume independent determination of aggregate employment and endogenous adjustment of real wage rates.

In every year of a policy simulation, we exogenize the quantity of capital available as an input to production in each industry at its level from the end of the previous year and we allow rates of return to adjust. Again reflecting its long-run focus, in the decomposition closure we exogenize shift variables determining rates of return and allow endogenous adjustment of the capital available to each industry.

Finally, with regard to public finance, in year-to-year policy simulations we usually exogenize government consumption but endogenize a tax rate to allow exogenous determination of either the public sector deficit or a related variable such as real national savings or real national wealth. Without an explicit endogenous tax adjustment, there is a danger in policy simulations of exaggerating the benefits of tariff cuts or cuts in other taxes. In decomposition simulations, we exogenize the share of government consumption in GNP thereby allowing long-run expansion in government consumption in response to income-enhancing shocks such as improvements in productivity or the terms of trade. We also exogenize the share of private consumption in GNP and all tax rates. Implicitly, we allow endogenous determination of the government deficit together with endogenous adjustment of a lump-sum tax to achieve the exogenously given value for C/GNP.

In historical and forecast simulations, our notion of exogeneity is quite different from that in policy and decomposition simulations. In the historical closure set out in section 47, the exogenous list includes outputs, inputs, demands, prices and incomes. It would be unreasonable to think of the economy as generating values for these variables independently of each other or independently of other variables represented in the MONASH model. Rather than independence, the main criterion for exogeneity in historical simulations is observability. Similarly, it would be unreasonable to suggest that the economy generates independent values for consumption, exports, imports, wages, employment and many of the other variables on the exogenous list for the forecasting closure discussed in section 48. For this closure, the main criterion for exogeneity is forecastabililty.

The different notions of exogeneity in decomposition and policy simulations on the one hand compared with historical and forecasting simulations on the other reflect different objectives. In decomposition and policy simulations we are trying to *explain* the effects of particular shocks to the economy. For this purpose we need to make realistic assumptions about which variables are unresponsive and which are responsive to the shocks under consideration. In historical and forecasting simulations we are not primarily concerned with explanation. In historical simulations, we choose the closure so that we can use all the available data for an historical period to *estimate* changes in technology, consumer preferences and other unobservable variables. In forecasting simulations, we choose the closure so that we can use all the available information for a future period to *generate forecasts* for industries, occupations and regions.

With the MONASH solution strategy (the Johansen/Euler algorithm implemented through GEMPACK), it is easy to make closure alterations. This is done in GEMPACK by swap statements which alter an existing exogenous list by deleting and adding variables. Using swap statements, it is possible to make minor variations within the four basic closures described in this chapter or to create radically new closures. In a recent MONASH application [Dixon and Rimmer (1999b)] we did both. By applying a single swap to the standard policy closure, we produced a variant in which wage rates are sticky in real pre-tax terms rather than post-tax terms. Then from a comparison of policy results under the original and altered closures, we showed that the short-run effects of the introduction of Australia's new goods and services tax (GST) will depend critically on whether union/government/business wage bargaining in the next two years produces pre- or post-tax real wage stickiness. By applying a series of swaps, we radically altered the standard decomposition closure, producing an input-output closure with fixed factor prices and no supply-side scarcities. This enabled us to uncover the unpublished shocks applied in GST simulations conducted for the Australian Government by the Treasury using PRISMOD, an input-output price model.

For creating radically new closures, we think that cautious step-by-step processes such as those in sections 47 to 49 are always helpful and sometimes unavoidable. In each step, we apply just a few swaps to an existing closure. Then we compute a solution and interpret the results. Without step-by-step processes, we certainly would not have been able to develop and explain the historical and forecasting closures. It may have been possible to handle the comparatively simple policy closure without reference to other closures. However, its step-by-step derivation from the forecast closure produced useful insights by showing the changes in the simulated effects of the policy shock as its scope for influencing the macroeconomy was gradually broadened.