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**An inter-temporal CGE model
with fiscal and sector balances**

Ganesh Nana

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Victoria University of Wellington, Wellington, New Zealand

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Ganesh Nana*

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Abstract

This paper records progress to date in the development of an inter-temporal version of the Research Project on Economic Planning's *Joanna* CGE model. The standard version includes 22 industries, with relative price induced substitution between capital and labour in production and also between imported and domestic commodities in both production and consumption. It is solved for one period and model experiments can be specified to examine issues in a comparative static framework.

In moving to a multi-period model the features introduced focus on forward-looking investment and consumer behaviour. In addition, explicit modelling of government and private sector income and expenditure is integrated into this cge framework. Assumptions relating to end-period investment and debt ratios are necessary in order to generate a steady-state solution.

A twelve-industry model of the New Zealand economy is constructed with a database commencing from 1990 input-output relationships. The model is constructed and solved over a horizon of 20 periods using the *Gempack* suite of programs. Two comparative dynamic exercises are discussed, an external price shock and an internal demand shock. A comprehensive flow-of-funds analysis, however, awaits the inclusion of a monetary sector.

Key words

CGE models, inter-temporal behaviour, comparative dynamics, debt

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I Introduction

In a previous paper [Nana (1995)] the incorporation of inter-temporal relationships into a previously atemporal input-output based computable general equilibrium (cge) model was described. This was illustrated with a focus on dynamically optimal investment and consumer behaviour and the imposition of *model-consistent* expectations. From the basis provided by the Research Project on Economic Planning's (RPEP) *Joanna*¹ - a one-period cge model of the Johansen-type - a multi-period model was constructed with a sequence of *static* models linked by several behavioural equations and associated accumulation identities. Such a development can encourage analysis previously limited to a comparative-static framework to proceed to a comparative-dynamic environment.

This paper records further developmental work aimed at integrating explicit sectoral income, expenditure and debt relationships within this inter-temporal cge construct. The model is expressed and solved for in percentage-changes a la *Johansen*. The *Gempack*² suite of programs is used as this package also contains several features (including various up-dating and extrapolation methods) designed to overcome the majority of the implicit linearisation errors inherent in such a modelling approach.

Section II provides a brief summary of the inter-temporal cge model as described in Nana (1995). Details of the sectoral income and expenditure relationships and data incorporated in the model are presented in section III. Section IV illustrates a steady-state solution and discusses some comparative dynamic experiments using the model.

II The inter-temporal *Jody* model

The structure of the dynamic cge model (*Jody*) consists of a multiple number of one-period or static sub-models with several inter-temporal links. The standard static model identifies 22 production industries each combining materials and primary factors to produce a commodity. These commodities can be used for various purposes: as intermediate inputs by other industries; by other industries for the production of capital goods; combined with others to make up composite commodities which are then exported; to make up composite commodities which are consumed by private domestic households; to contribute to stock holdings or to public consumption. A *market-clearing* assumption for each commodity ensures that each industry's output is equal to the total usage of that particular commodity across the economy.

Choices faced by agents are resolved consistent with neo-classical cost minimisation and/or utility maximising behaviour. In particular, imperfect substitution between imported commodities and those produced domestically is incorporated with relative price movements playing the crucial role. Prices of domestic commodities hinge on a *zero pure-profits* assumption, while the price of imported items is determined by the world price, exchange rate and the appropriate tariff protection level. Imperfect substitution between capital and labour in the production processes of each industry is also captured, again determined by relative prices.

The focus of the static cge, therefore, is on the allocation of an exogenous quantity of production resources in a (neo-classical) optimal manner and how this allocation is altered by exogenous or policy shocks. Thus, in common with all *Walrasian* general equilibrium models, the *Joanna* model does not determine (nor is responsive to) the absolute price

¹ Philpott (1989) has a summary and bibliography of past RPEP research while Nana and Philpott (1983) provides full details of the equation structure of the *Joanna* model.

² Codsi and Pearson (1988) and Pearson (1988) give an outline of this package.

level. The role of one price as a *numeraire* is usually served by the exchange rate variable as international financial capital flows are not explained by the model.

The inherent inter-temporal nature of the process of capital formation is difficult to examine in a one-period *snapshot* model. By introducing a time dimension and explicitly modelling investment behaviour the exogeneity of the quantity of production resources can be lifted. The behaviour incorporated in the model is consistent with the neo-classical criteria that an activity is undertaken up to the point where the marginal revenue equates to the marginal cost. The latter is made up of the interest (or opportunity) cost associated with the purchase price of the capital item and the depreciation cost. Note, however, that industry-specific risk or premium factors may alter the interest cost. The former involves the revenue from the additional output produced by the capital item and any gain (or loss) arising from changes over time in the resale price of the unit of capital.

In contrast to the static expenditure function where consumer spending is determined by a single-period's income, the dynamic model postulates a consumer maximising utility over the planning horizon constrained by their total income over that period. The first-order conditions to this constrained maximisation problem require the ratio of inter-temporal marginal utilities to be brought in line to the interest rate adjusted by the rate of time preference as follows:

$$\frac{\left[\frac{MU_t}{P_t} \right]}{\left[\frac{MU_{t+1}}{P_{t+1}} \right]} = \frac{1+i}{1+\rho}$$

where MU_t = the marginal utility of consumption at time t
 P_t = price level
 i = interest rate
 ρ = the rate of time preference

A steady-state solution was described in Nana (1995) with terminal or end-period criteria requiring the stabilising of the ratio of investment to the stock of capital in each industry. Similarly, the external debt-to-GDP ratio in the final period was set equal to that in the penultimate period where the external debt was passively determined by the current account balance and interest payments in each period. In the absence of monetary or financial capital flows, however, interest rates remain fundamentally exogenous to the model.

III Income, expenditure and debt

The developments described in Nana (1995) were introduced to form a dynamic model consisting of seven production industries. The refinements illustrated in this paper were undertaken adopting a finer level of disaggregation. Based on the 22-industry 1990 input-output tableau described in Philpott and Nana (1993) an inter-temporal cge model was constructed incorporating twelve production industries, nine export commodities and eight household consumption commodities as summarised in Table 1.

Furthermore, the model now explicitly identifies the three sectors: private, government and foreign. For these sectors, the income and expenditure relationships captured by the model are given in Table 2 with the base data provided in Table 3, both illustrating the degree of disaggregation in this area. In constructing this database concordance with input-output classifications and conventions was of prime importance. More sectors³ may

³ For example, dividing the private sector into its household and corporate components and the government sector into central and other units.

Table 1 Industry and commodity classifications

<u>Industry</u>	<u>SNA equivalent</u>	<u>including</u>
1 Primary	1, 2 and 5	agriculture, fishing and food processing
2 Forestry	3,7 and 8	logging and associated processing
3 Energy	4 and 14	mining & quarrying, electricity, gas & water
4 Chemicals	9	chemicals, petroleum, plastics etc
5 Metals	11 and 12	base metals & fabricated metal products
6 Other manufacturing	6, 10 and 13	textiles, ceramics and other manufacturing
7 Building	15	building and construction
8 Transport	17 and 18	transport and communications
9 Finance	19	finance, insurance, real estate etc
10 Own dwellings	20	ownership of owner-occupied dwellings
11 Other services	16, 21, 24 and 25	trade, hotels, and other private services
12 Public	22 and 23	central and local "non-mkt" services

<u>Export commodity</u>	<u>including</u>
1 Traditional	dairy, meat and wool products
2 Other primary	horticulture, fish and other food products
3 Forestry	logs, wood and paper
4 Energy	mining and energy
5 Chemicals	chemicals etc
6 Metals	basic and fabricated metal products
7 Other goods	textiles, ceramics and other goods
8 Tourism	tourism services
9 Other services	other services

Household consumption commodity (equivalent to HIES major group)

1 Food
2 Housing
3 Household operation
4 Apparel
5 Transportation
6 Tobacco and alcohol
7 Other goods
8 Other services

be desirable but the data and relationships presented provide a *core* or *border* to which any schema must agree in order to be compatible with the input-output cge framework. The following details expand on the information illustrated in Tables 2 and 3.

i income of private sector

Wage and profit income data are from the input-output table with adjustments (from profits to wages) for returns to owners' labour in the agriculture and fishing industries accounting for differences between this measure and the official SNA statistics. Note that profit income is the sum of operating surplus and consumption of fixed capital. In model simulations wage income is, of course, determined by labour employed multiplied by the wage rate, aggregated across all the industries. Similarly, capital employed and profit rates determine profit income (eqns 4.1 and 4.2).

The item labelled *excess of import duty* is related to the non-tariff portion of import protection. This is implicitly paid by consumers and represents a return to importers as the *premium* they extract indicative of the market power conferred upon them by the protective barrier. This is calculated as the difference between imports valued at purchasers' prices and imports valued at cif less the amount received by the authorities as tariff revenue. A similar relationship is incorporated in model simulations to determine this component of private sector income (eqn 4.3).

Table 2 Sector income and expenditure relationships

(1) Debt accumulation

$$D_t^{gfo} = \left[\frac{\Phi_t}{\Phi_{t-1}} \right] D_{t-1}^{gfo} - \Omega GB_t \quad (1.1)$$

$$D_t^{gdm} = D_{t-1}^{gdm} - [(1 - \Omega)GB_t] \quad (1.2)$$

$$D_t^{fpr} = \left[\frac{\Phi_t}{\Phi_{t-1}} \right] D_{t-1}^{fpr} - [CB_t - \Omega GB_t] \quad (1.3)$$

(2) Sector balances

$$PB = YP - EP \quad (2.1)$$

$$GB = YG - EG \quad (2.2)$$

$$CB = GB + PB \quad (2.3)$$

(3) Sector income and expenditure totals

$$YP = YP^{wag} + YP^{pro} + YP^{xmp} + YP^{gdm} + YP^{ubn} + YP^{nsp} + YP^{owf} + YP^{xfr} \quad (3.1)$$

$$EP = EP^{con} + EP^{inv} + EP^{sto} + EP^{ofp} + EP^{fpr} + EP^{itx} + EP^{odt} + EP^{soe} + EP^{xfr} \quad (3.2)$$

$$YG = YG^{itx} + YG^{odt} + YG^{gst} + YG^{dut} + YG^{oid} + YG^{soe} \quad (3.3)$$

$$EG = EG^{con} + EG^{inv} + EG^{ubn} + EG^{nsp} + EG^{owf} + EG^{gdm} + EG^{gfo} \quad (3.4)$$

(4) Private sector income categories

$$YP^{wag} = \sum_j w_j L_j \quad (4.1)$$

$$YP^{pro} = \sum_j r_j K_j \quad (4.2)$$

$$YP^{xmp} = \sum_i [MP_i - MC_i] - YG^{dut} \quad (4.3)$$

$$YP^{gdm} = EG^{gdm} \quad (4.4)$$

$$YP^{ubn} = avupNUN \quad (4.5)$$

$$YP^{nsp} = avnp(\theta POP) \quad (4.6)$$

$$YP^{owf} = avwp(\lambda POP) \quad (4.7)$$

$$YP^{xfr} = \alpha YP \quad (4.8)$$

(5) Private sector expenditure categories

$$EP^{con} = \sum_q P_q C_q \quad (5.1)$$

$$EP^{inv} = \sum_j PI_j I_j \text{ where } j \neq \text{public} \quad (5.2)$$

$$EP^{sto} = NSTO \quad (5.3)$$

$$EP^{ofp} = \beta NGDP \quad (5.4)$$

$$EP^{fpr} = \left[\frac{\Phi_t}{\Phi_{t-1}} \right]_{it}^{fpr} D_{t-1}^{fpr} \quad (5.5)$$

$$EP^{itx} = YG^{itx} \quad (5.6)$$

$$EP^{odt} = YG^{odt} \quad (5.7)$$

$$EP^{xfr} = \gamma EP \quad (5.8)$$

$$EP^{soe} = YG^{soe} \quad (5.9)$$

(6) Government sector income categories

$$YG^{itx} = t^{itx} [YP^{wag} + YP^{ubn} + YP^{nsp} + YP^{gdm}] \quad (6.1)$$

$$YG^{odt} = t^{odt} YP^{pro} \quad (6.2)$$

$$YG^{gst} = t^{gst} [\sum_q P_q C_q + PG_x G] \text{ where } q \neq \text{housing} \quad (6.3)$$

$$YG^{dut} = \sum_i t_i^{dut} MC_i \quad (6.4)$$

$$YG^{oid} = NGDP - [YP^{wag} + YP^{pro} + YP^{xmp}] - YG^{gst} - YG^{dut} \quad (6.5)$$

$$YG^{soe} = \psi YP^{pro} \quad (6.6)$$

(7) Government sector expenditure categories

$$EG^{con} = PG_x G \quad (7.1)$$

$$EG^{inv} = PI_j I_j \text{ where } j = \text{public} \quad (7.2)$$

$$EG^{ubn} = YP^{ubn} \quad (7.3)$$

$$EG^{nsp} = YP^{nsp} \quad (7.4)$$

$$EG^{owf} = YP^{owf} \quad (7.5)$$

$$EG^{gdm} = t_t^{gdm} D_{t-1}^{gdm} \quad (7.6)$$

$$EG^{gfo} = \left[\frac{\Phi_t}{\Phi_{t-1}} \right]_{it}^{gfo} D_{t-1}^{gfo} \quad (7.7)$$

Variables

D	stock of debt at end of period
Φ	exchange rate (\$NZ/\$world)
PB	private sector balance
GB	government sector balance
CB	current account balance
YP	private sector income
EP	private sector expenditure
YG	government sector income
EG	government sector expenditure
t	tax/tariff rate
i	interest rate
w	wage rate
r	profit (rental) rate
L	labour employed
K	capital stock employed
avup	average unemployment benefit payment
avnP	average national super payment
avop	average other welfare payment
NUN	number receiving unemployment benefit
POP	population
MP	imports valued at purchasers' prices
MC	imports valued at cif
C	real consumption expenditure
I	real investment expenditure
G	real govt consumption expenditure
P	price of consumption commodity
PG	price of government consumption
PI	price of capital good
NSTO	nominal stock formation
NGDP	nominal gdp

Share parameters

$\alpha, \beta, \theta, \gamma, \lambda, \psi$

Policy parameters

Ω	proportion of govt balance applied to foreign holdings of government debt
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Subscripts

t	time period
i	industrial commodity
j	industry
q	consumption commodity

Superscripts

wag	wages
pro	profits
xmp	excess import premium on duty
gdm	government debt held domestically
gfo	government debt held overseas
fpr	foreign debt owed by private sector
ubn	unemployment benefit
nsp	national superannuation/GRI
owf	other welfare (net) transfers
xfr	other current transfers
soe	soe transfers
itx	direct taxes on individuals
odt	other direct taxes
gst	goods and services tax (GST)
dut	import duty
oid	other indirect taxes
con	consumption expenditure
inv	investment (capital formation)
sto	stock change
ofp	net factor payments overseas

Interest income of the private sector represents receipts from the stock of public debt held domestically and is determined within the model by the domestic bond rate and the stock of debt held at the end of the previous period (eqns 4.4 and 7.6). Other elements of interest flows within the private sector are assumed to net out, as are dividend payments distributed domestically.

Unemployment benefit income is associated in the model with number of unemployed and the average benefit rate (eqn 4.5). The former is determined as a constant proportion of the difference between labour supply and total employment, while the latter is assumed related to the wage rate in *other manufacturing*. There is an allowance for a (user-specified) *shift-factor* in the model enabling an alternative benefit rate determination routine.

Similarly, national superannuation income follows from the number of recipients times the average rate. In this case the former is determined as a constant proportion of the total population (eqn 4.6), while the latter is also related to the wage rate in *other manufacturing*. Again, alternative assumptions can be incorporated.

The figure for other (net) welfare transfers to the private sector follows from the Household Income and Outlay data for total benefits and grants less compulsory fees and

Table 3: Base period (1990) sector balances using I-O categorisation

\$ m	Income			Expenditure			Source
	Pvte	Govt	Foreign	Pvte	Govt	Foreign	
Wages	wag	34417					IO
Profits	pro	26299					IO
Excess of impt duty	xmp	667					IO
Interest	gdm	3280			3280		RB
	gfo		1542		1542		RB
	fpr		2277	2277			RB
Transfers							
unempmt benefit	ubn	1550			1550		B
national super	nsp	5600			5600		B
oth welfare (net)	owf	2925			2925		HH
current	xfr	675	170	170		675	HH
	soe		730	730			SNZ
Direct taxes							
individual	itx		13400	13400			B
other	odt		3765	3765			B
Indirect taxes							
GST	gst		5427				IO
duty	dut		629				B
other	oid		4063				IO
Consumption	con			44022	11759		IO
Investment	inv			13464	1215		IO
Stock formation	sto			1684			IO
External trade			19250			18608	IO
Net factor payments	ofp		950	950			SNZ
		75413	28014	24189	80462	27871	19283

Sector balance	-5049	143	4906
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The abbreviations used in the final column represent the following sources:

IO Input-Output table : unofficial 1990 version based on update of official 1987 table as described in Philpott & Nana (1993).

RB Reserve Bank of New Zealand Model XIIF database.

B Budget and Estimates of Expenditure data (various)

HH Household Income and Outlay Accounts (Statistics New Zealand)

SNZ Statistics New Zealand & NZIER (general govt and private sector income and outlay accounts).

contributions (including ACC), minus the transfers explicitly identified in the form of unemployment benefit and national superannuation. In model simulations income from this category is related to the population and an average benefit rate (eqn 4.7), the latter being assumed constant in real (consumer price) terms.

Only current transfers from overseas (as per the Household Income and Outlay Account) is included explicitly in the model's base as transfers between residents and private non-profit organisations are assumed to net out within the total private sector. Income from this category is assumed to remain as a constant proportion of total private sector income in model experiments (eqn 4.8).

ii expenditure of private sector

Expenditure by the private sector on consumption, investment and stock formation follow clearly from input-output data. Note that private investment includes investment by all industries except the *public* industry described previously (industry number 12). These categories of expenditure are incorporated using the obvious relationships to model variables (eqns 5.1, 5.2 and 5.3).

Interest expenditure represents payments on the stock of foreign debt held by the private sector. The model determines this item dependent on the market interest rate, the stock of debt held at the end of the previous period as well as allowing for any valuation adjustment resulting from the movement in the exchange rate between the current and the previous period (eqn 5.5).

Direct taxes on the private sector are a component of income to the government sector and are directly related to the appropriate variables (eqns 5.6 and 5.7) as is the category representing the transfer to the government sector (eqn 5.9).

Current transfers to overseas are treated in a fashion similar to their income counterpart. That is, this expenditure is assumed to remain as a constant proportion of total private sector expenditure (eqn 5.8).

The figure for net factor payments abroad follows from data for net property income paid abroad minus the amount identified as interest payments abroad (from the private and the government sector). In model experiments, expenditure in this category is assumed to remain as a constant proportion of GDP (eqn 5.4).

iii income of government sector

The direct tax revenue categories are incorporated through expressions determining the relevant tax base and average tax rate. Direct taxes on individuals are assumed to be applied on wage, interest, unemployment benefit and national super income (eqn 6.1). The figure for other direct taxes includes company tax, other income tax as well as other direct tax, and is assumed in the model to be levied on profit income (eqn 6.2). The average tax rates are, by default, assumed constant (unchanged) in model simulations. As a result of accounting for only *net* interest flows between the sectors⁴ the average tax rate implicit in Table 3 (30%) is undoubtedly an over-estimate.

A similar routine is adopted for revenue from goods and services tax. In the model the tax base is defined as private consumption expenditure (excluding that on the *housing* commodity) plus public consumption expenditure with, of course, the rate being 12.5% (eqn 6.3). The resulting figure listed in Table 3 compares favourably with the \$5680m given in the 1991 Budget data as revenue for the June 1990 year.

Revenue from import duties is directly related to the model's imports (at cif value) and tariff rate variables (eqn 6.4).

Other indirect tax revenue follows from the input-output table aggregate of taxes less subsidies in each industry and each commodity minus those explicitly identified in the form of GST, import duty, or the private sector income category labelled *excess of import duty* described previously. The resulting figure appears high in comparison with Budget data, but it should be remembered that the government sector includes local and regional authorities in addition to the central government. Revenue from this source is directly associated in the model (eqn 6.5) with the aggregate of indirect taxes (less subsidies) in each industry and each commodity and is identically equivalent to the

⁴ In addition, dividend income is not incorporated but, on the other hand, not all unemployment benefit and national super income should be included in the tax base.

indirect tax component of the income measure of GDP (excluding those explicitly identified as stated). The indirect tax rates in this category are assumed to remain constant in real (consumer price) terms in model simulations.

Income in Table 3 listed as a transfer from the private sector is an estimate of *soe* profit transfers along with other fees. In model experiments, income to the government sector from this source is assumed to move in line with total profit income (eqn 6.6).

iv expenditure of government sector

Final consumption expenditure by public (including local) authorities along with investment by industry 12 *public* follow directly from input-output classifications and are associated in relationships with the obvious model variables (eqns 7.1 and 7.2).

Interest expenditure by the government sector takes two forms. Payments to the private sector represents interest on domestic holdings of public debt (eqn 7.6). Payments to the foreign sector involves interest payments on overseas holdings of public debt. This is related in the model to the market interest rate and the stock of debt held overseas at the end of the previous period as well as allowing for any valuation adjustment resulting from the movement in the exchange rate between the current and the previous period (eqn 7.7).

Transfers to the private sector are equivalent to the relevant component of private sector income (eqns 7.3, 7.4 and 7.5).

v foreign sector

Transactions with the foreign sector follow directly from the above descriptions of the private and the government sectors, with the only additional data required being that related to external trade. Input-output data on export receipts (fob value) yield one expenditure component of the foreign sector. The income counterpart is taken from import payments (cif) data from the input-output table. Both these components are related to aggregate export and import variables already existing in the cge model.

Equations 3.1 to 3.4 yield an aggregation of the private and government sector income and expenditure components with the balances calculated in an obvious manner (eqns 2.1 and 2.2). Using the identity that the foreign sector balance is equivalent to the negative of the current account balance in addition to the requirement that the sum of the three sector balances equal zero yields equation 2.3.

vi debt stocks

The information listed in Table 4 is taken from the RB model XIII database. These numbers are interpreted as the stock of debt existing at the end of the base period (1990). Thus, in model simulations where the base period equates to year 0 and is considered to be past history, these figures are equivalent to the stock held at the beginning of period 1. Sector balances in period 1 and beyond as determined by the model's relationships effectively allow the updating of Table 4.

Table 4 Debt stocks 1990 quarter 1

		\$ m		Held by	
				Pvte	Foreign
Issued by	Pvte		27645	27645	9862
	Govt	17783	18724	36507	36507
	Foreign				-46368
	TOTAL	17783	46368		0

In updating these stocks the model equations assume that the balance of the government sector is applied to private and foreign debt holdings in a constant proportion (represented by the parameter Ω). Alternative assumptions in this regard need to be explored. Hence,

the government sector balance determines the holdings of public debt by both the private and the foreign sectors (eqns 1.1 and 1.2), leaving the remainder of the private sector balance to be applied to foreign holdings of private sector debt (eqn 1.3).

IV A steady-state and comparative dynamics

Associated with the refinements outlined in the previous section, some modifications from the previous version of the model were required to project a steady-state solution to the inter-temporal model. These adjustments were related to end-period criteria and other exogenous assumptions as follows.

While the determination of private household consumption expenditure follows that described in section II above, the related end-period criterion was amended from one of stabilising the total foreign debt-to-GDP ratio to one of stabilising (as a ratio to GDP) that portion of the stock of foreign debt held by the private sector. This allows the portion of the foreign debt held by the government sector to have a similar, but independent, end-period constraint. Associated with the latter is the endogenous determination in period one of a fiscal policy instrument - either a tax rate (or a group of tax rates) or government consumption expenditure.

Within the investment nexus, the neo-classical behaviour described in section II above was suppressed in two of the industries owing to difficulties with implementation and interpretation. Investment in each of these two (industries 10 and 12, viz *own dwellings* and *public*) were exogenously set to grow at the steady-state growth rate (2%pa). The levels of investment in period one, however, were endogenously determined to meet the end-period criteria that the growth of the capital stock in each of these industries equal the steady-state growth rate.

The reasons for requiring special treatment lie in particular characteristics unique to each of these industries. In the case of *own dwellings*, there are two aspects. Firstly, capital accounts for 100% of the primary factor input to this industry; thus investment pre-determines the industry's output - unlike other industries which can substitute to varying degrees labour for capital. Secondly, all of the output of this industry is sold to the household consumption category 2 *housing*, which has profound consequences in the determination of aggregate household consumption. As for *public*, the input-output convention that records zero returns to capital carries the implication (in a cge model framework) that capital does not enter into this industry's production function. In such a context the neo-classical behavioural model becomes unsuitable as there are no gains to be obtained from investment.

The modelling of behaviour in these two industries is an area requiring further work and the choice of exogenously stipulating a steady-state path should be viewed as a *default* option.

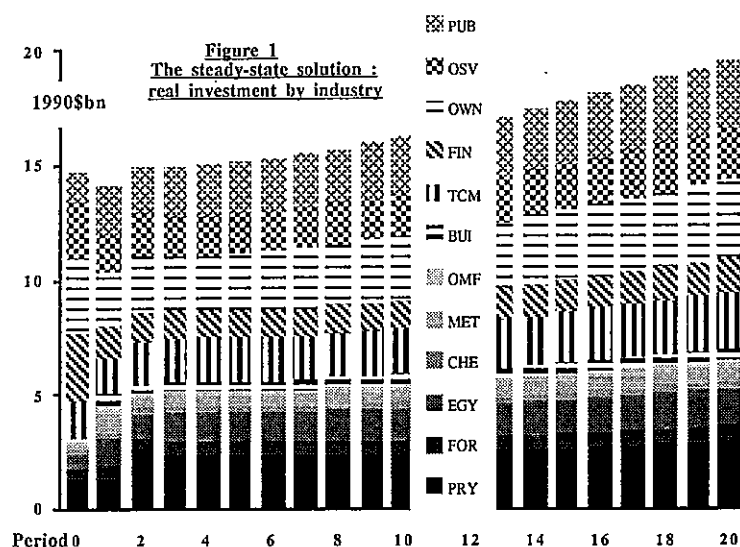
In comparative dynamic exercises the end-period criteria just described were retained although the period in which the level of the appropriate variable was allowed to adjust to the shock⁵ depended on the period in which the shock occurred and whether or not the shock was anticipated.

i a steady state solution

Given the above, the model was solved over a 20-period time horizon. With these industry, commodity, sector and time dimensions and given some prior condensing, the model comprised 6997 variables of which 5012 were endogenous. However, only 137825 (0.5%) of the elements of the 5012x5012 matrix are non-zero. Solution of the

⁵ That is, be endogenously determined by the model.

model using *Gempack* which exploits the sparse nature of the matrix takes approximately 20 minutes on a 66 MHz 486DX2 with 8mb RAM. The procedure involved a *Griggs* extrapolation based on 2, 4 and 6-step solutions of the model⁶.



Detailed model results for the steady-state solution⁷ where all real variables converge to a growth rate of 2% and all domestic prices to 0% are attached in the appendices. The adjustments required to move the 1990 base economy to a steady-state path of 2% growth are most vividly exhibited in the movements in investment by industry as illustrated in Figure 1. These are consistent with those obtained in the previous version of the inter-temporal model and

were described in Nana (1995). Note, though, the previous model version contained only seven production industries and had slightly different end-period criteria as mentioned above. Investment expenditure in each of the industries appears to converge to a steady growth path and this can be confirmed by inspection of detailed results provided in the appendices. The composition of debt holdings illustrated in Figure 2 provides evidence that the end-period conditions requiring a stabilising of debt to GDP ratios have indeed been met.

To achieve such a steady-state requires an initial increase in overall competitiveness vis-a-vis the rest of the world of 7% as indicated by the result for the aggregate gross output price index, with prices thereafter stabilising at this lower level. This change in domestic prices (costs) relative to the world prices (which are exogenously unchanged) facilitates a large adjustment in the first period in real exports (+20%) and import volumes (-7%). These external trade results are accompanied by a reduction in the level of aggregate real household consumption of 9.5%. Again, following these initial adjustments in the levels of these variables, they stabilise around a 2%pa growth rate. These findings are in broad agreement with those from the previous version of the model.

The additional information now provided by the model lies in making explicit the adjustments to sector income and expenditure which previously remained implicit. This revolves around the choice of which fiscal policy instrument is model determined in period 1. The steady-state presented here was obtained by endogenising the level of real government consumption expenditure.

**Table 5 The steady-state :
a sector summary for
period 1**

Sector	% change in period 1	
	Income	Expenditure
Private	-7.2	-12.1
Government	-7.9	-4.6

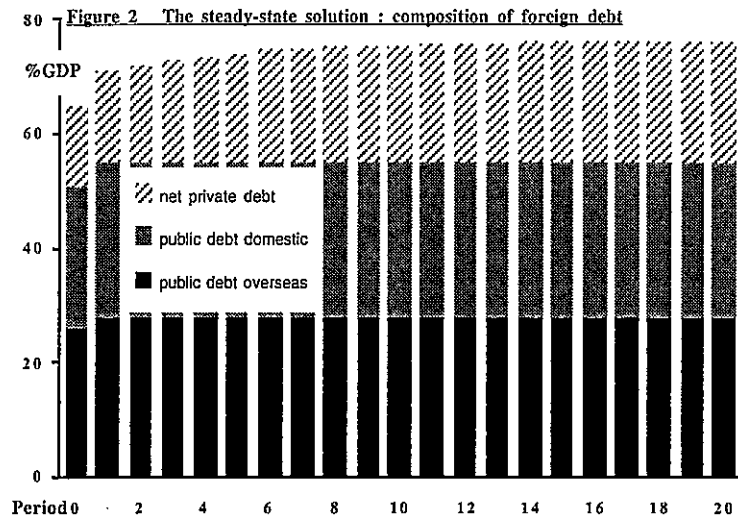
Table 5 shows at a glance that there is a relative shift in the pattern of total expenditure away from the private sector and towards the government sector. This is reflected in the

⁶ Solution can be significantly speedier if the number of steps is reduced, although this does entail some lessening in the accuracy of the extrapolation.

⁷ The exogenous input and other procedures required to obtain a steady-state solution are discussed in detail in Nana (1995).

detailed results recording government consumption expenditure in nominal terms rising by over 2% but that of households falling by more than 16%.

The imposed adjustment on the private sector is, in part, due to its relatively large financial imbalance in the base period. It is also a reflection of the relative import contents of the consumption baskets of the private compared to the government sector allied with the requirements of the end-period criteria. In this context it should be noted that while the model does allow the household consumer to respond to import-to-domestic relative price movements government consumption is made up of a fixed basket of commodities. Of course, in satisfying government consumption demands domestic industries can alter their production patterns in response to such relative price movements.



Of the other changes in sector income and expenditure in period 1 the most stark are those for the interest on debt categories. The large shifts here are due to the requirement that the interest rates incorporated in the model (which are exogenous) conform to neo-classical criteria consistent with a general equilibrium steady-state. In this context, the relationship between the interest rate, the rate of time preference and the inflation rate is pivotal. That is:

$$i = \rho + \frac{dP}{P}$$

In a cge model which is invariant to the absolute price level a steady-state solution implies no change in relative prices - leading to a zero inflation rate. As a consequence the rate of time preference should equal the interest rate. The interest, sector balances and debt stock data in Tables 3 and 4 imply interest rates as calculated in Table 6.

As indicated in the last column of Table 6, modified rates have been adopted for the model's data base although these still imply a somewhat high rate of time preference.

Table 6 Interest rates

	Interest	D ₀	Implied D ₀ -D ₋₁	D ₋₁	i	Jody i
		\$m			%	%
gdm	3280	17783	-Ω*143	17853	18.4	8.50
gfo	1542	18724	-(1-Ω)*143	18798	8.2	8.50
fpr	2277	27645	4906+(Ω*143)	22665	10.1	10.67

where Ω = 0.513 calculated as the base period share of foreign held public debt in total public debt

The implicit changes in interest rates in period 1, therefore, are responsible for the large movements in the interest categories of the model results for sector income and expenditure. This difficulty serves to reinforce the conclusion expressed in Nana (1995) that the strict neo-classical environment limits the ability to model the *transition* from an initial position to a steady-state path satisfactorily. This aspect may be improved once adjustment costs in capital formation are imposed and hence restrain the model from immediately leaping to the steady-state path. Differing

gestation lags between the industries may also allow a more satisfactory modelling of the transition periods.

Other noteworthy income and expenditure categories include GST, wages, profits, investment and direct taxes on individuals. Proceeds from the goods and services tax in the first period fall by nearly 13% and is a direct result of the reduction in household consumption expenditure countered, to a degree, by the rise in government consumption expenditure.

The comparison between the outcome for wage and profit incomes in the initial period indicate an increase in the labour share of national income. This follows from the fall in profit rates, most noticeably in the *energy, building, finance, own dwellings* and *other services* industries⁸. Remembering that the capital available in period 1 is pre-determined by the investment expenditure undertaken by the industry in period 0, a reduced demand for capital is fully reflected in lower profit rates. On the other hand real wage rates need not fall⁹ as labour, although exogenous in the aggregate, can be distributed amongst the industries to those most requiring (willing to pay for) this factor of production.

The sizable fall in private investment expenditure in period 1 follows directly from the fall in real investment arising from the need to lower capital stock growth rates in the *finance, own dwellings* and *other services* industries¹⁰. Investment in the *public* industry, however, requires a large increase to achieve the (exogenously imposed) growth rate in its stock of capital. This accounts for the large increase in government sector investment in the first period.

The result for direct tax revenue from individuals is a consequence of private sector income in the wages, unemployment benefit, national superannuation and interest categories. This interest category is responsible for the apparently large reduction in period 1 in tax revenue from this source and the discussion above concerning interest rates is relevant here.

As stated earlier in this section, in generating a steady-state solution to this model there is an exogenous choice as to which fiscal policy instrument is used to satisfy the end-period debt criteria placed on the stock of public debt held by the foreign sector. In the result presented above that instrument was real government consumption in period 1, with all tax rates fixed at no change from period 0. While not reported in detail, it is interesting to note an alternative steady-state which was generated using the tax rate on individuals (t^{ix}) as the fiscal policy instrument. Government consumption was set at a constant 2% growth rate throughout in that exercise.

In most macroeconomic aspects that simulation produced little difference from the above with, again, a 7% competitiveness improvement required resulting in debt stocks stabilising at a similar level. The only noticeable difference was, not surprisingly, in the relative government to private sector consumption patterns. Household consumption adjusting in that experiment in period 1 by only -8.2%, in contrast to the -9.5% recorded above. This, of course, follows from the tax instrument adjustment (a tax rate cut of 7.2%) which impinges directly on private sector incomes, replacing the fiscal adjustment in the above experiment of a 9% rise in government consumption.

ii comparative dynamics

The steady-state solution detailed in the previous section can be used as the basis or *control path* for comparative dynamic exercises. Two are presented here, an external price

⁸ These industries account for nearly 65% of returns to capital in the base period.

⁹ Not shown in tables, but inspection of model output show real (consumer) wage rates rise by 1% in period 1 and by period 20 are nearly 3% higher than in period 0.

¹⁰ These industries account for nearly 65% of private investment expenditure in the base period.

shock and an internal demand shock; both being similar to shocks discussed in Nana (1995). Summary aggregate outcomes for both experiments is listed in Table 7, with detailed model results with regard to sector income, expenditure and debt being provided in the appendices.

Table 7 Comparative dynamics : summary

% change on <i>CONTROL</i>	Price shock				Demand shock				
	Period	4	10	18	20	4	10	18	20
Real									
GDP		-1.6	-2.9	-3.6	-3.7	0.6	0.6	0.6	0.6
Household consumption		-0.8	-1.4	-1.9	-1.9	-0.6	-0.6	-0.6	-0.6
Total investment		-3.1	-4.4	-3.4	-3.4	-0.2	0.1	0.1	0.1
Government consumption		-7.6	-7.6	-7.6	-7.6	*5.0	*5.0	*5.0	*5.0
Tax rate (t^{ix} and t^{dt})		*0.0	*0.0	*0.0	*0.0	2.6	2.6	2.6	2.6
Labour employment		-2.1	-3.3	-3.8	-3.9	0.9	1.0	1.0	1.0
Capital stock		0.0	-1.0	-1.7	-1.8	0.0	0.0	0.0	0.0
Gross output prices		0.1	0.9	1.4	1.5	0.0	0.0	0.0	0.0
Sector									
Private income		-1.0	-1.2	-1.2	-1.2	0.4	0.4	0.4	0.4
Private expenditure		-1.0	-1.4	-1.2	-1.3	0.4	0.4	0.4	0.4
Government income		-1.0	-1.4	-1.4	-1.4	1.9	2.0	2.0	2.0
Government expenditure		-2.4	-1.9	-1.6	-1.5	1.9	1.9	1.9	1.9

* = exogenous

The external price shock beginning in period 4 consists of a 2% rise in the world price of all imports and in the world price of the export commodity *other goods* only. This shock is sustained over the entire horizon and is modelled with no change in real wage rates, thus assuming a quantity adjustment in the aggregate labour market. In response, both household and government consumption are assumed to adjust contemporaneously with the shock, in order to meet the end-period debt criteria. It is clear that this shock has a permanent effect on the level of the steady-state growth path consistent with previous findings.

More noteworthy here, though, is the explicit sector detail which remained implicit in the previous version of the model. With the choice of fiscal policy instrument being government consumption the adjustment appears evenly spread between the private and the government sectors. An experiment which used tax rates as the fiscal instrument though, yielded a different picture¹¹. In that case there was a shifting of the relative burden of adjustment to the private sector with period 20 income and expenditure of -0.6% contrasted with government sector income of +1.7% and expenditure of +1.4%.

Amongst the income and expenditure categories, of note are the interest components. By the final period government sector interest expenditures are nearly 6% lower than *control* while those of the private sector are more than 7% lower. These reflect the lower levels of debt stocks (in both absolute and % of GDP terms) that can be sustained in the face of this adverse terms of trade movement. Remember that interest rates are exogenous to the model and so are unchanged from those in *control*.

The change in wage and profit income caused by the shock shows a relative gain in the profit share. The above assumption concerning the labour market adjustment process is relevant here. With real wages and hence the cost of labour not changing, cost-minimising producers shift to relatively capital-intensive processes. The lower numbers employed outweighs the maintenance of real wage rates in the outcome for wage income.

¹¹ The response to the shock in macroeconomic terms, however, was similar in both experiments (other than, of course, the relative household to government consumption results) - hence the latter is not reported in detail here.

This is also reflected in the large change in the unemployment benefit category of the sectors' balances.

The internal demand shock consisted of a 5% rise in government consumption expenditure in real terms. Again the shock began in period 4, was sustained over the entire horizon and was modelled assuming no change in real wage rates. Given the nature of the shock it was necessary to choose another fiscal instrument which would adjust in order to satisfy the relevant end-period criterion. The two direct tax rates (t^{ix} and t^{odt}) were chosen for this role, both assuming to adjust by the same percentage amount.

Again, the macroeconomic results show little differences from those of the previous version of the model. There is minimal effect on the overall steady-state path given a demand shock of this nature. Household consumption declines in response to the shock, being *crowded out* by the extra consumption being undertaken by the government.

What becomes explicit now, though, is the means by which this adjustment is imposed. Not surprisingly, additional expenditure by the government sector must be matched by more income. Furthermore, given the end-period debt criteria on the stock of public debt held by the foreign sector this income must come from the domestic private sector. Hence the 2.6% rise in tax rates, which forces the private sector to adjust its expenditure plans in response to the initial shock.

In comparison to the results of the previous model version, however, there is a small but noticeable gain to GDP as a result of this shock. The reason for this apparent discrepancy can be traced to the unique characteristics and the consequent exogenous treatment of capital in the *public* industry mentioned at the beginning of this section. Note that almost all (over 99%) of government consumption demand is met by output from this industry. With capital having no function in this industry, the additional output must entail extra employment of labour. Thus the compositional effect of expanding this relatively labour intensive industry leads to greater GDP in aggregate consistent with the higher aggregate employment. This anomaly reinforces the need for the further work in modelling behaviour in this industry stated earlier.

This aspect is also relevant in inspecting the categories of the two sectors' income and expenditure. Apart from the tax and consumption categories which change for obvious reasons, the only categories showing more than a negligible response to the demand shock are those related to labour employment: that is, the wage income and the unemployment benefit categories.

V Conclusion

The integration of sector income, expenditure and debt relationships into an input-output based multi-sectoral cge model in a consistent manner involves numerous difficulties. These, however, can now be addressed given a working model which can better direct efforts. In particular, improving the modelling of the transition to the steady-state needs to be investigated. Related to this issue is whether the strict neo-classical behaviour should be modified in some form. This is already the case in regard to the two *special-case* industries, although not in an entirely satisfactory way.

Nevertheless, a movement from comparative static analysis to comparative dynamics is undoubtedly an advance and is shown to be achievable to a reasonable degree of disaggregation with not too onerous a burden on computing (time) resources.

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Appendices - detailed model results

The attached tables provide details of three model solutions described in the text.

The tables on the first three pages relate to the steady state solution listing results in the following order:

- Private sector income (% growth)
- Private sector expenditure (% growth)
- Government sector income (% growth)
- Government sector expenditure (% growth)
- Sector balances (\$m)
- Debt (\$m)
- Debt (% of GDP)

- GDP (% growth)
- Real gross output (% growth)
- Labour employed (% growth)
- Real capital stock (% growth)
- Real gross investment (% growth)
- Real household consumption (% growth)

- Gross output prices (% growth)
- Real export volumes (% growth)
- Real import volumes (% growth)
- Trade balance of payments (\$m)
- Real profit rate¹² index (period 0 = 100)
- Rate of return¹³ (%)

For each of the two comparative dynamic experiments one page of tables is provided as follows:

- Private sector income (% change on CONTROL [steady-state])
- Private sector expenditure (% change on CONTROL [steady-state])
- Government sector income (% change on CONTROL [steady-state])
- Government sector expenditure (% change on CONTROL [steady-state])
- Sector balances (absolute change on CONTROL [steady-state] in \$m)
- Debt (absolute change on CONTROL [steady-state] in \$m)
- Debt (post-shock level as a % of GDP)

¹² For each industry, this is the profit (or rental) per unit of capital translated into real (producer price) terms via that industry's gross output price.

¹³ The rate of return in each industry is defined in net terms viz: nominal profit rate less the rate of depreciation, all divided by the price of new capital (investment) goods.

Appendix i Detailed model results for steady state

Period	1	2	3	4	5	6	7	8	10	12	14	16	18	20
Private sector income (% growth)														
WAG	-3.65	2.69	1.98	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01
PRO	-6.80	2.24	1.86	1.86	1.90	1.91	1.93	1.94	1.96	1.98	1.98	1.99	1.99	2.00
XMP	-4.97	3.14	1.70	1.88	1.87	1.91	1.94	1.96	1.98	1.99	2.00	2.00	2.00	2.01
GDM	-53.92	2.13	2.04	2.01	2.00	1.99	1.99	1.99	2.00	2.00	2.00	2.00	2.00	2.00
UBN	-4.45	2.68	1.96	1.99	2.00	2.00	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01
NSP	-4.45	2.68	1.96	1.99	2.00	2.00	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01
OWF	-5.39	2.07	1.69	1.78	1.85	1.88	1.91	1.93	1.96	1.97	1.98	1.99	1.99	2.00
XFR	-7.12	2.50	1.92	1.94	1.96	1.97	1.98	1.98	1.99	1.99	2.00	2.00	2.00	2.01
TOT	-7.12	2.50	1.92	1.94	1.96	1.97	1.98	1.98	1.99	1.99	2.00	2.00	2.00	2.01

Private sector expenditure (% growth)														
FPR	29.54	3.93	4.99	4.19	3.69	3.26	2.95	2.72	2.41	2.23	2.12	2.05	2.01	1.99
SOE	-6.80	2.24	1.86	1.86	1.90	1.91	1.93	1.94	1.96	1.98	1.98	1.99	1.99	2.00
XFR	-12.07	2.98	1.66	1.77	1.80	1.85	1.89	1.91	1.95	1.97	1.98	1.99	2.00	2.01
ITX	-7.45	2.67	1.98	2.00	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01
ODT	-6.80	2.24	1.86	1.86	1.90	1.91	1.93	1.94	1.96	1.98	1.98	1.99	1.99	2.00
CON	-16.13	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
INV	-14.08	6.75	-0.68	0.12	0.38	0.74	1.04	1.27	1.56	1.73	1.84	1.91	1.97	2.03
STO	-0.74	1.34	1.94	1.85	1.86	1.89	1.91	1.93	1.95	1.97	1.98	1.99	1.99	2.00
OFP	-5.56	2.49	1.92	1.94	1.96	1.97	1.97	1.98	1.99	1.99	2.00	2.00	2.00	2.01
TOT	-12.07	2.98	1.66	1.77	1.80	1.85	1.89	1.91	1.95	1.97	1.98	1.99	2.00	2.01

Government sector income (% growth)														
ITX	-7.45	2.67	1.98	2.00	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01
ODT	-6.80	2.24	1.86	1.86	1.90	1.91	1.93	1.94	1.96	1.98	1.98	1.99	1.99	2.00
GST	-12.98	2.11	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
DUT	-7.56	3.26	1.15	1.53	1.54	1.65	1.74	1.80	1.89	1.93	1.96	1.98	1.99	2.01
OID	-3.59	2.64	1.92	1.88	1.90	1.91	1.93	1.94	1.96	1.97	1.98	1.99	2.00	2.01
SOE	-6.80	2.24	1.86	1.86	1.90	1.91	1.93	1.94	1.96	1.98	1.98	1.99	1.99	2.00
TOT	-7.86	2.51	1.93	1.95	1.96	1.97	1.98	1.98	1.99	1.99	2.00	2.00	2.00	2.01

Government sector expenditure (% growth)														
GDM	-53.92	2.13	2.04	2.01	2.00	1.99	1.99	1.99	2.00	2.00	2.00	2.00	2.00	2.00
GFO	3.21	2.13	2.04	2.01	2.00	1.99	1.99	1.99	2.00	2.00	2.00	2.00	2.00	2.00
UBN	-4.45	2.68	1.96	1.99	2.00	2.00	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01
NSP	-4.45	2.68	1.96	1.99	2.00	2.00	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01
OWF	-5.39	2.07	1.69	1.78	1.85	1.88	1.91	1.93	1.96	1.97	1.98	1.99	1.99	2.00
CON	2.20	2.42	1.89	1.94	1.96	1.97	1.98	1.99	1.99	2.00	2.00	2.00	2.00	2.01
INV	53.94	1.69	1.72	1.85	1.89	1.91	1.93	1.95	1.97	1.98	1.99	1.99	2.00	2.00
TOT	-4.59	2.36	1.89	1.94	1.96	1.97	1.98	1.98	1.99	2.00	2.00	2.00	2.00	2.01

Period	0	1	2	3	4	5	6	7	9	11	13	15	19	20
Sector balances (\$m)														
CB	-4906	-1485	-1825	-1656	-1558	-1469	-1404	-1362	-1318	-1310	-1323	-1349	-1436	-1465
GB	143	-780	-761	-764	-776	-790	-805	-821	-855	-891	-928	-966	-1046	-1067
PB	-5049	-705	-1064	-891	-783	-679	-599	-540	-463	-419	-395	-383	-390	-398

Debt (\$m)														
GFO	18724	19124	19514	19906	20303	20708	21121	21542	22410	23314	24256	25237	27320	27867
GDM	17783	18163	18533	18905	19283	19667	20059	20459	21284	22143	23037	23969	25947	26466
FPR	27645	28730	30165	31429	32589	33653	34645	35586	37370	39087	40782	42485	46001	46919
PUB	36507	37286	38047	38811	39586	40376	41180	42001	43694	45457	47293	49205	53266	54333
Net PVT	9862	10568	11632	12524	13307	13986	14586	15126	16086	16944	17745	18517	20054	20453
FOR	46369	47854	49679	51335	52893	54361	55766	57127	59780	62401	65038	67722	73321	74785

Debt (% GDP)														
GFO	26.56	28.32	28.20	28.22	28.24	28.25	28.25	28.26	28.27	28.27	28.27	28.28	28.28	28.28
GDM	25.22	26.90	26.78	26.80	26.82	26.83	26.83	26.84	26.85	26.85	26.85	26.86	26.86	26.86
FPR	39.21	42.55	43.59	44.55	45.32	45.90	46.35	46.68	47.14	47.40	47.54	47.60	47.62	47.61
PUB	51.78	55.22	54.97	55.02	55.05	55.07	55.09	55.10	55.11	55.12	55.13	55.13	55.14	55.14
Net PVT	13.99	15.65	16.81	17.75	18.50	19.08	19.51	19.84	20.29	20.55	20.68	20.75	20.76	20.75
FOR	65.77	70.87	71.78	72.77	73.56	74.15	74.60	74.94	75.40	75.67	75.81	75.88	75.90	75.89

Appendix i Detailed model results for steady state

Period	1	2	3	4	5	6	7	8	10	12	14	16	18	20
GDP (% growth)														
Real	2.27	2.46	2.37	2.28	2.24	2.20	2.18	2.16	2.14	2.12	2.11	2.11	2.11	2.10
Nomnl	-5.56	2.49	1.92	1.94	1.96	1.97	1.97	1.98	1.99	1.99	2.00	2.00	2.00	2.01
Real gross output (% growth)														
PRY	5.46	1.57	2.63	2.43	2.33	2.24	2.18	2.14	2.08	2.05	2.03	2.02	2.01	2.01
FOR	4.25	3.01	2.19	2.23	2.22	2.16	2.13	2.10	2.06	2.04	2.03	2.02	2.01	2.01
EGY	-0.13	2.32	2.35	2.27	2.23	2.19	2.15	2.12	2.08	2.05	2.04	2.03	2.02	2.02
CHE	2.68	1.93	2.45	2.37	2.32	2.26	2.20	2.16	2.11	2.07	2.04	2.03	2.02	2.01
MET	6.20	4.64	1.38	1.97	1.84	1.88	1.92	1.95	1.98	1.99	2.00	2.00	2.01	2.01
OMF	5.33	2.21	2.36	2.27	2.25	2.18	2.14	2.11	2.06	2.04	2.03	2.02	2.01	2.01
BUI	-7.28	4.68	0.97	1.15	1.43	1.55	1.65	1.73	1.83	1.90	1.94	1.97	1.99	2.02
TCM	8.59	1.98	2.76	2.54	2.42	2.32	2.25	2.19	2.11	2.07	2.04	2.03	2.02	2.01
FIN	3.44	2.44	2.50	2.30	2.19	2.14	2.10	2.08	2.04	2.03	2.02	2.01	2.01	2.01
OWN	3.09	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
OSV	-1.91	2.00	2.55	2.27	2.21	2.17	2.12	2.09	2.06	2.03	2.02	2.01	2.01	2.01
PUB	8.36	2.12	2.01	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
TOT	2.63	2.45	2.25	2.18	2.14	2.10	2.08	2.06	2.04	2.02	2.01	2.01	2.01	2.01
Labour employment (% growth)														
PRY	8.79	2.17	2.13	2.05	2.02	2.02	2.02	2.01	2.01	2.01	2.00	2.00	2.00	1.99
FOR	6.82	1.38	2.17	2.12	2.11	2.09	2.07	2.06	2.04	2.02	2.02	2.01	2.00	2.00
EGY	-2.97	3.19	2.71	1.90	1.77	1.70	1.68	1.69	1.75	1.82	1.87	1.91	1.94	1.96
CHE	4.99	1.72	2.32	2.30	2.23	2.19	2.15	2.12	2.08	2.05	2.03	2.02	2.01	2.01
MET	8.91	3.47	1.32	1.69	1.65	1.75	1.83	1.88	1.94	1.97	1.98	1.99	2.00	2.01
OMF	7.16	1.98	2.29	2.18	2.11	2.09	2.07	2.06	2.03	2.02	2.01	2.01	2.01	2.00
BUI	-9.69	2.85	0.67	1.18	1.41	1.53	1.63	1.72	1.82	1.89	1.93	1.96	1.99	2.02
TCM	12.86	2.02	2.56	2.44	2.28	2.21	2.17	2.13	2.08	2.05	2.03	2.02	2.01	2.00
FIN	-3.76	1.47	1.93	1.88	2.02	2.01	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
OWN	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
OSV	-6.62	1.48	2.14	2.10	2.09	2.07	2.05	2.04	2.02	2.02	2.01	2.01	2.00	2.00
PUB	8.36	2.12	2.01	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
TOT	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Real capital stock (% growth)														
PRY	0.60	0.68	3.39	3.02	2.80	2.59	2.43	2.32	2.19	2.11	2.07	2.05	2.03	2.03
FOR	2.72	4.00	2.20	2.30	2.28	2.20	2.16	2.12	2.08	2.05	2.03	2.02	2.01	2.01
EGY	0.84	2.02	2.23	2.40	2.38	2.35	2.31	2.27	2.19	2.13	2.09	2.06	2.05	2.04
CHE	0.65	2.11	2.58	2.44	2.40	2.32	2.25	2.20	2.13	2.08	2.05	2.04	2.03	2.02
MET	0.42	7.24	1.50	2.58	2.26	2.16	2.13	2.11	2.07	2.05	2.03	2.03	2.03	2.03
OMF	-0.53	2.95	2.60	2.58	2.74	2.50	2.36	2.28	2.16	2.10	2.06	2.04	2.03	2.03
BUI	-1.62	9.01	1.66	1.08	1.49	1.60	1.69	1.76	1.85	1.91	1.94	1.97	1.99	2.02
TCM	2.17	1.92	3.05	2.70	2.63	2.50	2.37	2.29	2.17	2.11	2.07	2.04	2.03	2.02
FIN	9.38	3.21	2.94	2.63	2.32	2.24	2.18	2.13	2.08	2.04	2.02	2.01	2.01	2.01
OWN	3.09	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
OSV	6.12	2.87	3.22	2.56	2.41	2.31	2.23	2.17	2.10	2.06	2.04	2.02	2.01	2.01
PUB	0.65	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
TOT	2.58	2.31	2.46	2.35	2.28	2.21	2.16	2.13	2.08	2.05	2.03	2.02	2.01	2.01
Real gross investment (% growth)														
PRY	3.21	89.15	-3.27	-1.04	-1.45	-0.61	0.15	0.64	1.25	1.57	1.75	1.87	1.95	2.02
FOR	27.25	-24.21	4.26	1.89	0.74	1.24	1.44	1.56	1.74	1.84	1.90	1.94	1.98	2.01
EGY	63.20	8.96	7.29	2.00	1.45	1.20	1.04	1.03	1.18	1.39	1.58	1.74	1.88	2.01
CHE	90.98	17.62	-1.24	1.25	-0.23	0.24	0.65	0.91	1.30	1.55	1.71	1.83	1.92	1.99
MET	313.51	-61.08	35.02	-5.02	-0.29	1.56	1.45	1.56	1.73	1.83	1.92	2.00	2.10	2.00
OMF	139.00	-3.16	2.15	5.54	-1.56	0.00	0.74	1.02	1.45	1.69	1.82	1.91	1.99	1.99
BUI	213.02	-42.72	-5.52	6.54	2.95	2.65	2.57	2.41	2.23	2.14	2.10	2.10	2.14	1.98
TCM	-1.97	21.20	-2.11	1.70	0.55	0.59	0.97	1.23	1.56	1.74	1.85	1.91	1.96	2.02
FIN	-54.42	-2.95	-4.71	-5.77	0.02	0.45	0.75	1.11	1.51	1.72	1.83	1.91	1.97	2.15
OWN	-28.31	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
OSV	-30.25	8.70	-7.18	0.02	0.64	0.84	1.18	1.40	1.66	1.80	1.88	1.93	1.97	2.02
PUB	64.16	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
TOT	-3.89	6.31	-0.14	0.49	0.70	0.99	1.24	1.41	1.65	1.79	1.87	1.93	1.98	2.02
Real household consumption (% growth)														
FD	-4.47	1.50	2.53	2.30	2.22	2.15	2.10	2.07	2.04	2.02	2.01	2.01	2.00	2.00
HG	3.09	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
HO	-20.91	0.93	1.79	2.47	2.58	2.57	2.53	2.47	2.34	2.24	2.16	2.11	2.07	2.05
AP	-11.50	1.87	2.38	2.17	2.14	2.09	2.05	2.04	2.02	2.01	2.00	2.00	2.00	2.00
TN	-29.52	2.11	2.06	1.98	2.00	1.98	1.98	1.98	1.98	1.99	1.99	1.99	2.00	2.00
TA	-3.93	1.68	2.50	2.28	2.19	2.13	2.09	2.06	2.03	2.02	2.01	2.01	2.00	2.00
OG	-10.03	2.52	2.08	2.03	2.01	2.00	1.99	1.99	1.99	1.99	1.99	2.00	2.00	2.00
OS	0.32	2.52	2.92	2.49	2.21	2.14	2.09	2.06	2.02	2.01	2.00	2.00	1.99	1.99
TOT	-9.58	1.93	2.32	2.22	2.15	2.12	2.09	2.07	2.04	2.03	2.02	2.01	2.01	2.00

Appendix ii Detailed model results for external price shock

unless otherwise stated numbers are % CHANGE ON CONTROL "steady-state" scenario

Period	1	2	3	4	5	6	7	8	10	12	14	16	18	20
Private sector income														
WAG	0.00	0.00	0.00	-2.09	-2.49	-2.52	-2.55	-2.56	-2.60	-2.62	-2.65	-2.67	-2.69	-2.73
PRO	0.00	0.00	0.00	-0.79	-1.18	-1.23	-1.25	-1.26	-1.28	-1.29	-1.30	-1.31	-1.33	-1.35
XMP	0.00	0.00	0.00	-0.26	-1.11	-1.21	-1.31	-1.35	-1.42	-1.50	-1.57	-1.63	-1.69	-1.77
GDM	0.00	0.00	0.00	0.00	-1.02	-1.79	-2.43	-2.99	-3.91	-4.60	-5.12	-5.49	-5.74	-5.86
UBN	0.00	0.00	0.00	13.04	15.34	16.82	17.99	18.93	20.52	21.78	22.80	23.62	24.31	24.95
NSP	0.00	0.00	0.00	0.36	0.32	0.51	0.66	0.78	0.98	1.14	1.26	1.36	1.44	1.50
OWF	0.00	0.00	0.00	0.36	0.32	0.51	0.66	0.78	0.98	1.14	1.26	1.36	1.44	1.50
XFR	0.00	0.00	0.00	-0.96	-1.28	-1.27	-1.26	-1.25	-1.24	-1.23	-1.22	-1.21	-1.21	-1.22
TOT	0.00	0.00	0.00	-0.96	-1.28	-1.27	-1.26	-1.25	-1.24	-1.23	-1.22	-1.21	-1.21	-1.22

Private sector expenditure														
FPR	0.00	0.00	0.00	0.00	-0.67	-1.80	-2.77	-3.63	-4.95	-5.87	-6.50	-6.88	-7.08	-7.16
SOE	0.00	0.00	0.00	-0.79	-1.18	-1.23	-1.25	-1.26	-1.28	-1.29	-1.30	-1.31	-1.33	-1.35
XFR	0.00	0.00	0.00	-0.98	-1.57	-1.54	-1.52	-1.47	-1.39	-1.34	-1.30	-1.26	-1.24	-1.25
ITX	0.00	0.00	0.00	-1.15	-1.44	-1.41	-1.40	-1.38	-1.36	-1.34	-1.33	-1.32	-1.31	-1.31
ODT	0.00	0.00	0.00	-0.79	-1.18	-1.23	-1.25	-1.26	-1.28	-1.29	-1.30	-1.31	-1.33	-1.35
CON	0.00	0.00	0.00	-0.45	-0.45	-0.45	-0.45	-0.45	-0.45	-0.45	-0.45	-0.45	-0.45	-0.45
INV	0.00	0.00	0.00	-2.96	-6.05	-5.62	-5.27	-4.76	-3.94	-3.34	-2.90	-2.58	-2.40	-2.42
STO	0.00	0.00	0.00	0.32	0.77	0.80	0.91	1.02	1.20	1.34	1.45	1.54	1.61	1.67
OFF	0.00	0.00	0.00	-1.45	-1.84	-1.88	-1.90	-1.92	-1.94	-1.97	-1.98	-2.00	-2.02	-2.05
TOT	0.00	0.00	0.00	-0.98	-1.57	-1.54	-1.52	-1.47	-1.39	-1.34	-1.30	-1.26	-1.24	-1.25

Government sector income														
ITX	0.00	0.00	0.00	-1.15	-1.44	-1.41	-1.40	-1.38	-1.36	-1.34	-1.33	-1.32	-1.31	-1.31
ODT	0.00	0.00	0.00	-0.79	-1.18	-1.23	-1.25	-1.26	-1.28	-1.29	-1.30	-1.31	-1.33	-1.35
GST	0.00	0.00	0.00	-2.48	-2.48	-2.44	-2.42	-2.40	-2.37	-2.35	-2.33	-2.32	-2.30	-2.30
DUT	0.00	0.00	0.00	-2.26	-2.86	-2.76	-2.73	-2.62	-2.45	-2.34	-2.26	-2.21	-2.19	-2.22
OID	0.00	0.00	0.00	1.07	0.41	0.26	0.16	0.09	-0.02	-0.10	-0.17	-0.23	-0.29	-0.37
SOE	0.00	0.00	0.00	-0.79	-1.18	-1.23	-1.25	-1.26	-1.28	-1.29	-1.30	-1.31	-1.33	-1.35
TOT	0.00	0.00	0.00	-1.02	-1.34	-1.35	-1.35	-1.35	-1.35	-1.35	-1.35	-1.35	-1.36	-1.37

Government sector expenditure														
GDM	0.00	0.00	0.00	0.00	-1.02	-1.79	-2.43	-2.99	-3.91	-4.60	-5.12	-5.49	-5.74	-5.86
GFO	0.00	0.00	0.00	0.00	-1.02	-1.79	-2.43	-2.99	-3.91	-4.60	-5.12	-5.49	-5.74	-5.86
UBN	0.00	0.00	0.00	13.04	15.34	16.82	17.99	18.93	20.52	21.78	22.80	23.62	24.31	24.95
NSP	0.00	0.00	0.00	0.36	0.32	0.51	0.66	0.78	0.98	1.14	1.26	1.36	1.44	1.50
OWF	0.00	0.00	0.00	0.36	0.32	0.51	0.66	0.78	0.98	1.14	1.26	1.36	1.44	1.50
CON	0.00	0.00	0.00	-7.28	-7.28	-7.10	-6.97	-6.86	-6.68	-6.54	-6.43	-6.34	-6.26	-6.21
INV	0.00	0.00	0.00	0.44	0.64	0.81	0.93	1.04	1.21	1.34	1.45	1.53	1.60	1.65
TOT	0.00	0.00	0.00	-2.42	-2.41	-2.27	-2.16	-2.08	-1.94	-1.83	-1.74	-1.66	-1.59	-1.52

Period	0	1	2	3	4	5	6	7	9	11	13	15	19	20
Sector balances [absolute CHANGE ON CONTROL in \$m]														
CB	0	0	0	0	425	550	498	464	374	305	247	197	120	110
GB	0	0	0	0	403	319	280	254	216	185	158	135	87	71
PB	0	0	0	0	21	231	217	210	158	120	89	63	33	38

Debt [absolute CHANGE ON CONTROL in \$m]														
GFO	0	0	0	0	-207	-370	-514	-644	-875	-1073	-1242	-1386	-1602	-1639
GDM	0	0	0	0	-196	-352	-488	-612	-831	-1019	-1179	-1316	-1522	-1556
FPR	0	0	0	0	-218	-604	-958	-1292	-1852	-2296	-2649	-2924	-3292	-3365
PUB	0	0	0	0	-403	-722	-1002	-1256	-1707	-2092	-2421	-2702	-3124	-3195
Net PVT	0	0	0	0	-21	-252	-470	-680	-1020	-1277	-1470	-1608	-1770	-1809
FOR	0	0	0	0	-425	-975	-1472	-1936	-2727	-3369	-3891	-4310	-4894	-5004

Debt [post-shock level as a % of GDP]														
GFO	26.19	28.32	28.20	28.22	28.36	28.26	28.09	27.95	27.70	27.51	27.37	27.27	27.17	27.17
GDM	24.87	26.90	26.78	26.80	26.93	26.84	26.68	26.54	26.31	26.13	25.99	25.90	25.81	25.81
FPR	38.66	42.55	43.59	44.55	45.68	45.92	45.93	45.86	45.68	45.50	45.35	45.23	45.13	45.12
PUB	51.06	55.22	54.97	55.02	55.29	55.10	54.77	54.49	54.00	53.63	53.36	53.17	52.98	52.98
Net PVT	13.79	15.65	16.81	17.75	18.75	19.08	19.24	19.32	19.38	19.38	19.35	19.33	19.32	19.32
FOR	64.85	70.87	71.78	72.77	74.04	74.18	74.02	73.80	73.38	73.01	72.71	72.50	72.30	72.29

Appendix iii Detailed model results for internal demand shock
 unless otherwise stated numbers are % CHANGE ON CONTROL "steady-state" scenario

Period	1	2	3	4	5	6	7	8	10	12	14	16	18	20
Private sector income														
WAG	0.00	0.00	0.00	1.08	1.13	1.12	1.12	1.13	1.13	1.13	1.13	1.13	1.13	1.13
PRO	0.00	0.00	0.00	-0.04	-0.02	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01
XMP	0.00	0.00	0.00	-0.07	0.01	-0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02
GDM	0.00	0.00	0.00	0.00	0.03	0.05	0.06	0.07	0.09	0.11	0.12	0.13	0.13	0.13
UBN	0.00	0.00	0.00	-5.55	-5.61	-5.63	-5.67	-5.68	-5.71	-5.74	-5.76	-5.77	-5.78	-5.80
NSP	0.00	0.00	0.00	-0.07	-0.03	-0.04	-0.04	-0.05	-0.05	-0.05	-0.05	-0.06	-0.06	-0.06
OWF	0.00	0.00	0.00	-0.07	-0.03	-0.04	-0.04	-0.05	-0.05	-0.05	-0.05	-0.06	-0.06	-0.06
XFR	0.00	0.00	0.00	0.37	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41
TOT	0.00	0.00	0.00	0.37	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41

Private sector expenditure														
FPR	0.00	0.00	0.00	0.00	-0.03	0.00	0.00	0.02	0.04	0.06	0.07	0.08	0.08	0.08
SOE	0.00	0.00	0.00	-0.04	-0.02	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01
XFR	0.00	0.00	0.00	0.35	0.42	0.40	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41
ITX	0.00	0.00	0.00	3.31	3.36	3.35	3.35	3.35	3.35	3.35	3.35	3.35	3.35	3.35
ODT	0.00	0.00	0.00	2.60	2.62	2.63	2.63	2.63	2.63	2.63	2.63	2.63	2.63	2.63
CON	0.00	0.00	0.00	-0.64	-0.64	-0.64	-0.64	-0.64	-0.64	-0.64	-0.64	-0.64	-0.64	-0.64
INV	0.00	0.00	0.00	-0.24	0.14	0.04	0.07	0.07	0.06	0.05	0.04	0.04	0.03	0.04
STO	0.00	0.00	0.00	0.02	-0.02	-0.01	-0.01	-0.01	-0.01	-0.01	-0.02	-0.02	-0.02	-0.02
OFF	0.00	0.00	0.00	0.51	0.54	0.54	0.54	0.54	0.55	0.55	0.55	0.55	0.55	0.55
TOT	0.00	0.00	0.00	0.35	0.42	0.40	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41

Government sector income														
ITX	0.00	0.00	0.00	3.31	3.36	3.35	3.35	3.35	3.35	3.35	3.35	3.35	3.35	3.35
ODT	0.00	0.00	0.00	2.60	2.62	2.63	2.63	2.63	2.63	2.63	2.63	2.63	2.63	2.63
GST	0.00	0.00	0.00	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88
DUT	0.00	0.00	0.00	0.04	0.09	0.05	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
OID	0.00	0.00	0.00	-1.23	-1.18	-1.17	-1.17	-1.17	-1.16	-1.16	-1.16	-1.16	-1.16	-1.16
SOE	0.00	0.00	0.00	-0.04	-0.02	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01
TOT	0.00	0.00	0.00	1.92	1.96	1.96	1.96	1.96	1.96	1.96	1.96	1.96	1.96	1.96

Government sector expenditure														
GDM	0.00	0.00	0.00	0.00	0.03	0.05	0.06	0.07	0.09	0.11	0.12	0.13	0.13	0.13
GFO	0.00	0.00	0.00	0.00	0.03	0.05	0.06	0.07	0.09	0.11	0.12	0.13	0.13	0.13
UBN	0.00	0.00	0.00	-5.55	-5.61	-5.63	-5.67	-5.68	-5.71	-5.74	-5.76	-5.77	-5.78	-5.80
NSP	0.00	0.00	0.00	-0.07	-0.03	-0.04	-0.04	-0.05	-0.05	-0.05	-0.05	-0.06	-0.06	-0.06
OWF	0.00	0.00	0.00	-0.07	-0.03	-0.04	-0.04	-0.05	-0.05	-0.05	-0.05	-0.06	-0.06	-0.06
CON	0.00	0.00	0.00	4.96	4.98	4.97	4.97	4.96	4.96	4.96	4.96	4.95	4.95	4.95
INV	0.00	0.00	0.00	-0.01	-0.01	-0.01	-0.02	-0.02	-0.02	-0.02	-0.03	-0.03	-0.03	-0.03
TOT	0.00	0.00	0.00	1.91	1.93	1.92	1.92	1.92	1.92	1.92	1.91	1.91	1.91	1.91

Period	0	1	2	3	4	5	6	7	9	11	13	15	19	20
Sector balances [absolute CHANGE ON CONTROL in \$m]														
CB	0	0	0	0	5	-15	-5	-8	-7	-6	-5	-4	-2	-2
GB	0	0	0	0	-11	-7	-7	-5	-5	-4	-3	-3	-2	-2
PB	0	0	0	0	16	-7	2	-2	-2	-2	-1	-1	0	0

Debt [absolute CHANGE ON CONTROL in \$m]														
GFO	0	0	0	0	6	10	13	16	21	25	29	32	37	38
GDM	0	0	0	0	5	9	12	15	20	24	27	30	35	36
FPR	0	0	0	0	-11	0	1	6	15	23	29	33	38	39
PUB	0	0	0	0	11	19	25	31	41	49	56	62	72	73
Net PVT	0	0	0	0	-16	-9	-11	-9	-4	-1	1	3	3	4
FOR	0	0	0	0	-5	9	14	22	36	48	58	65	75	77

Debt [post-shock level as a % of GDP]														
GFO	26.19	28.32	28.20	28.22	28.10	28.11	28.12	28.13	28.14	28.15	28.15	28.16	28.16	28.16
GDM	24.87	26.90	26.78	26.80	26.69	26.69	26.71	26.71	26.73	26.73	26.74	26.74	26.75	26.75
FPR	38.66	42.55	43.59	44.55	45.08	45.65	46.10	46.44	46.90	47.17	47.31	47.38	47.40	47.39
PUB	51.06	55.22	54.97	55.02	54.79	54.80	54.82	54.84	54.86	54.88	54.89	54.90	54.91	54.91
Net PVT	13.79	15.65	16.81	17.75	18.39	18.96	19.39	19.72	20.17	20.43	20.57	20.64	20.65	20.65
FOR	64.85	70.87	71.78	72.77	73.18	73.76	74.21	74.56	75.04	75.31	75.47	75.54	75.56	75.55

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