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Working Paper No. 182

A Macro/Financial Sector for Disaggregated

General Equilibrium Models*

by Philippa S. Dee

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I. Introduction*

The point of reference for this paper is the theoretical structure of disaggregated, general equilibrium models of the ORANI type, as outlined in Dixon et al. (1982) and Vincent (1981). This theoretical structure has been applied in a variety of contexts, with particular models differing widely, depending on data availability and the purpose at hand.¹ However, all applications use some subset of the theoretical structure described by Dixon et al. and Vincent. These references are therefore taken as benchmarks, from a theoretical viewpoint.

The ORANI structure gives a disaggregated, price-responsive general equilibrium picture of the real side of an open economy. The standard neoclassical assumptions of optimising behaviour by producers and consumers are used to generate the building blocks of a country model and the resulting structural equations fall into one of six categories:

(i) demands for commodities (domestically produced goods, competitive and non-competitive imports) by commodity demand

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Many applications have been undertaken in the "Sonderforschungsbereich 86" (Hamburg-Kiel) "Teilprojekt 3". See, for example, Dick et al. (1982) and Vincent (1983).

category (demand for intermediate inputs to current production, demand for inputs to capital creation, household demands, export demands and other, mainly government, demands)

- (ii) demands for primary factors (labour disaggregated by occupation, capital, land) by industrial sectors
- (iii) supplies of domestically produced commodities by industrial sectors
- (iv) conditions of zero pure profits in all activities (production for current consumption, production for capital creation, importing, exporting)
- (v) market clearing conditions for domestically produced goods and for primary factors
- (vi) miscellaneous equations to define useful summary variables and macroeconomic aggregates

Thus the ORANI structure gives a full explanation of the various commodity flows in an economy. It can be used to analyse the aggregate, structural and trade impacts of exogenous shocks (to world commodity prices, for example) or of specific commercial and fiscal policies (a tariff reduction, devaluation or change in government spending). It can also be used to determine the size of the commercial or fiscal policy action required to achieve a particular policy target (some target price or employment level, for example). By stressing commodity flows and abstracting from stock monetary and financial considerations, however, the system omits some important economic linkages relevant to these policy issues and is unable to address questions in other policy areas.

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Firstly, the system cannot be used to examine the impact of monetary and financial policies. Secondly, while the system allows endogenous determination of trade flows, it does not incorporate international capital flows and so omits a key channel by which exogenous shocks or policy actions can affect balance of payments surpluses or deficits and, through their monetary impact, the whole economy.² Thirdly, while total domestic absorption can be calculated from the system by summing up domestic final demands, there is no internal explanation of how absorption is divided between consumption and investment. In particular, without a full treatment of asset stocks and stock/flow interaction, the system cannot incorporate interest rate effects on these separate components.³ Interest rates are a further channel by which exogenous shocks or policy actions can have real effects on the economy (or, conversely, by which the real structure of the economy can influence policy targets). Finally, an internally consistent explanation of aggregate investment behaviour also allows a more satisfactory definition of long-run, as opposed to short- or medium-run, policy analysis.

The purpose of this paper is to develop a model of the macroeconomic, monetary and financial sector of an open economy in a form which can be appended to ORANI-type models so as to correct

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² Vincent (1983) incorporates the monetary impact of the balance of payments on aggregate real income and the price level, but excludes capital flows. Gerken (1983) incorporates a single capital inflow equation, but excludes consideration of stock asset equilibrium.

⁷ The system does use implicit real rates of return to capital to explain how a given level of aggregate investment will be allocated across industries, but because these rates are not seen to be reflected in any asset market, the approach does not explain aggregate investment.

these deficiencies. As well as introducing a monetary sector, therefore, the model must do two things - it must explain international capital flows and it must specify the aggregate behaviour of the various components of domestic absorption. It will be shown in subsequent sections that these requirements can be met by providing a full, general equilibrium, choice-theoretic treatment of all assets and not just money. The model presented here is indicative, in the sense that it is developed for a specific menu of assets. Furthermore, the menu is more appropriate for industrialized countries than for NICs or LDCs. Some attempt is made to indicate how policy issues specific to these latter countries may be addressed by altering the menu of assets accordingly. Nevertheless, the general approach is not only formally compatible with the existing ORANI modelling structure, but it is also, we feel, in keeping with the ORANI spirit of flexibility and internal consistency.

2. The Macro/Financial Sector Model in Outline

One requirement for internal consistency of a financial asset model is that asset holding be constrained to follow the stock balance sheet identities of the asset holders involved. Consistency between the real and financial sectors requires that goods flows and changes in asset stocks be constrained to follow the various flow national income accounting identities. The description of our macro/financial sector model therefore begins with a brief review of the standard macroeconomic stock and flow identities and their interrelationships.

The first flow identity comes from the balance of payments

 $\mathcal{D} = \{ p_i \} \in \{ p_i \}$

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accounts:

CurrentCapitalOfficialBalanceAccount+Account=Settlements = of(1)BalanceBalanceBalancePayments

On a more disaggregated level, the component balances can be broken up as follows:

Current Account Surplus:

- Trade surplus, i.e. exports minus imports

 Private transfer receipts, i.e. income on net foreign assets owned by domestic residents, less service payments on net domestic assets owned by foreigners

Capital Account Surplus:

- Private capital inflows⁴
- Government capital inflows
- Official transfer receipts, i.e. interest on reserve assets
 minus service payments on external debt

Official Settlements (Accommodation of Surpluses):

- Increase in official reserve assets
- Decrease in liabilities to other foreign official agencies,
 i.e. decrease in external debt

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This component is sometimes subdivided into private portfolio investment, i.e. net sales of foreign financial assets by domestic residents plus net purchases of domestic financial assets by foreigners, and direct investment. Alternatively, it is sometimes divided into long and short term capital inflows. Both sets of distinctions appear in flow, rather than stock approaches to the capital account but neither plays a role in our model.

The ORANI structure can currently determine only the trade component of the current account. The macro/financial model presented in this paper will specify, either directly or indirectly, the behaviour of each of the other components of the balance of payments account.

The second flow identity, or set of identities, comes from the national income accounts. These define gross domestic product (GDP) and gross national product (GNP) as follows: ⁵

$$GDP = C + I + G + (X-M)$$
 (2)

 $(3)^{2}$

and GNP = C + I + G + (X-M+PT)

where (X-M) and PT denote the trade surplus and private transfer components of the current account and where C, I and G denote consumption, investment and government expenditure, respectively. These latter three components together define absorption, i.e. total domestic expenditure on all goods and services, both domestic and imported. In terms of the definition of GDP, the ORANI structure currently explains the trade surplus component, as mentioned above. It also explains how given levels of C and I will be allocated among goods and/or industries, but it does not explain the aggregate levels of C and I themselves. The macro/financial sector model will include both an aggregate consumption function and an aggregate investment function. Government expenditure is one of several key macro policy variables, and thus remains exogenous.

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⁵ Related accounting concepts are those of net national product and personal disposable income, which shall be discussed later.

The flow balance of payments and national income accounting identities are in turn related to the stock balance sheets of the banking system and the government. First consider the balance of payments account. This is related to the balance sheet of the central bank as follows:

Official settlements balance = ΔNFA^{CB} (4) $\Delta H = \Delta NFA^{CB} + \Delta DC^{CB}$ (5)

The first relationship notes that a surplus or deficit in the official settlements balance, or balance of payments, involves a change in the net foreign asset position of the central bank ΔNFA^{CB} , either on the asset side directly, through a change in reserves, or on the liabilities side, through a change in external debt. The second relationship is a statement of the central bank's balance sheet identity. Changes in net foreign assets ΔNFA^{CB} , or changes in the domestic credit of the central bank to the rest of the economy ΔDC^{CB} , must be reflected in changes in central bank liabilities, that is, changes in the stock of high powered money ΔH .

Secondly, consider the relationship between the government budget deficit and the national income accounts. By subtracting net taxes T (that is, taxes less domestic transfers) from GNP we have

(6)

GNP - T = C + I + (G-T) + (X-M+PT)

But since saving S is defined as disposable income GNP-T less consumption C, we can write

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$$(S-I) + (T-G) = (X-M+PT)$$
 (7)

so that the current account surplus is identically equal to the sum of net private and government saving.

However, the method by which the government finances its deficit (G-T) has both monetary and balance of payments implications. Suppose, as is the case in many countries, that -all domestic government debt instruments are held by the central bank. Suppose, in addition, that the domestic credit of the central bank comprises only these government obligations. Now the government budget deficit must be financed by borrowing either domestically or abroad. Under our assumptions, this implies

$$(G-T) = \Delta DC^{CB} - \Delta NFA^{G}$$
(8)

Thus the domestic borrowing option, in this case, has a direct expansionary effect on the money supply.⁶ The foreign borrowing option, through a decrease in the net foreign assets of the government ΔNFA^{G} , appears as government capital inflow in the capital account of the balance of payments.

The various international accounting and balance sheet identities therefore provide a basis for the development of a consistent model and establish links between the balance of payments

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^o When the bon-bank private sector also holds government debt, this direct link between budget deficits and the money supply can be broken. However, bond sales to the private sector then affect interest rates and thereby induce indirect effects throughout the economy.

account, the national income account, the money supply process and the government budget deficit. It remains to specify relationships describing those components of the identities which reflect private sector behaviour. When specifying these behavioural relationships, we utilize the portfolio balance approach which uses the private sector balance sheets as an organising framework, while also allowing the stock/flow interaction implicit in the above macroeconomic identity framework. We now outline the main features of these behavioural relationships before turning, in the next section, to the detailed derivation of the full model.

The behavioural assumptions underlying the model can best be described in stages. The current account of the balance of payments (except for the private transfer component) measures pure flows of goods and services. The capital account (except for the official tranfer component) measures changes in asset stocks. Finally, the official settlements balance is one source of change in the stock of high powered money. Thus it is sometimes said that flows of goods and assets, through the current and capital accounts, represent "above-the-line" items and that the resulting "below-the-line" money flows appear in the official settlements balance. For the purpose of discussing the balance of payments we could, as a first approximation, simply note that these money flows must be willingly accommodated by money-holders. Examination of the conditions for stock monetary equilibrium would then be sufficient to determine balance of payments impacts, irrespective of

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of what "above-the-line" behaviour such impacts represented. 7

The next step is to note that the willingness of money-holders to hold money stocks is crucially dependent on the menu of other assets available and their relative returns. Thus money holding behaviour is analysed in the context of the general problem of portfolio composition. The resulting money demand behaviour, as before, has implications for the balance of payments. The capital account implications can also be made explicit through the demands for alternative assets.⁸

The final step is to consider the problem not just of portfolio composition, but also of portfolio size. This is an outcome of the consumption/savings decision, since savings flows are undertaken precisely to augment an individual's total stock of assets, or wealth. A unified treatment of portfolio composition and portfolio size therefore determines both stock asset demand behaviour and flow consumption (or savings) behaviour. Furthermore, both depend on disposable income and relative asset returns, thus giving a crucial link between the real and financial sides of the economy. The asset demand functions have implications for the capital account and balance of payments account, as before, and current

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⁷ This is the central assumption made in the monetary approach to the balance of payments. See, for example, Dornbusch (1973) and Whitman (1975).

⁸ This is essentially the line taken in the asset or portfolio balance approach, also sometimes called the stock adjustment approach. See, for example, Ujiie (1978) and Kouri (1980).

account implications can be made explicit through consumption behaviour.⁹

In the previous section it was argued that the macro/financial model must do two things - it must explain international capital flows and it must specify the aggregate behaviour of the various components of domestic absorption. We have now indicated that a general equilibrium treatment of portfolio balance with stock/flow interaction goes a long way towards achieving that aim, since it provides not only asset demand functions, but also an aggregate consumption function. It remains to specify an aggregate investment function. Here we assume that a firm's investment decision is at least partly dictated by the behaviour of wealth-holders, in the following sense. We argue that the relevant margin of choice is between the purchase of new capital equipment, i.e. investment proper, or the purchase of additional existing capital equipment. The second option, however, puts entrepreneurs in competition with other private wealth-holders, since they too can hold claims to the ownership of existing capital. Thus aggregate flow investment is determined by the price of new capital equipment relative to the price of ownership claims to existing capital, where the latter price is determined in the appropriate asset market.¹⁰

⁹ See, for example, Niehans (1978).

¹⁰Tobin (1969) makes this suggestion.

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Finally, it was suggested that the model is indicative, in the sense that it is derived for a specific menu of assets, namely money government bonds and claims to the ownership of existing capital which we shall call "shares". This menu will not be appropriate for all applications. For example, the bond market could be omitted altogether in countries where government debt is held primarily by the banking system. However, all countries will have institutional arrangements whereby individuals, whether they be entrepreneurs or otherwise, can hold or transfer ownership of existing capital stock and where additions to this capital stock can then be financed, even though this institutional framework need not be an actual stock market. Much of the art of applying a model such as this will involve identifying what these institutions are. A number of different ownership/financing instruments may exist, but so long as capital markets are well-integrated, so that real returns to these different instruments are kept (approximately) in line, the artifice of a "share" can be used to cover the sum of a firm's liabilities and net worth, which is the balance sheet counterpart of its physical assets.¹¹ The major difficulty will arise where capital markets are segmented as, say, when bank credit at administered interest rates is supplemented by a curb or unofficial money market as a source of financing. The model will be developed for the case of an integrated capital market, but we shall indicate how the treatment can be amended for the case of

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¹¹ In this context, the distinction between debt and equity is that the latter bestows control, as well as ownership.

segmented capital markets. The key point is that although we use the terminology of the stock market, the model does not hinge on the existence of this particular institution.

We have now outlined the basic identity framework of the macro/financial sector model and indicated the sort of behavioural assumptions that will be superimposed on that framework. We now turn to the detailed derivation of the model equations.

3. Detailed Derivation

The equations of our macro/financial sector model fall into six categories:

- (i) specification of net real asset returns for domestic and foreign assets, asset demand functions, consumption and savings functions
- (ii) market clearing conditions for domestic assets
- (iii) definition of balance of payments and components
- (iv) definition of government budget and components
- (v) specification of investment behaviour, in aggregate and by industrial sector
- (vi) optional equations defining the long-run

In this section we give the theoretical derivation of each type of equation and then convert each to a form compatible with the ORANI modelling structure.

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3.1 Notation

The theory will be presented in level form. The ORANI solution technique requires the model equations to be in percentage change form.¹²We shall follow the ORANI notation convention of using lower case letters to denote percentage changes in the corresponding upper case variables. The percentage change in any variable V is therefore given by v where v = 100 dV/V.

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At various stages in the theoretical development we shall introduce real-side variables which have exact counterparts in existing ORANI models. When this occurs, we shall note the variables'origin and follow the ORANI notation exactly.

On the asset side, the use of lower case letters to denote percentage changes puts us slightly at odds with the usual macroeconomic modelling conventions, since by these conventions lower case letters are frequently used to distinguish real from nominal variables, and are almost always used to denote rates of return. By contrast, we must use upper case letters for rate of return levels and lower case letters for their percentage changes. In other respects, however, we lean towards the standard macroeconomic modelling notation. Thus, for example, we use the asterisk (*) to differentiate foreign variables from their domestic counterparts.

The solution technique, pioneered by Johansen (1964), is as follows. Logarithmic differentiation of the system of non-linear structural equations gives a system which is homogeneous and linear in all growth rates. Solution of this linear system then gives the elasticities of each of the endogenous variables with respect to each of the exogenous variables.

Finally, our notation is developed specifically for the particular menu of assets considered. We feel this will facilitate understanding of the underlying economic issues. However, in Appendix A we suggest a general notation for modelling asset preference, one which is necessarily more abstract, but which is also more in keeping with the ORANI real side notation and more easily adapted to computer coding.

3.2 Net Real Asset Returns and Asset Demands

The first step is to specify the menu of assets available to domestic wealth-holders. We shall deal with the case of three nominal assets and two real assets. The nominal assets are domestic and foreign government bonds and domestic money. The two real assets are ownership claims to domestic and foreign real capital. We shall assume that all assets except money are internationally tradeable, since non-tradeability can then be treated as a special case. We shall also assume that all assets, including money, yield some market rate of return, so that a zero interest rate on money can likewise be treated as a special case.¹³

The notation is developed in Table 1:

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¹³ The importance of allowing for interest payments on money will of course depend on the broadness of the definition of money. For example, when money is defined as M_2 , an appropriate interest rate would be that on time deposits.

Table	1	-	Asset	Notation	•

Asset	Supply		Holdings	· .	Market
		Domestic Banks	Domestic Residents	Foreign Residents	Rate of Return
Domestic Bond	B (nominal)	D	B _d	Bf	I _B (nominal)
Foreign Bond	-	-	B * d	-	I [*] (nominal)
Domestic Capital	K (real)	-	Kd	K _f	R _s (real)
Foreign Capital	-		к * d	· · -	R*s (real)
Domestic Money	M (nominal)	:	Md		I _M (nominal)

The blank spaces reflect the assumption that the domestic country is "small" in the markets for foreign assets. However, the foreign country is not assumed to be "small" in the markets for domestic assets. These assumptions parallel those made in ORANI concerning the markets for imports and exports. ¹⁴

3.2.a Net Real Asset Returns

Table 1 gives notation for the market rates of return to each

¹⁴ The small country assumption could be relaxed by specifying aggregate supplies of and foreign demands for the foreign assets and invoking market clearing conditions for these assets.

asset. From these, we shall define net rates of return, where the difference reflects appropriate capital gains and losses. However, we shall first comment further on the market for claims to domestic capital.

We have hypothesized a demand by wealth-holders for ownership claims to the aggregate domestic capital stock K, an entity defined in ORANI. These claims yield a real market dividend which we have called R_s . However, ORANI models also specify industryspecific capital stocks K_j , each with its own rate of return R_j , defined as

$$R_{j} = \frac{P_{2j}}{\Pi_{j}} - d_{j}$$
 $j = 1...h$ (9)

where P_{2j} is the rental rate on capital in industry j, Π_j is the price of new capital goods in industry j and d_j is that industry's rate of (physical) depreciation.

By asserting that wealth-holders demand claims to aggregate, rather than industry-specific, capital, we are assuming that claims to capital in the different industries are seen as perfect substitutes. For this reason, too, the real dividend return on claims to capital R_s will be equalized across industries, even though the rate of return to capital itself, R_j , need not be.

These arguments can be formalized as follows. We define

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the real return on claims to industry j's capital, or the dividend in industry j, R_{sj} , as follows:

$$R_{sj} = \frac{\pi_{j}}{P_{sj}} R_{j} = \frac{P_{2j}}{P_{sj}} - \frac{\pi_{j}d_{j}}{P_{sj}} j = 1,...h$$
(10)

where P_{sj} is the price paid for claims to the existing capital stock, or the share price, in industry j. Note that this price need not equal the replacement cost π_j of new capital in that industry.¹⁵ With perfect substitution, but with a given distribution of real returns R_j across industries, the share prices P_{sj} will adjust to ensure that dividend returns are equalized, while at the same time the claims to each industry's capital stock are willingly held:¹⁶

We can then define the aggregate share price index

$$P_{s} = \prod_{j=1}^{h} P_{sj}^{S} kj$$
(12)

where ${\rm S}_{\rm kj}$ are industry capital shares,with capital valued at its market value ${\rm P}_{\rm sj}.$

- ¹⁵ This definition of R_{sj} follows Tobin's (1969) treatment. We shall argue later that $P_{sj} = \pi_j$, or equivalently $R_{sj} = R_j$, is an appropriate definition of the "long-run". There's is therefore a strict parallel between P_{sj} and P_{2j} . In the short run, the rental price P_{2j} will be that required to satisfy the zero profit condition in production and may contain an economic rent component, while in the long run, when capital is variable, it will reflect the marginal productivity of capital. Similarly, in the short run the price P_{sj} will be whatever is required to ensure that the existing capital stock is willingly held, while in the long run, it will reflect the true production cost of capital equipment.
- Note that in the ORANI percentage change notation, equation (11) is also consistent with constant multiplicative risk differentials between industries. A relationship q.R. = R, where q. is a constant risk premium, also yields the same percentage

(11)

Thus equation (11) allows us to proceed with the derivation of a single net return and a single asset demand function for claims to the aggregate capital stock. In the more general case of less-than-perfect substitution, we could not claim that dividend returns were equalized across industries, but would have to define separate net returns and derive separate demand functions for claims to capital in each industry.

In a well-integrated capital market, the single rate of return R_c is paid by firms to all holders of ownership claims to capital and is therefore the rate relevant to their willingness to hold such claims, as indicated in Table 1. A segmented capital market is generally characterized by the following features. Firstly, the banking system holds a significant portion of corporate liabilities in the form of bank credit. Secondly, the rate of return paid by firms to the banking system is an administered one, and significantly lower than that paid to the private sector through the stock market or curb money market. Table 1 can then be amended to allow for bank, as well as private, ownership of claims to capital, where each type of holder then receives a different real rate of return. Sweder van Wijnbergen (1982) shows the implications this has for asset demand functions and asset market clearing conditions. However, our equations (10) and (11) must also be extended. According to these equations, the total nominal dividend (and interest) payment made by industry j to the holders of its

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capital stock is given by $P_{sj}R_s$. With segmented capital markets, this total amount can be further expressed as the sum of interest payments to banks and the private sector, and where bank interest payments will depend both on the bank lending rate and on the quantity of bank credit a particular industry can obtain. It is through this further subdivision that the model can take account of interest rate controls and credit rationing policies in segmented capital markets.¹⁷

Now return to the market rates of return shown in Table 1. Net asset returns comprise these market returns plus a component reflecting appropriate capital gains and losses. To specify the capital gain component, we must specify appropriate measures of the real value of asset holdings. The reason is that assets, as stores of wealth, are held not for their own sake, but because of their future real purchasing power. Thus the price changes which should enter the definition of net real asset returns are those which affect that future real purchasing power.

We define the real values of domestic residents' asset holding as follows:

Money:	M _d /P _C
Domestic bonds:	^B d ^{∕P} C
Domestic capital:	^K d ^P s ^{/P} C
Foreign bonds:	^B d [∲] / ^P C
Foreign capital:	K * P*∲/P _C

(13)

¹⁷ Work is in progress on a segmented market version of our model for South Korea.

where P_s is the domestic share price index, P_s^* is the foreign share price index, ϕ is the exchange rate (defined as the domestic currency price of foreign currency) and P_c is the domestic consumer price index. The first price is defined above and the last two are given in ORANI. We use the consumer price index as deflator on the grounds that if asset holding behaviour by domestic residents reflects a desire for future real consumption, then the consumer price index best reflects the cost of that goods basket into which most assets would be eventually converted. ¹⁸ From this specification of the real value of asset holdings, the appropriate definitions of net asset returns are as follows:

Money:	$R_{M} = I_{M} - I_{C}$	(14)
Domestic bonds:	$R_B = I_B - I_C$	(15)
Domestic capital:	$R_{K} = R_{s} + \Pi_{s} - \Pi_{C}$	(16)
Foreign bonds:	$R_B^* = I_B^* + \Pi_{\phi} - \Pi_C$	(17)
Foreign capital:	$R_{K}^{*} = R_{S}^{*} + \Pi_{S}^{*} + \Pi_{\phi} - \Pi_{C}$	(18)

where Π_{C} , Π_{s} and Π_{s}^{*} are the expected rates of inflation of P_{C} , P_{s} and P_{s}^{*} and where Π_{ϕ} is the expected rate of exchange depreciation.

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¹⁸ We could alternatively use some capital goods price index, government purchases price index, or some combined index of domestic absorption. However, on a theoretical level we tend to follow Hirshleifer's (1970) argument that even "intermediate" expenditure on investment goods is simply a reflection of wealth-holders demands for future consumption. Furthermore, empirical estimation has usually shown the consumer price index to outperform other indices, at least in money demand functions.

We must also define the net real returns for holdings of domestic assets by foreigners. By similar arguments, the real values of foreign residents' holdings of domestic assets are given by:

Domestic bonds: $B_{f}/\Phi P_{C}^{*}$ Domestic capital: $K_{f}P_{s}/\Phi P_{C}^{*}$ (19)

where P_C^* is the foreign consumer price index. From this, we define the net real returns for foreigners as

Domestic bonds: $R_{Bf} = I_B - \Pi_{\phi} - \Pi_C^*$ (20) Domestic capital: $R_{Kf} = R_s + \Pi_s - \Pi_{\phi} - \Pi_C^*$ (21)

We also define, for use in the foreigner's demand functions for domestic assets, the relevant net real rates of return for alternative assets, namely, foreign bonds and capital:

R [*] Rf	=	I_{B}^{*}	-	Π^{*}_{C}
		D		C

 $R_{Kf}^{*} = R_{s}^{*} + \pi_{s}^{*} - \pi_{C}^{*}$ (23)

We now write the equations of this subsection in the ORANI percentage change notation. Equations (9)-(12) define the relationship between industry returns to capital, real industry dividend returns and share prices. These become, in percentage change form,

 $r_{j} = Q_{j} (p_{2j} - \pi_{j})$ j = 1, ... h (24)

$$\mathbf{r}_{s} = \pi_{j} - \mathbf{p}_{sj} + \mathbf{r}_{j} \qquad j = 1, \dots h$$

$$\varepsilon^{(s)} = \sum_{\substack{j=1 \\ j=1}}^{h} S_{kj} \mathbf{p}_{sj} \qquad (26)$$

where $Q_j = (R_j + d_j)/R_j$ is the ratio of the gross to net rate of return to capital in industry j and $S_{kj} = P_{sj}K_j/\Sigma P_{sj}K_j$ is the share of industry j's market value in the market value of the aggregate capital stock.

Equations (14)-(18) define net real asset returns for domestic residents. In percentage change form, these become

$$\mathbf{r}_{\mathrm{M}} = \mathbf{Q}_{\mathrm{IM}} \mathbf{i}_{\mathrm{M}} - \mathbf{Q}_{\mathrm{CM}} \mathbf{\pi}_{\mathrm{C}}$$
(27)

$$r_{\rm B} = Q_{\rm IB}i_{\rm B} - Q_{\rm CB} \pi_{\rm C}$$
(28)

$$\mathbf{r}_{\mathrm{K}} = \mathcal{Q}_{\mathrm{RK}}\mathbf{r}_{\mathrm{s}} + \mathcal{Q}_{\mathrm{sK}} \pi_{\mathrm{s}} - \mathcal{Q}_{\mathrm{CK}} \pi_{\mathrm{C}}$$
(29)

$$r_{B}^{*} = Q_{IB}^{*} i_{B}^{*} + Q_{\phi B}^{*} \pi_{\phi}^{*} - Q_{CB}^{*} \pi_{C}^{*}$$
(30)

$$\mathbf{r}_{K}^{*} = Q_{R^{*}K^{*}}\mathbf{r}_{s}^{*} + Q_{s^{*}K^{*}}\pi_{s}^{*} + Q_{\phi K^{*}}\pi_{\phi}^{*} - Q_{CK^{*}}\pi_{C}^{*}$$
(31)

where, for example, Q_{IM} is the ratio I_M/R_M , Q_{CM} is the ratio π_C/R_M , and the other Q parameters are defined similarly.

Equations (20)-(23) define net real asset returns for foreign residents. In percentage change form, these become

$$r_{Bf} = Q_{IBf} i_{B} - Q_{\phi Bf} \pi_{\phi} - Q_{C^{*}Bf} \pi_{C}^{*}$$
(32)

$$\mathbf{r}_{\mathrm{Kf}} = \mathcal{Q}_{\mathrm{RKf}} \mathbf{r}_{\mathrm{s}} + \mathcal{Q}_{\mathrm{sKf}} \mathbf{\pi}_{\mathrm{s}} - \mathcal{Q}_{\mathrm{\phi Kf}} \mathbf{\pi}_{\mathrm{\phi}} - \mathcal{Q}_{\mathrm{C}} \mathbf{Kf} \mathbf{\pi}_{\mathrm{C}}^{*}$$
(33)

$$r_{Bf}^{*} = Q_{IBf}^{*} i_{B}^{*} - Q_{C}^{*}_{Bf}^{*} c^{\pi} C$$
(34)

$$r_{Kf}^{*} = Q_{R^{*}Kf^{*}} r_{s}^{*} + Q_{s^{*}Kf^{*}} r_{s}^{*} - Q_{C^{*}Kf^{*}} r_{C}^{*}$$
(35)

where Q_{IBf} is the ratio I_B/R_{Bf} , $Q_{\phi Bf}$ is the ratio Π_{ϕ}/R_{Bf} and the other Q parameters are defined similarly.

3.2.b Asset Demands, Consumption and Savings Functions

We proceed by outlining the domestic resident's portfolio size and portfolio composition problems. As explained in Section 2, a unified treatment of both these choice problems can yield not only stock asset demand functions, but also a flow consumption function. For exposition purposes, we have two choices. We could follow the strategy of Tobin (1969) or Metzler (1951) and simply assert demand functions of a particular form. Alternatively,we could follow the strategy of Hirshleifer (1970) or Niehans (1978) and note that issues of saving and asset accumulation can be sensibly treated only in a full intertemporal choice-theoretic framework. This raises a problem, however. The ORANI modelling structure is comparative-static in growth rates - it is neither multiperiod nor fully dynamic. For this reason, we shall try to steer a middle course. We shall attempt to provide at least some justification for the demand functions we produce, while avoiding an explicit intertemporal treatment.

In the same way that ORANI assumes a representative consumer, we assume a representative asset- or wealth-holder.¹⁹ Individuals are assumed to choose their total real consumption expenditure C_R (defined in ORANI) and the real value of their asset holdings to maximize a utility function defined over these quantities, that is

$$U = U \int_{C_{R}}^{C_{R}} \frac{M_{d}}{P_{C}}, \frac{B_{d}}{P_{C}}, \frac{K_{d}P_{s}}{P_{C}}, \frac{B_{d}^{*}\phi}{P_{C}}, \frac{K_{d}^{*}P_{s}^{*}\phi}{P_{C}}$$
(36)

We use this utility function as a proxy for a full intertemporal treatment. It is often questioned whether simply having assets to hold can yield utility directly. Nevertheless, U can be justified on the grounds that it represents an indirect utility function, one derived from an intertemporal optimization problem which recognizes explicitly that assets are desired only for their future purchasing power and for the way they facilitate conversion of a given income stream into an optimal consumption stream.²⁰

The maximization of U is subject to an income constraint, one which states that disposable income $Y_{\rm p}$ equals consumption plus

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¹⁹ Thus, for example, we do not allow different marginal savings propensities as between workers and capitalists, cf. Taylor et al. (1980). We feel that, certainly in countries with welldeveloped union pension funds, such distinctions are irrelevant.

²⁰ Niehans (1978, Ch. 4) has made this process explicit, firstly by considering money's unique role as a medium of exchange, as well as its shared role as a store of value, and secondly, by developing precise relationships between the marginal stock and marginal flow utility of assets.

asset accumulation or saving:

$$Y_{R} = C_{R} + \Delta W_{R}$$
 (37)

where real wealth W_{R} is defined as the sum of real asset holdings

$$W_{R} = / M_{d} + B_{d} + K_{d}P_{s} + B_{d}^{*}\Phi + K_{d}^{*}P_{s}^{*}\Phi / / P_{C}$$
(38)

and where real disposable income Y_R is defined as total real income from both human and financial sources, less real direct taxation. We can write its separate components as follows:

$$Y = P_{L}L + P_{N}N + I_{M}M_{d} + I_{B}B_{d} + R_{s}K_{d}P_{s} + I_{B}^{*}B_{d}^{*} + R_{s}^{*}K_{d}^{*}P_{s}^{*}\phi$$
(39)
$$T = T_{P} (P_{L}L + P_{N}N) + T_{C}(I_{M}M_{d} + I_{B}B_{d} + R_{s}K_{d}P_{s} + I_{B}^{*}B_{d}^{*}\phi$$
$$+ R_{s}^{*}K_{d}^{*}P_{s}^{*}\phi)$$
(40)

so that $Y_R = (Y-T)/P_C$

Appearing in equation (39) are aggregate labour income P_L^L and aggregate income from land ownership P_N^N , nominal magnitudes which can be defined from ORANI as follows:

(41).

$$P_{L}^{r} = \sum_{q=1}^{r} \sum_{j=1}^{n} P_{1,q}, \cdot X_{1,q,j}^{P}$$

$$(42)$$

where $x_{1,q,j}^{P}$ represents the employment by industry j of labour in occupation q and $P_{1,q,\cdot}$ is the wage paid to labour in occupation q, and

$$P_{N}N = \sum_{j=1}^{h} P_{3j} X_{3j}^{P}$$
(43)

where X_{3j}^P is land use by industry j and P_{3j} is the rent paid on land in industry j.

Appearing in equation (40) is our treatment of direct taxation. Income from labour and land rental is assumed to be taxed at the same constant proportionate rate T_p , corresponding to an average tax rate on personal income, while interest and dividend income is taxed at an average rate T_c , corresponding to some corporate or capital tax rate. ²¹

We shall now pause to consider how our definition of disposable income relates to the normal accounting definition of personal disposable income. Consider the dividend return on domestic capital. Since $R_s = (\pi_j/P_{sj}) R_j$ is the real dividend return, equalized across industries, and since $R_j = (P_{2j}/\pi_j) - d_j$ is the real rate of return to capital, we can for the moment suppress the industry subscripts and write the aggregate nominal dividend return as

 $R_{s}K_{d}P_{s} = \frac{\pi}{P_{s}} \left\{ \frac{P_{2}}{\pi} - d \right\} K_{d}P_{s} = P_{2}K_{d} - d\pi K_{d}$

 $(44)^{\prime}$

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²¹ We abstract from double-taxation agreements, since the domestic tax rate T_C is applied to income from foreign sources. It would, however, be a simple matter to define separate tax rates for each component of income, some of which could then be set to zero (and where I_B^* and R_s^* would then be market rates net of foreign taxes). Tax progressivity could be introduced either by using a power function formulation for equation (40), or by making T_p and T_C functions of total income. Tax indexation could be introduced by applying a progressive tax rate to some measure of real rather than nominal income.

Thus the dividend return equals the value of factor payments (at a rental rate P_2) to that portion of the capital stock that is domestically owned, less depreciation allowances (valued at replacement cost π).²² This term, together with the labour, land and foreign dividend components of income, gives a conventional measure of net national product (NNP), as measured by adding up factor payments. The addition of bond interest payments to NNP and the subtraction of direct taxation gives a conventional measure of personal disposable income. Thus our measure of disposable income corresponds to the standard accounting concept. As was argued in Section 2, this is important for ensuring consistency between the real and financial sides of the economy.²³

We return to the domestic resident's optimization problem. Maximization of the utility function of equation (36), subject to the budget constraint given by equations (37)-(41), gives a flow consumption function and stock asset demand functions of the following form:

As a further check on consistency, we can use the equivalence between the income and expenditure sides of GNP, $P_LL + P_NN + R_SKP_S + dIK + IT = C + I + G + (X-M+PT)$, where IT is indirect taxes less subsidies, to generate a relationship equivalent to equation (7). This would be, in nominal terms and assuming $I_M = O$, $(\Delta W + dIK - I) + (T + IT - G - I_B(B-D)) =$ (X - M + PT) where ΔW is the sum of household and corporate saving from equation (37) and where PT is defined later, in equation (90).

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²² In reality, not all of the rental on capital, net of depreciation allowances, need be distributed as dividends or as interest on some corporate liability, but some may appear as retained earnings. In this situation, the model of saving which emerges is a model of saving by both households and firms. The balance sheet counterpart of corporate saving would be a change in firm liabilities, or a loan by the firm itself. See van Wijnbergen (1982) on this point.

 $C_{R} = F^{1}(R_{M}, R_{B}, R_{K}, R_{B}^{*}, R_{K}^{*}, Y_{R})$ (45)

$$M_{d}/P_{C} = F^{2}(R_{M}, R_{B}, R_{K}, R_{B}^{*}, R_{K}^{*}, Y_{R})$$
 (46)

$$B_{d}/P_{C} = F^{3}(R_{M}, R_{B}, R_{K}, R_{B}^{*}, R_{K}^{*}, Y_{R})$$
 (47)

$$K_{d}P_{s}/P_{c} = F^{4}(R_{M}, R_{B}, R_{K}, R_{B}^{*}, R_{K}^{*}, Y_{R})$$
 (43)

$$K_{d}^{*}P_{s}^{*}\Phi/P_{c} = F^{5}(R_{M}, R_{B}, R_{K}, R_{B}^{*}, R_{K}^{*}, Y_{R})$$
 (49)

Note that these demand functions, unlike those derived from models which treat only the portfolio composition problem, do not include asset stocks or some measure of wealth as a separate argument $\langle cf. Tobin (1969) / 7$. When the decision on portfolio size is also taken into account, wealth is no longer given, but an endogenous object of choice. However, the demand functions do depend on net real asset returns and real disposable income in the usual way.²⁴

We must also specify demand functions to describe foreign residents' demands for domestic bonds and capital. In the absence of a full treatment of the foreign country, we do not need to spell out the foreign residents' optimization problem. We can instead argue by analogy with the domestic residents' demand functions and simply assert the following:

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²⁴ See Niehans (1978, Ch. 5,10) on these points. He notes, however, that wealth effects do play a role in disequilibrium situations, when there is lagged adjustment to stock and flow equilibrium.

$$\frac{B_{f}}{\Phi P_{C}^{*}} = G^{1}(R_{Bf}, R_{Kf}, R_{Bf}^{*}, R_{Kf}^{*}, H_{Bf})$$
(50)

$$\frac{K_{f}P_{s}}{\Phi P_{C}^{*}} = G^{2}(R_{Bf}, R_{Kf}, R_{Bf}^{*}, R_{Kf}^{*}, H_{Kf})$$
(51)

where $H_{\rm Bf}$ and $H_{\rm Kf}$ are shift parameters designed to capture all other foreign influences on foreigners' demands for domestic assets.

We now write the equations of this subsection in the ORANI percentage change notation. Although we have not assumed any particular functional form for the utility function or demand functions of this subsection, 25 the asset demands in equations (46)-(51) take on a particularly simple form:

$$m_{d} = \varepsilon^{(3)} + \Sigma n_{Ma} r_{a} + n_{MY} Y_{R}$$
(52)

where the subscript a takes the values M, B, K, B*, K*

$$b_{d} = \varepsilon^{(3)} + \Sigma \eta_{Ba} r_{a} + \eta_{BY} Y_{R}$$
(53)

$$k_{d} = \varepsilon^{(3)} - \varepsilon^{(s)} + \sum_{a} \eta_{Ka} r_{a} + \eta_{KY} \gamma_{R}$$
(54)

$$b_{d}^{*} = \varepsilon^{(3)} - \phi + \Sigma \eta_{B}^{*} a^{r} a^{+} \eta_{B}^{*} Y^{Y} R$$
(55)

$$k_{d}^{*} = \varepsilon^{(3)} - \varepsilon^{(s^{*})} - \phi + \sum_{a} \eta_{K^{*}a} r_{a} + \eta_{K^{*}Y} Y_{R}$$
(56)

$$b_{f} = \varepsilon^{(3^{*})} + \phi + \sum_{b} n_{Bfb} r_{b} + h_{Bf}$$
(57)

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²⁵ In particular, we have not prejudged the degree of substitutability between assets.

where the subscript b takes the values B_{f} , K_{f} , B_{f}^{*} and K_{f}^{*}

$$k_{f} = \varepsilon^{(3^{*})} - \varepsilon^{(s)} + \phi + \Sigma \eta_{Kfb} r_{b} + h_{Kf}$$
(58)

where $\varepsilon^{(3)}$ is the ORANI notation for the percentage change in the consumer price index, $\varepsilon^{(3^*)}$ and $\varepsilon^{(s^*)}$ are the percentage changes in the foreign consumer price and share price indices, and the η .. are elasticity parameters.

We similarly write the aggregate consumption function in percentage change form as

$$c_{\rm R} = \sum_{a}^{\Sigma n} Ca^{r} a^{+ n} CY^{Y} R$$
⁽⁵⁹⁾

Real disposable income is defined in equations (39)-(43). In , percentage change form, the labour and land components of income become

$$p_{\ell} = \sum_{j=1}^{r} \sum_{j=1}^{h} S_{\ell q j} (p_{1,q,j} + x_{1,q,j}^{P})$$
(60)

where S_{lqj} is the share of the total wage bill accounted for by employment of occupation q in industry j, and

$$p_{n} = \sum_{j=1}^{h} S_{nj} (p_{3j} + x_{3j}^{P})$$
(61)

where S_{nj} is the cost share of industry j's land in the total factor payments to land. We then write nominal personal income as $y = S_{LY}pl + S_{NY}pn + S_{MY}(i_M + m_d) + S_{BY}(i_B + b_d) + S_{KY}(r_s + \epsilon^{(s)} + k_d)$ $+ S_{B*Y}(i_B^* + \phi + b_d^*) + S_{K*Y}(r_s^* + \epsilon^{(s*)} + \phi + k_d^*)$ (62)

where S_{.Y} are nominal shares of the appropriate income components in total nominal personal income. We write total nominal direct taxes as

$$t = S_{PT} t_{P} + S_{CT} t_{C} + S_{LT} p\ell + S_{NT} pn + S_{MT} (i_{M} + m_{d})^{\dagger}$$
$$+ S_{BT} (i_{B} + b_{d}) + S_{KT} (r_{s} + \epsilon^{(s)} + k_{d}) + S_{B} *_{T} (i_{B}^{*} + \phi + b_{d}^{*}).$$

$$+ S_{K^*T}(r_s^* + \varepsilon^{(s^*)} + \phi + k_d^*)$$
(63)

where S_{PT} and S_{CT} are the shares of personal and corporate/capital taxes in the total tax take, and the remaining $S_{.T}$ parameters are the shares of the individual components of personal and corporate taxation in the total tax take. We then write real personal disposable income as follows:

$$y_{R} = Q_{TR}y - Q_{TR}t - \varepsilon^{(3)}$$
(64)

where Q_{YR} and Q_{TR} are the ratios Y/(Y-T) and T/(Y-T).

Finally, from equation (37), we can define total real saving as

$$\mathbf{s}_{\mathbf{R}} = \mathbf{Q}_{\mathbf{V}\mathbf{S}}\mathbf{Y}_{\mathbf{R}} - \mathbf{Q}_{\mathbf{C}\mathbf{S}}\mathbf{c}_{\mathbf{R}} \tag{65}$$

where $Q_{\rm YS}$ is the inverse of the ratio of nominal saving to nominal disposable income and $Q_{\rm CS}$ is the nominal consumption/savings ratio.

3.3 Market Clearing for Domestic Assets

The market clearing condition for claims to the ownership of domestic capital is straightforward. From Table 1 in Section 3.2, the condition is
$$K = K_d + K_f$$

or in percentage change form

$$k = S_{KI} k_{d} + S_{Kf} k_{f}$$
(67)

(66)

where the total capital stock k is defined in ORANI and S $_{\rm Kd}$ and S $_{\rm vf}$ are the domestic and foreign ownership shares.

The market clearing conditions for domestic money and domestic bonds are less straightforward. Here we must be a little more careful in the way we specify the stock supplies, since these must not only be equated to stock demands in this section, but also related, through the balance of payments accounts and government budget deficit, to flows of goods and services in subsequent sections. We shall illustrate the problem with reference to the money supply, although the problem with bond supplies is similar.

Suppose bonds and claims to capital are not internationally tradeable, so that there are no international capital flows. We can then identify the balance of payments with the balance of trade. The monetary equilibrium condition can be written straightforwardly enough as

$$q(R + D) = M_{d}$$
(68)

where the monetary base has a foreign exchange component R and a domestic component D and the money supply is some constant

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multiple q of the monetary base. However, in our simple economy we also have the relationship

$$\Delta R = B \tag{69}$$

where B is the flow trade balance. The problem arises when we are required to write equation (69), a stock/flow relationship, in a uniform percentage change form, as required by the ORANI solution technique. We could follow Vincent (1983), who implicitly assumes that the balance of trade is initially zero, so that $B = \Delta B$ and equation (69) becomes $\Delta R = \Delta B$. However, we prefer to follow an approach suggested by Taylor et al. (1980).

The ORANI solution technique solves for the percentage changes in the endogenous variables between some base year and some solution year. Over this solution horizon, the relationship between the stock variable R and the flow variable B can be visualized using Figure 1. We consider the example of a two year solution horizon. However, the approach can also be applied with solution horizonsof shorter or longer duration.

Figure 1 - Stock/Flow Relationships

Flow:	<u> </u>	$-B_{10} \rightarrow \leftarrow$	$B_{21} \longrightarrow \leftarrow B_{3}$	$_2 \longrightarrow$	
	t=0	t=1 (Base year)	t=2 , (soluti	t=3 on year)	_ time
Stock	R _O	R ₁	R ₂	R ₃	

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The diagram shows the flow variable B defined over time intervals and the stock variable R defined at points in time. All subscripts are time subscripts.

Now a stock/flow relationship of the form given in equation (69) tells us

- $B_{10} = R_1 R_0$
- $B_{21} = R_2 R_1$ $B_{32} = R_3 - R_2$ (70)

The change in the flow variable is then given by

$$\Delta B_{31} = B_{32} - B_{10} = (R_3 - R_2) - (R_1 - R_0)$$
(71)

. . .

The change in the stock variable is, by definition,

 $\Delta R_{31} = R_3 - R_1 \tag{72}$

However, this can also be written as

$$\Delta R_{31} = R_2 - R_0 + \langle (R_3 - R_2) - (R_1 - R_0) \rangle$$
(73)

If we then define the new variables

 $\hat{R}_{32} = R_3 - R_2$ $\hat{R}_{21} = R_2 - R_1$ $\hat{R}_{10} = R_1 - R_0$ (74)

i

.

we can alternatively specify the change in the stock variable as

$$\Delta R_{31} = \Delta R_{20} + \Delta \hat{R}_{31} \tag{75}$$

This corresponds to Taylor's distinction between changes in the stock of money and changes in the rate of new emissions of money. By making a similar definition for ΔD_{31} we can write the monetary equilibrium condition of equation (63) as

$$q \sum_{\alpha R_{20}}^{\Delta R_{20}} + \Delta D_{20}^{\alpha} + \Delta \hat{R}_{31}^{\alpha} + \Delta \hat{D}_{31}^{\alpha} = \Delta M_{d31}^{\alpha}$$
(76)

and the stock/flow relationship of equation (69) as

$$\Delta B_{31} = \Delta \hat{R}_{31} \tag{77}$$

These equations now involve only changes in variables, so can easily be converted to a uniform percentage change form.

This simple case demonstrates that because the money supply is linked to the balance of payments, it should be specified in a way comparable to that in equation (76) rather than equation (68). A similar argument applies to the bond supply, since this will be related, not only to stock bond demand, but also to the government budget constraint. With this in mind, we proceed with market clearing conditions for money and domestic bonds. In the full model, the monetary base is again divided into a domestic component D and a foreign component. We further divide the foreign component into foreign exchange reserves R and liabilities to other foreign official agencies, or external debt, F. Following our notation in equation (76), we then write the monetary equilibrium condition as

$$q \sqrt{\Delta R_{20}} - \Delta F_{20} + \Delta D_{20} + \Delta \hat{R}_{31} - \Delta \hat{F}_{31} + \Delta \hat{D}_{31} - 7 = \Delta M_d$$
 (78)

where external debt has been subtracted since it represents a liability; rather than an asset, of the domestic banking system. Since q is assumed constant, this equation can be written in percentage change form, as

$$s_{RM}^{m}m_{R} - s_{FM}^{m}m_{F} + s_{DM}^{m}m_{D} + s_{RM}^{m}m_{R}^{2} - s_{FM}^{m}m_{F}^{2} + s_{DM}^{m}m_{D}^{2} = m_{d}$$
(79)

where s_{RM} , s_{FM} and s_{DM} are the ratios of the beginning-of-baseyear values for R, F and D to the end-of-base-year monetary base, and $s_{\widehat{R}M}$, $s_{\widehat{F}M}$ and $s_{\widehat{D}M}$ are the ratios of base year changes in R, F and D to the end-of-base-year monetary base.²⁶

Again, following the notation of equation (76), the market clearing condition for domestic bonds can be written as

$$\Delta B_{20} + \Delta \hat{B}_{31} = \Delta B_d + \Delta B_f + \Delta D_{20} + \Delta \hat{D}_{31}$$
(30)

²⁶ With q assumed constant, the percentage changes in the various components of the monetary base $m_{\rm R}$, $m_{\rm F}$, etc., are also equal to the percentage changes in the associated components of some broader money supply aggregate. Either interpretation is possible, even when such variables appear in subsequent identity equations.

where we have consolidated the government with the central bank and assumed that the domestic credit D is backed entirely by government debt instruments²⁷. This equation becomes, in percentage change form,

$$s_{B}b + s_{B}b = S_{dB}b_{d} + S_{fB}b_{f} + S_{DB}m_{D} + S_{DB}m_{D}$$
 (81)

where $s_B^{}$ and $s_B^{}$ are the ratios of the beginning-of-base-year stock, and base year change, respectively, of government bonds to the end-of-base-year stock. The parameters $S_{dB}^{}$ and $S_{fB}^{}$ are the ratios of end-of-base-year domestic and foreign private sector holdings of government bonds to the total end-of-base-year stock. The parameters $S_{DB}^{}$ and $S_{DB}^{}$ are the ratios of the beginning-ofbase-year stock, and base year change, respectively, of central bank holdings of government bonds to the total end-of-base-year stock.

3.4 Balance of Payments

As noted in Section 2, balance of payments surpluses or deficits are directly reflected in changes to the foreign exchange reserve or external debt position of the central bank. Accordingly, we can define the balance of payments BP as follows:

²⁷ In some countries, the principle instrument of monetary policy is not open market operations but changes in required reserve ratios. In this case, the bond market can be omitted entirely but the money market clearing condition must be altered slightly. Equation (78) would then become $\Delta R - \Delta F + \Delta D_{\rm G} + \Delta D_{\rm p} + \Delta R$ $-\Delta \hat{F} + \Delta \hat{D}_{\rm G} + \Delta \hat{D}_{\rm P} = \Delta M_{\rm d}$ where, in level form, R-F^G is the net foreign asset position of the consolidated banking system, and $D_{\rm G}$ and $D_{\rm P}$ represent domestic credit of the banking system to the government and the private sector, respectively. Government budget deficits are then linked directly to $D_{\rm G}$, but $D_{\rm P}$ remains a policy variable.

$$BP = \hat{R} - \hat{F}$$
(82)

Following the ORANI procedure, we do not write this in percentage change form, since BP can change sign. Instead we write the absolute change in the balance of payments, $100 \Delta BP$, as follows

$$100\Delta BP = \hat{R} \, \tilde{m}_{\hat{R}} - \hat{F} \, \tilde{m}_{\hat{F}} \tag{83}$$

where \hat{R} and \hat{F} are the base year changes in reserves and external debt.

We can also define the component balances of the balance of payments, namely, the trade, current and capital accounts. The trade account can be defined directly from the ORANI structure. Total nominal imports M* and exports E* are given by:²⁸

$$M^{*} = \sum_{i=1}^{g} P_{i2}^{m} \Phi X_{i2} + \sum_{\ell=1}^{n} P_{\ell}^{Nm} \Phi X_{\ell}^{N}$$
(84)

$$E^{*} = \sum_{i=1}^{g} P_{i1}^{e} \Phi X_{i}^{(4)}$$
(85)

where X_{i2} , X_{ℓ}^{N} and $X_{i}^{(4)}$ are quantities of competing imports, noncompeting imports and exports and where P_{i2}^{m} , P_{ℓ}^{Nm} and P_{i1}^{e} are their respective foreign currency prices. The trade balance is then given by

$$BT = E^* - M^*$$
 (36)

In ORANI notation, these equations defining the trade balance become

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²⁸ For balance of payment purposes, we value exports and imports exclusive of tariffs and subsidies, since these represent transactions with domestic residents and do not give rise to reserve flows. For the purposes of defining GDP, however, we will want to include tariffs and subsidies.

$$m^{*} = \sum_{i=1}^{g} (p_{i2}^{m} + \phi + x_{i2}) M_{i2}^{*} + \sum_{\ell=1}^{n} (p_{\ell}^{Nm} + \phi + x_{\ell}^{N}) M_{\ell}^{N*}$$
(37)

$$e^{*} = \sum_{i=1}^{g} (p_{i1}^{e} + \phi + x_{i}^{(4)}) E^{*}_{i}$$

$$100 \Delta BT = E^{*} e^{*} - M^{*} m^{*}$$
(88)
(88)

where M_{i2}^* and M_{ℓ}^{N*} are import shares in the total import bill, exclusive of tariffs, and E_i^* are export shares, exclusive of subsidies.

(89)

In order to define the current account, we must first identify private transfer receipts. These are given by

$$PT = I_B^* B_d^* \phi + R_s^* K_d^* P_s^* \phi - I_B B_f - R_s K_f P_s$$
(90)

The absolute change in private transfer receipts is then given by

$$100 \Delta PT = PT_{B*}(i_{B}^{*} + \phi + b_{d}^{*}) + PT_{K*}(r_{S}^{*} + \varepsilon^{(S^{*})} + \phi + k_{d}^{*})$$

 $- PT_{Bf}(i_B + b_f) - PT_{Kf}(r_s + \epsilon^{(s)} + k_f)$ (91)

where PT_{B^*} is the total interest received by domestic residents on their foreign bond ownership, $I_B^{*B}_d^* \Phi$, and the parameters PT_{K^*} , PT_{Bf} and $\ensuremath{\mathtt{PT}}_{\ensuremath{\mathtt{Kf}}}$ are defined similarly for the other components of PT. The current account CA is then defined, in ORANI notation, as

$$100\Delta CA = 100\Delta BT + 100\Delta PT$$
(92)

The capital account CAP can be defined either directly or indirectly. The direct definition would be

 $CAP = \Delta B_{f} + \Delta (K_{f}P_{s}) - \Delta (K_{d}^{*}P_{s}^{*} \Phi) - \Delta (B_{d}^{*}\Phi) + I_{R}^{R} - I_{F}^{F}$ (93) The first term reflects government borrowing abroad. Note that because we have assumed perfect international capital mobility, though not necessarily perfect substitutability, the division of total government private sector borrowing into domestic (ΔB_{d}) and foreign (ΔB_{f}) components is entirely demand-determined. The next three terms of the capital account measure net private capital inflows. The last two terms measure net official transfer receipts, where the interest rates I_{R} and I_{F} on reserve assets and external debt may or may not be the same as the rate I_{B}^{*} on foreign government bonds. It is difficult to convert this direct definition into ORANI notation, however, since it is a stock/flow relationship of the form discussed previously. Nevertheless, we can define

the capital account indirectly as follows:

 $100\triangle CAP = 100\triangle BP - 100\triangle CA$

Because the portfolio composition and asset accumulation behaviour which affect $\triangle BP$ and $\triangle CA$ have been specified elsewhere in an internally consistent fashion, this residual definition of the capital account will indeed correspond to the direct definition.

(94);

3.5 Government Budget Deficit

Government expenses comprise government expenditure on goods

and services, plus debt service payments on government bonds. Government revenues comprise direct taxes plus net trade revenue.²⁹ These components of the government budget deficit will now be defined.

Nominal government expenditure on goods and services can be defined from ORANI as follows:

$$G = \sum_{i=1}^{g} \sum_{s=1}^{2} P_{is} X_{is}^{(5)}$$
(95)

This is written in percentage change form as follows

$$g = \sum_{i=1}^{g} \sum_{s=1}^{2} S_{is}^{(5)} (p_{is} + x_{is}^{(5)})$$
(96)

where $S_{is}^{(5)}$ is the nominal share of good i from source s in total government expenditure on goods and services.

Debt service payments are given by

 $DSP = I_{B} B$ (97)

Remembering that we have divided the total bond supply B into two components, we can then write debt service payments in percentage change form as

$$dsp = i_{B} + s_{B}b + s_{B}\hat{b}$$
(98)

where s_{B} and $S_{\hat{B}}$ were defined previously in equation (81).

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²⁹ Where indirect taxes other than trade revenue form a significant portion of government revenue, they can be calculated from the ORANI variable "other costs". Government investment spending could also be included on the expenditure side.

Total direct taxes are given in equation (63) by the expression for t. Trade revenue can be calculated from the difference between the trade deficit valued at domestic prices and the deficit valued at the domestic currency value of foreign prices. Imports and exports at the domestic currency value of foreign prices are given in equations (37) and (38) by the expressions for m^{*} and e^{*}. We can define percentage changes in imports and exports at domestic prices from ORANI as follows:

$$m = \sum_{i=1}^{q} (p_{i2} + x_{i2}) M_{i2} + \sum_{\ell=1}^{n} (p_{\ell}^{N} + x_{\ell}^{N}) M_{\ell}^{N}$$
(99)
$$e = \sum_{i=1}^{q} (p_{i1} + x_{i}^{(4)}) E_{i}$$
(100)

where M_{i2} , M_{ℓ}^{N} and E_{i} are import and export shares at domestic prices. We can then define percentage changes in tariff revenue tr and export subsidies es as

$$tr = Q_{MTR} m - Q_{M*TR} m^*$$
(101)

$$es = Q_{EES} e - Q_{E*ES} e^*$$
(102)

where $Q_{\rm MTR}$ and $Q_{\rm M*TR}$ are the ratios of M and M* to total tariff revenue, and $Q_{\rm EES}$ and $Q_{\rm E*ES}$ are the ratios of E and E* to total export subsidies. The percentage change in net trade revenue ntr is then given by

$$ntr = Q_{TTR} tr - Q_{ETR} es$$
(103)

where Q_{TTR} and Q_{ETR} are the ratios of total tariff revenue and total export subsidies to net trade revenue.

We have now defined the individual components of the government budget deficit. The percentage change in the deficit itself is given by

$$gbd = Q_{GGD} g + Q_{PGD} dsp - Q_{TGD} t - Q_{NGD} ntr$$
 (104)
where Q_{GGD} , Q_{PGD} , Q_{TGD} and Q_{NGD} are the ratios of the individual

deficit components to the total government budget deficit.

Finally, we specify that the government budget deficit must be financed by new bond issues:

$$gbd = b$$
 (105)

As noted previously, the division into borrowing from the domestic and foreign private sectors is demand-determined.

3.6 Investment

By considering an individual wealth-holder's portfolio size and portfolio composition problem in Section 3.2, we were able to derive both a series of asset demand functions and an aggregate consumption function. Both depended on disposable income and relative asset returns, thus giving a crucial link between our macro/ financial sector and the ORANI model of the real side of the economy. An aggregate investment function which likewise depends on asset returns can provide an additional link between the real and financial sides. The ORANI structure does not explain aggregate investment, but does give an ad hoc explanation of how a given level of aggregate investment will be "allocated" across industries according to the industry-specific rates of return to capital R_j . Within ORANI itself, these rates are merely implicit rates of return and are not reflected in any market interest rate. For this reason, the ORANI investment equations cannot be interpreted as a theory of aggregate investment. However, we have now developed a model of the financial side of the economy sufficiently to show how the real rates of return R_j are reflected in market dividend returns R_{sj} and market share prices P_{sj} . We now propose to replace the ORANI investment equations which explain industry investment with reference to these market prices and returns. And because they are market, rather than implicit, price variables, the resulting theory will also explain aggregate investment.

In what follows, we adopt the ORANI assumption that investment behaviour is dominated by business fixed capital formation, so that we abstract from expenditure on consumer housing and inventories. We have also made a clear distinction between decisions on capital formation and considerations of the financing of such investment. The firm or industry makes the investment decision and consumers, as ultimate wealth-holders, provide the financing. In earlier sections we discussed consumers' willingness to hold additional claims to domestic capital and thus provide investment financing. Here we consider the determinants of the firms' decision on fixed capital formation.

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We take the approach suggested by Tobin (1969) and implicit in Friedman (1976). They argue that decisions on capital formation are governed by relative cost considerations. For a business firm, the relevant margin of choice is that between the purchase of new capital equipment, i.e. investment proper, or the purchase of existing capital from other firms in the industry. The former will be undertaken when it is cheap, relative to the latter. For a firm in industry j, the price of new capital equipment is π_j and the price of existing capital elsewhere in the industry is P_{sj} . Net real capital formation will then be an increasing function of the relative price P_{sj}/π_j .

Thus we can write gross real capital formation Y_j in industry j as a function of this relative price and the rate of physical depreciation in that industry:

$$Y_{j} = A_{j} \left(\frac{P_{sj}}{\Pi_{j}}\right)^{\alpha_{j}} + d_{j}K_{j} \qquad j = 1, \dots h \qquad (106)$$

where we allow that the parameters A and α may differ between industries. One implication is that, other things being equal, investment will be higher when share prices are high than when they are low <u>/</u> See Metzler (1951)_7. Note also that, from equations (10) and (11), the relative price term P_{sj}/π_j is equal to the ratio of the rates of return R_j/R_s . Thus our theory indirectly relates investment negatively to the cost of financing R_s and positively to the real rate of return on capital R_j . Aggregate nominal gross investment expenditure I is then given by the sum of industry nominal expenditures:

$$I = \sum_{j=1}^{h} \Pi_{j} Y_{j}$$
(107)

In ORANI percentage change form, these equations become

$$Y_{j} = \alpha_{j}G_{j}(p_{sj} - \pi_{j}) + (1 - G_{j})k_{j} \qquad j = 1,...h$$
(108)
$$i = \sum_{j=1}^{h} (\pi_{j} + Y_{j})T_{j} \qquad (109)$$

where $G_j = (Y_j - d_j K_j)/Y_j$ is the ratio of net to gross investment in industry j and $T_j = \pi_j Y_j/\Sigma \pi_j Y_j$ is industry j's share in aggregate gross investment.

3.7 Equations Defining the Long Run

We leave full discussion of the model closure until the next section. Here, we simply note that in short run experiments the industry, and therefore the aggregate, capital stocks are fixed. In terms of the ORANI solution technique, these variables are designated as exogenous. In the long run, however, capital is variable, so that the industry capital stocks K_j , j = 1, ...h, become endogenous. Other things being equal, we then need an additional h equation to close the model.

We assert that the following set of equations appropriately define the long run:

$$P_{sj} = \Pi_{j}$$
 $j = 1, ... h$ (110)

or in ORANI percentage change notation

$$p_{sj} = \pi_{j}$$
 $j = 1,...h$ (111)

Thus in the long run, capital must be valued at its replacement $\cos t.^{30}$

The imposition of this condition has several implications. Firstly, via equations (10) and (11), it implies $R_j = R_{sj} = R_s$, j = 1, ...h. In the short run, the rate of return on corporate shares R_{sj} can deviate from the underlying real rate of return to capital R_j . In the long run, these rates are brought into line. Furthermore, in situations where claims to capital in the different industries are seen as perfect substitutes, the long run adjustment of industry capital stocks must also occur in such a way as to equate real rates of return to capital across industries $\sqrt{-}$ this from the equality $R_j = R_s$, $j = 1, ...h_7$. In the short run, the rates of return on pieces of paper are equated across industries. In the long run, the underlying real physical rates of return are also equated.

Secondly, in the long run, via equation (106), gross industry investment is given by $Y_j = A_j + d_j K_j$. Thus the "long run" is not so long that gross real investment covers only physical depreciation / cf. Friedman (1976, Ch. 17) 7. However, in answer to the question "How long is the long run?", we can say that it is that length of time required for investment at a rate dictated by equa-

³⁰ Again, this treatment follows Tobin (1969).

tion (106) to lead to the capital stocks consistent with our long run condition of equation (110). Presumably, the actual length of time will be shorter, the higher is the value of α_j , that is, the more responsive is the business decision-making process, subject to accommodating adjustments in the rate of output of new capital goods, to differentials between the market value of capital and its replacement cost.³¹

4. The Complete Sector Model and Closure within ORANI

Our model of the macro/financial sector is given in Appendix C. Table C1 reproduces the structural equations of previous sections. All model variables are listed and defined in Table C2. In Table C3 we list and define the model parameters and indicate the kinds of data sources from which parameter estimates for a particular country can be made.

We cannot discuss closure of our macro/financial sector model in total isolation, since these sectoral equations are to be combined with an ORANI-type model of the real side of the economy. Indeed, some of the variables in Table C2 are defined and used in ORANI real models, and some of the equations in Table C1 reproduce or replace equations in ORANI. We therefore propose to net out the overlapping equations and unknowns and discuss closure of that submodel which remains. For this purpose we need to choose a

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³¹ Note that by leaving open the actual number of periods involved, we are not required to impose a stock/flow consistency condition of the form $I = \Delta K$.

specific version of ORANI, since although there are many features of these models common to all applications, the applications do differ in some respects.We therefore discuss closure of the macro side with reference to the version of ORANI given in Vincent (1983).

Tables C1 and C2 show that for short run experiments, our full macro/financial sector model comprises 3h + 44 equations in 10g + 8h + 3n + r + rh + 67 unknowns. However, Table C2 also indicates which of these unknowns are defined and used in all ORANI models of the real side. It also indicates those additional variables which are defined and used in Vincent's (1983) particular application.³² There are a total of 10g + 7h + 3n + r + rh + 10overlapping variables. Thus our macro/financial sector model introduces a total of h + 57 variables which are not defined and used elsewhere in ORANI.

We now consider overlapping equations. In Table C1, our equation (1), defining the real rates of return to domestic capital, reproduces the ORANI definition \angle Vincent's equation (23)_7. Our equation (20), the aggregate consumption function, replaces that ORANI equation which fixes a relationship between real consumption and investment \angle Vincent's equation (32)_7. Our equations (28) and (30), giving domestic monetary equilibrium and defining the balance of payments, replace Vincent's monetary sector \angle his equations (18) and (18a)_7. Our equation (33), defining the balance

 $^{^{32}}$ Our variables m_{D} and m_{R} correspond roughly to Vincent's m_{n}^{d} and m_{n}^{f} .

of trade, replaces the ORANI definition \angle Vincent's equation (22)_7. Our equations (20) and (21), defining aggregate nominal imports and exports, replace the ORANI real definitions \angle Vincent's equations (20) and (21)_7.³³Our investment equations (46) and (47) replace the ORANI equations \angle Vincent's equations (24) and (25)_7. Thus there are a total of 2h + 7 overlapping equations, so that our macro/financial sector model introduces h + 37 new equations which do not have counterparts in ORANI.

Having netted out equations and variables which overlap with Vincent's (1983) ORANI model, we are left with h + 37 equations in h + 57 unknowns. Closure of this macro/financial sector submodel therefore requires 20 variables to be designated exogenous. The submodel provides some freedom, and the final choice will depend on the questions which the full model will address. One closure which would be appropriate for examining, say, the impact of some real side exogenous shock within a given macro policy environment would be the following:

Foreign variables: i_{B}^{*} , r_{s}^{*} , $\varepsilon^{(s^{*})}$, $\varepsilon^{(3^{*})}$, h_{Bf} , h_{Kf} Expectations variables: π_{C}^{*} , π_{C}^{*} , π_{s}^{*} , π_{ϕ}^{*} Policy variables: t_{P} , t_{C} , i_{M} , m_{D}^{*} , and either $m_{\widehat{F}}$ or $m_{\widehat{R}}$ Variables included for technical reasons: m_{R} , m_{D} , m_{F} , b

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³³ For this reason, Vincent's equation (36) defining real GDP would have to be respecified.

The foreign variables are "naturally" exogenous, given our assumption that the domestic country is small in the markets for foreign assets. In the absence of any explicit treatment of expectations formation, the expectations variables must be designated exogenous.³⁴ When a given macro policy environment is being modelled, the exogeneity of policy variables is obvious. The inclusion of i_M on the list of policy variables follows Tobin (1969). The exogeneity of $m_{\hat{D}}$, together with m_D , reflects the fact that domestic credit is a policy variable under the control of the monetary authorities. The choice of either $m_{\hat{P}}$ or $m_{\hat{R}}$ as exogenous determines whether balance of payments deficits will be accommodated by reserve changes or foreign official borrowing. For countries which are close to their international credit limits, the foreign borrowing option may no longer be possible, in which case $m_{\hat{P}}$ would be exogenous.³⁵

Finally, the variables m_R , m_D , m_F and b must be included on the exogenous list for technical reasons. Recall from Section 3.3 that in order to model stock/flow relationships within the ORANI modelling structure, we had to divide the supplies of money and bonds into two components. Thus m_R , m_D , m_F and b represent per-

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³⁴ One application where these could conceivably be designated endogenous without further modelling is in a policy targeting exercise of the form, "By how much would expectations have to change to achieve target x." The value of such an exercise is, however, dubious. In Appendix B, we show how expectations formation can be treated explicitly so that expectations variables can be endogenized in a useful way.

³⁵ Alternatively, an equation of the form $m_{\hat{F}} = h_R m_{\hat{R}} + h_F$ could be added, where the scaling parameters h_R and h_F determine the proportion of balance of payments deficits that are financed by changes in reserves or external debt.

centage changes in the monetary base components and the total bond supply between the beginning of the base year period and the beginning of the solution period, whereas m_R^2 , m_D^2 , m_F^2 and \hat{b} reprepresent percentage changes in within-period changes of the monetary base components and the total bond supply between the base period and the solution period. Now imagine a one period solution horizon, where the end of the base period is the same as the beginning of the solution period. In this case the variables m_R , m_D , m_F and b simply measure changes in the monetary base and bond supply within the base period. Obviously such changes are exogenously given. In order to specify that, for example, domestic credit is exogenously fixed over the entire solution horizon, we must also specify m_D^2 as exogenous, as has already been noted.

The model can be solved once an appropriate number of variables have been designated exogenous. The generation of quantitative results, however, also requires numerical values to be attached to the exogenous variables. In most cases, these values will follow naturally from the question being addressed. However, care must be taken in assigning quantitative values to the technical variables m_R , m_D , m_F and b. The appropriate values will in general depend on two things - the length of the solution horizon, and whether or not the associated hatted (^) variable has also been designated exogenous. As our example above illustrates, when the solution

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horizon is one period long, the appropriate values for m_R , m_F , m_D and b are base year percentage changes in the underlying economic variable R, F, D or B. If the associated hatted variable has also been designated exogenous with the intent of keeping the underlying variable fixed, then that hatted variable should be assigned the value -100.

Now consider a solution horizon of more than one period. Such a horizon would reflect the model-user's judgement that all economic adjustments would take more than one period to complete. It is an unfortunate necessity that in this instance, the choice of numerical values for m_R , m_D , m_F and b has implications for the path of adjustment, since these values determine changes in all intervening periods while the associated hatted variables, when endogenous, capture adjustment in the solution period.³⁷One possible approach would be to again assign to m_R , m_F , m_D and b the values of base year percentage changes in the underlying variables. The resulting changes in the associated endogenous hatted variables could perhaps then be pro-rated back through the intervening years.

- ³⁶ Remember that in a one period solution horizon, $m_{\hat{D}}$, for example, equals 100 / $(D_2-D_1) (D_1-D_0) / / (D_1-D_0)$, so that when (D_2-D_1) is set to zero, $m_{\hat{D}}$ takes the value -100. Domestic credit expansion is captured by giving $m_{\hat{D}}$ some value greater than -100. As a special case of this, a value greater than zero would imply credit expansion faster than occurred in the base period.
- ³⁷ Our market clearing conditions of equations (79) and (81) ensure stock equilibrium in money and bond markets only at two points in time - the end of the base period and the end of the solution period. They do not ensure equilibrium in intervening periods. Thus our solution to the stock/flow problem has implicitly used the same technique as Dornbusch (1973), among others, because it implicitly involves some (user-specified) lagged adjustment to full stock equilibrium. However, because stock equilibrium is reached eventually, we are still justified in ignoring wealth effects, as argued in Section 3.2.b.

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Suppose, for example, that m_R has been given its base period value. An endogenously generated value for m_R can then be reinterpreted a measure of reserve changes in all intervening periods. However, care must then be taken in interpreting the associated endogenously generated value for the balance of payments variable 100ABP, since this now represents the cumulative change in the balance of payments in both the solution and intervening periods over the balance of payments in the base period. When the associated hatted variable is exogenous, however, this problem does not arise. The values which should be assigned to both hatted and unhatted variables are the same as for the one period solution horizon.

The model closure we have suggested is not the only one possible. For example, experiments in which monetary policy is aimed at some target can be modelled by designating the target variable as exogenous and endogenizing $m_{\hat{D}}$. Further flexibility in choosing macroeconomic environments comes from the ORANI real side, since within ORANI there is scope to model either sticky wages (the Keynesian case) or full wage flexibility (the monetarist case). We refer the reader to Vincent (1981) for detailed discussion of model closure on the real side. Here we note, finally, that in short run experiments the industry capital stocks will be designated exogenous. For long run experiments, these stocks can be made endogenous by adding our equations which define the long run to the list of structural equations.

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5. Concluding Remarks

ORANI models are real, disaggregated general equilibrium models which give a full treatment of commodity flows but abstract from monetary and financial considerations. One implication is that they can address questions relating to the balance of trade, but not to the balance of payments.

In this paper we have developed a model of a country's monetary and financial sector in a form which can be appended to ORANI-type real models. In the same way that the ORANI structural equations are derived from neoclassical assumptions with respect to consumption and production, the structural equations of our macro/financial sector model are derived from neoclassical assumptions with respect to asset preference and asset accumulation. In addition, our equations are written in a form compatible with the ORANI solution algorithm.

The behaviour of international capital flows and the balance of payments is specified within the monetary and financial sector. Links between the real and financial sectors are provided through the influence of financial rates of return on aggregate real consumption and investment, on the one hand, and through the influence of real disposable income and price levels on asset demands,

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on the other hand. Through these links, the combined model establishes new channels by which monetary, fiscal, commercial and exchange rate policies can have real structural effects. Such channels have so far been missing from ORANI models. The combined model also allows the real structure of the economy to influence macroeconomic targets. Such effects cannot be captured with more simple macroeconomic models. Thus the combined model can not only address balance of payments questions, it also lays open a whole new sphere of potential policy analysis.

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Appendix A - A Generalized Asset Notation

The macro/financial sector model of this paper was developed for a specific menu of assets - domestic money, domestic and foreign bonds and domestic and foreign capital. The notation was likewise developed for this particular menu. In this appendix, we suggest a general asset notation, one that is more abstract than that in the text, but also more in keeping with the ORANI real side notation. We also show how some of our key structural equations can be converted into the generalized notation. While the benefits of this notation, in terms of conciseness, may not be great in relation to our simple model, the savings in a larger model could be substantial.

Let there be k nominal assets and t real assets. We can represent quantities of these assets as follows:

Quantities of nominal assets: W_{ns} n = 1,...k s = 1,2Quantities of real assets: W_{rs} r = 1,...t s = 1,2

where s = 1 denotes assets originating from domestic sources and s = 2 denotes assets from foreign sources. As in the text, W_{ns} is measured in money values and W_{rs} in physical units.³⁸ Therefore,

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 $^{^{38}}$ Thus we do not measure the number of bonds outstanding, but rather their money value.

we need only specify asset prices for the real assets:

Prices of real assets: P_{rs} r = 1,...t s = 1,2Expected price change of real assets: Π_{rs} r = 1,...t s = 1,2The market returns on nominal and real assets are denoted as follows:

Nominal market returns of nominal assets: I_{ns} n = 1,...k s = 1,2Real market returns of real assets: I_{rs} r = 1,...t s = 1,2The net real returns on nominal and real assets are denoted as: Net real returns on nominal assets: $R_{ns}^{(h)}$ n = 1,...k s = 1,2 h = 1,2Net real returns on real assets: $R_{rs}^{(h)}$ r = 1,...t s = 1,2 h = 1,2where the superscript h denotes net returns to domestic holders (h = 1) or foreign holders (h = 2). Thus we can also denote asset demands by domestic residents and foreigners as follows: Demands for nominal assets: $W_{ns}^{(h)}$ n = 1,...k s = 1,2 h = 1,2Demands for real assets: $W_{rs}^{(h)}$ r = 1,...k s = 1,2 h = 1,2

The structural equations which specify net real asset returns become, in ORANI percentage change notation:

 $r_{n1}^{(1)} = Q_{In1}^{(1)} i_{n1} - Q_{Cn1}^{(1)} \pi_{C1} \qquad n = 1, \dots k$ (A1) $r_{n2}^{(1)} = Q_{In2}^{(1)} i_{n2} + Q_{\phi n1}^{(1)} \pi_{\phi} - Q_{Cn1}^{(1)} \pi_{C1} \qquad n = 1, \dots k$ (A2)

r(1) rr1	= Q	(1) Ir1	ⁱ r1	+	Q _{[[} 1)	ⁿ r1	- റ(1) r1 ^π C1		r =	1,.	t		(A3)
r(1) r2	= Q	(1) Ir2	ⁱ r2	+	Q _{[12}	^π r2	+ Q (1) r2 ^π φ	- 0 ⁽¹ Cr) ·2 ^π C1		a .		
							·			r =	1,.	t		(A4)
r(2) rn1	= Q	(2) In1	ⁱ n1	-	Q <mark>(2)</mark> Q _{¢n1}	π -	• Q(2 Cn) π 1 C2		n =	1,.	k		(A5)
r(2) r _{n2}	= Q	(2) In2	ⁱ n2	-	Q(2) Q _{Cn2}	^π C2			. •	n =	1,.	k		(A6)
r(2) r1	= Q	(2) Ir1	ⁱ r1	+	Q _{[[} 2)	^π r1	- Q(2) r1 ^π φ	- Q _{Cr} (2) 1 ^π C2	2			·*
										r =	1,.	t		(A7)
r(2) r2	= Q	(2) Ir2	ⁱ r2	+	Q _{[[122}]	$^{\pi}$ r2	- Q _C	2) r2 ^T C2	2	r =	1,.	t		(A8)
where	[∍] ^π C	1 ar	ıd ⊤(22 ^a	re (p	erce	entag	e char	nges i	n) th	ie e	xpect	ed	rates

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of inflation of the domestic and foreign consumer price indices, respectively.

The asset demand functions become, in percentage change notation,

 $w_{n1}^{(1)} = \varepsilon_{1}^{(3)} + \frac{k}{\Sigma} \sum_{n=1}^{\Sigma} \eta_{n1ns}^{(1)} r_{ns}^{(1)} + \frac{t}{\Sigma} \sum_{r=1}^{\Sigma} \eta_{n1rs}^{(1)} r_{rs}^{(1)} + \eta_{n1y}^{(1)} y_{R}$ $n = 1, \dots k \quad (A9)$ $w_{n2}^{(1)} = \varepsilon_{1}^{(3)} - \phi + \frac{k}{\Sigma} \sum_{r=1}^{\Sigma} \eta_{n2ns}^{(1)} r_{ns}^{(1)} + \frac{t}{\Sigma} \sum_{r=1}^{\Sigma} \eta_{n2rs}^{(1)} r_{rs}^{(1)} + \eta_{n2y}^{(1)} y_{R}$ $n = 1, \dots k \quad (A10)$ $w_{r1}^{(1)} = \varepsilon_{1}^{(3)} - p_{r1} + \frac{k}{\Sigma} \sum_{n=1}^{\Sigma} \eta_{r1ns}^{(1)} r_{ns}^{(1)} + \frac{t}{\Sigma} \sum_{r=1}^{\Sigma} \eta_{r1rs}^{(1)} r_{rs}^{(1)} + \eta_{r1y}^{(1)} y_{R}$ $r = 1, \dots t \quad (A11)$

$$w_{r2}^{(1)} = \varepsilon_{1}^{(3)} - P_{r2} - \phi + \sum_{n=1}^{k} \sum_{s=1}^{2} \eta_{r2ns}^{(1)} r_{ns}^{(1)} + \sum_{r=1}^{t} \sum_{s=1}^{2} \eta_{r2rs}^{(1)} r_{rs}^{(1)} + \eta_{r2y}^{(1)} r_{rs}^{(1)} + \eta_{rs}^{(1)} r_{rs}^{(1)} + \eta_{rs}^{(1)}$$

The market clearing conditions for domestic assets then become:

$$w_{n1} = \sum_{h=1}^{2} S_{n1}^{(h)} w_{n1}^{(h)} \qquad n = 1, \dots k$$
(A15)
$$w_{r1} = \sum_{h=1}^{2} S_{r1}^{(h)} w_{r1}^{(h)} \qquad r = 1, t$$
(A16)

where the asset supplies w_{n1} and w_{r1} may need to be divided into two components, as was done in the text with the supplies of money and bonds. Furthermore, with market clearing conditions of this form the bond supply must be specified net of central bank holdings.

The remaining definitional and identity equations of our model can also be converted into this generalized notation in a straightforward manner.

Appendix B - Endogenizing Expectations

It has been standard practice in ORANI applications to designate all expectations variables as exogenous.³⁹ Furthermore, quantitative results have generally been reported only for the case where expectations are exogenously set to zero. This corresponds to an assumption that expectations are static. This assumption may be appropriate in very short run experiments, but becomes harder to justify over the two or five year solution horizons that are usually assumed in ORANI applications. In this Appendix, we discuss how quantitative results may be obtained under the assumption that expectations are rational.

Suppose for some variable X, we have a corresponding variable Π_X which represents the expected rate of change of X. The assumption of full-information rational expectations in a non-stochastic model such as ours implies

$$\Pi_{X} = \frac{\Delta X}{X} \cdot 100 = x$$
(B1)

Such consistency conditions are stock/flow relations of the type that has already proved problematic. However, because the right hand side expression involves percentage changes, not absolute changes, the conditions can be converted into ORANI notation in a reasonably straightforward fashion. / cf. equation (69) 7.

Consider the case of a one period solution horizon. The percentage change in X is given by

³⁹ See, for example, Vincent (1983).

$$x = \frac{X_2 - X_1}{X_1} \cdot 100$$
 (B2)

and the percentage change in $\ensuremath{\mathbbm I}_X$ is given, under rational expectations, by

$$\pi_{\rm X} = \frac{(X_2 - X_1)/X_1 - (X_1 - X_0)/X_0}{(X_1 - X_0)/X_0} \cdot 100$$
(B3)

Equation (B3) can be rearranged, and combined with (B2) to give

$$\left\{ (x_1 - x_0) / x_0 \right\} (\pi_x + 100) = x$$
 (B4) ... (B4)

where the first term on the left hand side is an observable parameter and is simply the relative change in X in the base period over the previous period. Finally, this equation can be converted into a homogeneous equation of the type required in ORANI by introducing a shift variable $h_{\pi x}$ and writing (B4) as

$$\Pi_{\rm XO} \left(\pi_{\rm X} + h_{\pi_{\rm X}} \right) = {\rm X} \tag{B5}$$

where h_{π_X} is designated exogenous and given a value of 100.

Now consider the case of a two period solution horizon. The equivalents of (B2) and (B3) are

$$x = \frac{X_3 - X_1}{X_1} . 100$$
(B6)

and
$$\int (X_1 - X_0) / X_0 \int (\pi_x + 100) = \frac{X_3 - X_2}{X_2} \cdot 100$$
 (B7)

We can now no longer combine these expressions without making some assumption about how expectations adjust in the intervening period between the base and solution periods. This is the counterpart to the adjustment problem discussed in Section 4. Perhaps the simplest assumption is that the two-period change $(X_3 - X_1)/X_1$ is twice the one-period change $(X_3 - X_2)/X_2$. Expectations are "eventually" rational, but need not be so in intervening periods. The counterpart to equation (B5) then becomes

$$\Pi_{\rm XO} (\pi_{\rm X} + h_{\pi \rm X}) = \frac{1}{2} {\rm x}$$
 (B8)

The appropriate equation for a T period solution horizon would then be

$$\Pi_{\rm XO}$$
 $(\pi_{\rm X} + h_{\rm TX}) = \frac{1}{T} {\rm X}$ (B9)

Equations of the form given in (B5), (B8) or (B9) can be introduced into our model so as to endogenize, or impose rationality on, an expectations term π_x in situations where its associated variable x is endogenous. In the context of the model closure discussed in Section 4, the approach can therefore be used to endogenize π_C and π_s , by linking these to the actual changes $\epsilon^{(3)}$ and $\epsilon^{(s)}$. However, it can also be used to impose rationality when the associated variable x is exogenous. Hence it can also be used to link the expectations terms π_C^* , π_s^* and π_{ϕ} to the actual changes $\epsilon^{(3^*)}$, $\epsilon^{(s^*)}$ and ϕ . Thus we could, for example, compare the effects of a currency devaluation that was anticipated (expectations rational) with one that was unanticipated (expectations static).

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Appendix C - Technical Details of the Macro/Financial Sector

Table C1 - The Linear Equation System

Identifier	Equation	Subscript Range	Number	Description
	1. a. Net Real Asset Returns			
(1)	$r_{j} = Q_{j}(p_{2j} - \pi_{j})$	j = 1,h	h	Real rate of return to domestic capital
(2)	$r_s = \pi_j - p_{sj} + r_j$	j = 1,h	h	Real market return on claims to domestic capi- tal
(3)	$\epsilon^{(s)} = \sum_{j=1}^{h} S_{kj} P_{sj}$		1	Domestic share price in- dex
(4)	$r_{M} = \Omega_{IM} i_{M} - \Omega_{CM} T_{C}$		1	Net real domestic returns: - on money
(5)	$r_{B} = Q_{IB} i_{B} - Q_{CB} c_{C}$		1	- on domestic bonds
(6)	$r_{K} = Q_{RK} r_{s} + Q_{SK} \pi_{s} - Q_{CK} \pi_{C}$		1	- on claims to domestic capital
(7)	$r_{B}^{*} = Q_{IB}^{*} i_{B}^{*} + Q_{\phi B}^{*} \pi_{\phi}^{-} Q_{CB}^{*} \pi_{C}^{-}$		1	- on foreign bonds
(8)	$r_{K}^{*} = Q_{R^{*}K^{*}}r_{S}^{*} + Q_{S^{*}K^{*}}r_{S}^{*} + Q_{\phi K^{*}}r_{\phi}^{*} - Q_{CK^{*}}r_{C}^{*}$		1	- on claims to foreign capital
			i	Net real foreign returns:
(9)	$r_{Bf} = Q_{IBf} i_B - Q_{\phi Bf} \pi_{\phi} - Q_C *_{Bf} C$		1	- on domestic bonds
(10)	$\mathbf{r}_{Kf} = \mathbf{Q}_{RKf} \mathbf{r}_{s} + \mathbf{Q}_{SKf} \mathbf{\pi}_{s} - \mathbf{Q}_{\phi Kf} \mathbf{\pi}_{\phi} - \mathbf{Q}_{C} \mathbf{K}_{f} \mathbf{\pi}_{C}^{*}$		1	- on claims to domestic capital
(11)	$r_{Bf}^{*} = Q_{IBf}^{*i}B_{B}^{*} - Q_{C}^{*}Bf^{*}C_{C}^{*}$		1	- on foreign bonds
(12)	$r_{Kf}^{*} = Q_{R^{*}Kf^{*}r_{S}^{*}} + Q_{S^{*}Kf^{*}r_{S}^{*}} - Q_{C^{*}Kf^{*}r_{C}^{*}}$		1	- on claims to foreign capital
	1.b Asset Demands, Consumption, Savings			
(13)	$m_d = e^{(3)} + \Sigma n_{Ma} r_a + n_{MY} Y_R$)	1	Domestic demands for: - nominal money balances
(14)	$b_{d} = \varepsilon^{(3)} + \Sigma \eta_{Ba} r_{a} + \eta_{BY} \gamma_{R}$	(_ a = M,B,	1	- nominal domestic bonds;
(15)	$k_{d} = \epsilon^{(3)} - \epsilon^{(s)} + \Sigma n r_{a} + n_{KY} Y_{R}$	K,B*,K*	1	- real claims to domes- tic capital
(16)	$b_{d}^{*} = \varepsilon^{(3)} - \phi + \Sigma \eta_{B}^{*}a r_{a} + \eta_{B}^{*}Y Y_{R}$		1	- nominal foreign bonds
(17)	$k_{d}^{*} = \varepsilon^{(3)} - \varepsilon^{(s^{*})} - \phi + \Sigma \eta_{K^{*}a} r_{a} + \eta_{K^{*}Y} Y_{R}$)	1	- real claims to foreign capital
				Foreign demands for:
' (18)	$b_{f} = \varepsilon^{(3^{*})} + \phi + \sum_{b}^{n} Bfb + b^{h}Bf$	$\left. \right\}_{b=B_{f},K_{f}}$	1	- nominal domestic bonds
(19)	$k_{f} = \varepsilon^{(3^{*})} - \varepsilon^{(s)} + \phi + \sum_{b} n_{Kfb} r_{b} + h_{Kf}$	$\int_{C} B_{f}^{*}, K_{f}^{*}$	1	- realclaims to domes- tic capital

Table C1 - Continued

dentifier	Equation	Range	Number	Description
(20)	$c_R = \sum_{a} n_{Ca} r_a + n_{CY} Y_R$		1	Aggregate real consump- tion
(21)	$ p^{\ell} = \sum_{\substack{z \\ q=1}}^{r} \sum_{j=1}^{h} S_{\ell}qj (p_{1,q,.} + x_{1,q,j}^{P}) $		1	Aggregate nominal la- bour income
(22)	$p_n = \sum_{j=1}^{h} S_{nj} (p_{3j} + x_{3j}^{P})$		1	Aggregate nominal land come
(23)	$y = S_{LY}pi + S_{NY}pn + S_{MY}(i_M + m_d) + S_{BY}(i_B + b_d)$			
	+ $S_{KY}(r_s + \varepsilon^{(s)} + k_d) + S_{B*Y}(i_B^* + \phi + b_d^*)$	-		
	+ $S_{K^{*}Y}(r_{S}^{*} + \varepsilon^{(S^{*})} + \phi + k_{d}^{*})$			Aggregate nominal per- sonal income
(24)	$t = S_{PT}t_{P} + S_{CT}t_{C} + S_{LT}P\ell + S_{NT}pn + S_{MT}(i_{M}+m_{d})$			
	+ $S_{BT}(i_B + b_d)$ + $S_{KT}(r_s + \epsilon^{(s)} + k_d)$			
	+ $S_{B*T}(i_B^* + \phi + b_d^*) + S_{K*T}(r_S^* + \varepsilon^{(S^*)} + \phi + k_d^*)$		1	Aggregate nominal direct taxation
(25)	$y_R = Q_{YR}y - Q_{TR}t - \epsilon^{(3)}$		1	Aggregate real perso- nal disposable income
(26)	$s_{R} = Q_{YS} Y_{R} - Q_{CS} c_{R}$		1	Aggregate real saving
	2. Market Clearing for Domestic Assets			
(27)	$k = S_{Kd} k_d + S_{Kf} k_f$		1	Supply equals demand fo - claims to domestic capital
(28)	$s_{RM} m_R - s_{FM} m_F + s_{DM} m_D + s_{RM} m_{\hat{R}} - s_{\hat{F}M} m_{\hat{F}}$			
ĺ	$+ s_{\widehat{D}M}^{m} \widehat{D} = m_{d}$		1	- domestic money
(29)	$s_{B}^{b} + s_{B}^{c}^{b} = S_{dB}^{b}_{d} + S_{fB}^{b}_{f} + S_{DB}^{m}_{D} + S_{DB}^{m}_{D}^{b}$		1	- domestic bonds
	3. Balance of Payments			
(30)	$100 \Delta BP = \hat{R}m_{\hat{R}} - \hat{F}m_{\hat{F}}$		1 '	Balance of Payments
(31)	$\mathfrak{m}^{*} = \sum_{i=1}^{g} (p_{i2}^{\mathfrak{m}} + \phi + x_{i2}) \mathfrak{M}^{*}_{i2} + \sum_{\ell=1}^{n} (p_{\ell}^{\mathfrak{N}\mathfrak{m}} + \phi + x_{\ell}^{\mathfrak{N}}) \mathfrak{M}^{\mathfrak{N}*}_{\ell}$		1	Aggregate imports, ex tariffs
(32)	$e^* = \sum_{i=1}^{q} (p_{i1}^e + \phi + x_i^{(4)}) E_i^*$		1	Aggregate exports, ex subsidies
(33)	$100\Delta BT = E^*e^* - M^*m^*$		1	Balance of trade
(34)	$100\Delta PT = PT_{B*}(i_{B}^{*} + \phi + b_{d}^{*}) - PT_{Bf}(i_{B} + b_{f})$			
	+ $r_{R^{\text{sl}}}r_{S}$ + ϵ + ϕ + κ_{d}			

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Table C1 - Continued

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Identifier	Equation	Subscript Range	Number	Description
(35)	100ACA = 100ABT + 100APT	۰.	1	Current Account
(36)	1:00ACAP = 100ABP - 100ACA		1	Capital Account
(37)	4. Covernment Budget Deficit $g = \frac{q}{r} = \frac{2}{r} S_{is}^{(5)} (p_{is} + x_{is}^{(5)})$		1	Nominal government
(38)	$dsp \approx i_B + s_B b + s_B \hat{b}$		1	Debt service payments
(39)	$m = \sum_{\substack{z \in 1 \\ i \neq 1}}^{q} (p_{i2} + x_{i2}) M_{i2} + \sum_{\substack{z = 1 \\ z = 1}}^{n} (p_{z}^{N} + x_{z}^{N}) M_{z}^{N}$		1	Imports, incl. tariffs
(40)	$e = \sum_{i=1}^{g} (p_{i1} + x_i^{(4)}) E_i$		1	Exports, incl. subsi- dies
(41)	$tr = Q_{MTR}^{m} - Q_{M*TR}^{m*}$		1	Tariff revenue
(42)	es = Q _{EES} e - Q _{E*ES} e*		1	Export subsidies
(43)	$ntr = Q_{TTR}tr - Q_{ETR}es$		1	Net trade revenue
(44)	$gbd = Q_{GGD} g + Q_{PGD} dsp - Q_{TGD} t - Q_{NGD} ntr$		1	Government budget de- ficit
(45)	$gbd = \hat{b}$		1	Deficit financing
	5. Investment			
(46)	$y_j = \alpha_j G_j (p_{sj} - \pi_j) + (1 - G_j) k_j$	j=1,h	h	Gross real industry investment
(47)	$i = \sum_{j=1}^{h} (\pi_j + y_j) T_j$		1	Aggregate gross nomi- nal investment
	6. Equations Defining Long Run (Optional)			
(48)	$p_{sj} = \pi_j$	j=1;h	h	Capital valued at re- placement cost
			· [

Total equations: 3h + 44 in short run experiments, 4h + 44 in long run experiments

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Table C2 - List of Variables

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Variable	Subscript	Number	Description (All variables in percentage changes, except where prefixed by Δ)
rj	j=1,,h	. h§	Industry real rates of return to capital
P _{2j}	j=1,,h	h §	Industry rental price of existing capital
т ј	j=1,,h	h §	Price of new units of capital in each industry
P _{sj}	j=1,,h	h	Price of claims to ownership of capital in each industry
ε ^(s)		1	Domestic share price index
1 _M		1	Nominal market interest rate on money
і _в		1	Nominal market interest rate on domestic bonds
i# B		1 .	Nominal market interest rate on foreign bonds
rs		1	Real market return on claims to domestic capital
r*s		1	Real market return on claims to foreign capital
^π С		1 .	Expected rate of inflation of domestic consumer price index
π #		1 .	Expected rate of inflation of foreign consumer price index '
^π s		1 :	Expected rate of inflation of domestic share price index
π# S		1.	Expected rate of inflation of foreign share price index
π _φ	-	. 1	Expected rate of exchange depreciation
r _M		1	Net real domestic return on money
r _B		1 ·	Net real domestic return on domestic bonds
r _K		1	Net real domestic return on claims to domestic capital
r _B *		1	Net real domestic return on foreign bonds
r [#] K		1	Net real domestic return on claims to foreign capital
r _{Bf}		1	Net real foreign return on domestic bonds
r _{Kf}		1	Net real foreign return on claims to domestic capital
r [*] Bf		1	Net foreign return on foreign bonds
r _{Kf}		1	Net foreign return on claims to foreign capital
ε ⁽³⁾		1 §	Domestic consumer price index
ε ^(3*)		1 .	Foreign consumer price index
ε (s*)		1	Foreign share price index
ф		1 §	Exchange rate (price of foreign currency)
m _d		1	Domestic demand for nominal money balances
^b d		1 .	Domestic demand for nominal domestic bonds
^k a		1	Domestic demand for claims to domestic real capital

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Table C2 - Continued

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Variable	Subscript	Number	Description (All variables in percentage changes, except where prefixed by Δ)
bå		1	Domestic demand for nominal foreign bonds
k *		1	Domestic demand for claims to foreign real capital
^b f		1.	Foreign demand for nominal domestic bonds
k _f		1	Foreign demand for claims to domestic real capital
h _{Bf}		1	Shift variable in foreign demand for domestic bonds
h _{Kf}		1	Shift variable in foreign demand for domestic capital
c _R		1 §	Aggregate real domestic consumption expenditure
pl		1	Aggregate nominal labour income
p _{1,q,.}	q=1,r	r §	Wage of labour by occupation
x ^P 1,q,j	$q=1,\ldots,r$	rh §	Demands for labour by occupation and industry
pn	2-1/11	1	Aggregate nominal income from land ownership
P _{3j}	j=1,h	h §	Rental price of land in each industry
× ^P 3j	j=1,h	h §	Demands for land by industry
У		1	Aggregate nominal personal income
t _P		1	Average tax rate on land and labour income
^t c		1	Average tax rate on income from financial sources
t		1	Aggregate nominal direct taxation
У _R		1	Aggregate real personal disposable income
s _R		. 1	Aggregate real saving
k		1 §,	Aggregate real domestic capital stock
^m R		1 §§	Beginning-of-period reserve component of monetary base
m _F		1	Beginning-of-period external debt component of monetary base
^m D		1 §§	Beginning-of-period domestic (bond) component of monetary base
^m R		1	Within-period change in reserve component of monetary base
^m f		1	Within-period change in external debt component of monetary base
^m D		1	Within-period change in domestic (bond) component of mone- tary base
b		1	Beginning-of-period supply of domestic government bonds
b		- 1	Within-period change in supply of domestic government bonds
ΔBP		1 .	Balance of payments - absolute change
m*		1 .	Aggregate nominal imports, excluding tariffs
1	1	-	1

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Table C2 - Continued

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Variable	Subscript	Number	Description (All variables in percentage changes, except where prefixed by $\Delta)$
íi2	i=1,g	g §	Competitive import volume
Nm L	ℓ=1,n	n §	C.i.f. foreign currency prices for non-competing imports
c ^N L	ℓ=1,n	n §	Non-competitive import volume
• *		1	Aggregate nominal exports, excluding subsidies
e i1	i=1,g	g §	F.o.b. foreign currency export prices
(4) i	i=1,g	g §	Export demands
BT		1 §	Balance of trade - absolute change
PT		1	Private transfer receipts - absolute change
CA		1	Current account balance - absolute change
CAP		1	Capital account balance ~ absolute change
J		1	Aggregate nominal government commodity expenditure
is	i=1,g	2g §	Domestic prices of commodities, domestic and imported
(5) is	i=1,g	2g §	Government demands for domestic and imported goods
lsp		1	Nominal debt service payments on government bonds
n		1 §	Aggregate nominal imports, including tariffs
² i2	i=1,g	^a §	Domestic prices of competing imports
p ^N ℓ	ℓ=1,n	_n §	Domestic prices of non-competing imports
9		1 §	Aggregate nominal exports, including subsidies
p _{i1}	i=1,g	g §	Domestic prices of exportables
tr		1	Aggregate nominal tariff revenue
s.		1	Aggregate nominal expenditure on export subsidies
ntr		1	Aggregate nominal net trade revenue
ıbd		1	Total nominal government budget deficit
'i	j=1,h	_h §	Gross real industry capital formation
ć	j=1,h	h §	Real industry capital stocks
-		1 \$	Aggregate nominal investment expenditure

§ Defined and used in ORANI

§§ Defined and used in ORANI, Vincent (1983) application

Total variables overlapping with ORANI: 10g + 7h + 3n + r + rh + 10

Table C3 - List of Parameters

Equation	Parameter	Description
(1)	Qj	Ratio of gross to net real rate of return to capital in industry j. Source: Econometric
(3)	s _{kj}	Share of industry j's capital in aggregate capital stock - capital valued at market (share) prices. Source: See note 1.
(4)	Q _{IM} , Q _{CM}	Ratios of nominal interest rate on money and expected inflation rate to net real return on money. See note 2.
(5)	Q _{IB} , Q _{CB}	Ratios of nominal bond interest rate and expected in- flation to net real return on bonds. Source: See note 2.
(7)	Q _{IB} *, Q _{¢B} *, Q _{CB} *	Ratios of nominal foreign bond interest rate, expected depreciation and expected inflation to net real return on foreign bonds. Source: See note 2.
(9)	Q _{IBf} , Q _{¢Bf} , Q _{C*Bf}	Ratios of nominal bond interest rate, expected depreci- ation and expected foreign inflation to net real fo- reign return on domestic bonds. Source: See note 2.
(11)	Q _{IBf} *, Q _C *Bf*	Ratios of nominal foreign bond interest rate and ex- pected foreign inflation to net real foreign return on foreign bonds. Source: See note 2.
(6)	Q _{RK} , Q _{SK} , Q _{CK}	Ratios of real market dividend, expected share price inflation and expected CPI inflation to net real return on claims to capital. Source: See note 3.
(8)	Q _{R*K*} , Q _{S*K} *, Q _{¢K} *, Q _{CK} *	Ratios of real foreign market dividend, expected fo- reign share inflation, expected depreciation and ex- pected domestic CPI inflation to net real return on claims to foreign capital. Source: See note 3.
(10)	Q _{RKf} ,Q _{SKf} ,Q _{¢Kf} ,Q _C *Kf	Ratios of real market dividend, expected share price inflation, expected depreciation and expected foreign CPI inflation to net real foreign return on claims to domestic capital. Source: See note 3.
(12)	Q _{R*Kf*} ,Q _{S*Kf*} ,Q _{C*Kf} *	Ratios of real foreign market dividend, expected fo- reign share price inflation and expected foreign CPI inflation to net real foreign return on claims to foreign capital. Source: See note 3.
(13)-(17)	ⁿ qa' ⁿ qy q,a = M,B,K,B*,K*	Elasticities of real domestic asset demand functions with respect to net real returns on money, domestic and foreign bonds, domestic and foreign capital, and with respect to real disposable income. Source: See note 4.
(18),(19)	ⁿ rb r = Bf, Kf b = Bf, Kf, Bf*, Kf*	Elasticities of real foreign demand functions with re- spect to net real returns on domestic and foreign bonds, domestic and foreign capital. Source: See note 4.
(20)	[¶] Ca' [¶] CY a ≈ M,B,K,B*,K*	Elasticities of aggregate consumption function with re- spect to net real returns on money, domestic and fo- reign bonds, domestic and foreign capital, and with respect to real disposable income. Source: See note 4.
(21)	S _{łqj}	Cost share of labour of occupation q, industry j, in economy's total labour cost. Source: Input-Output.
(22)	s _{nj}	Cost share of industry j's land in economy's total land cost. Source: Input-Output.
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Table C3 - Continued

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Equation	Parameter	Description
(23)	s _{ly} ,s _{ny} ,s _{my} ,s _{by} ,s _{b*y} ,s _{ky} ,s _{K*y}	Nominal shares of income from labour, land, interest on money, domestic bonds, foreign bonds, domestic dividends (plus profit), foreign dividends (plus pro- fit) in aggregate nominal personal income. Source: See note 5.
(24)	S _{PT} , S _{CT}	Nominal shares of personal and corporate/capital taxes in total nominal direct taxation. Source: See note 5.
(24)	$s_{LT}^{}, s_{NT}^{}, s_{MT}^{}, s_{BT}^{}, s_{KT}^{}, s_{B*T}^{}, s_{K*T}^{}$	Nominal shares of taxes on income from labour, land, interest on money, domestic bonds, foreign bonds, do- mestic dividends (plus profit), foreign dividends (plus profit) in total nominal direct taxation, $S_{LT} + S_{NT} = S_{DT}$ and $S_{MT} + S_{BT} + S_{KT} + S_{B*T} + S_{K*T} = S_{CT}$. Source: See note 5.
(25)	Q _{YR} , Q _{TR}	Ratios of total personal income and total direct taxa- tion to total nominal personal disposable income. Source: See note 5.
(26)	Q _{YS} , Q _{CS}	Ratios of nominal personal disposable income and nomi- nal consumption to nominal saving. Source: See note 5.
(27)	s _{Kd} , s _{Kf}	Domestic and foreign ownership shares in aggregate domestic capital stock. Source: See note 5.
(28)	^s RM ^{, s} FM ^{, s} DM ^{, s} R̂M ^{, s} F̂M ^{, s} D̂M	Shares of beginning-of-period levels, and within-pe- riod changes, of reserve component, external debt component and domestic component of monetary base in total end-of-period monetary base. Source: IFS.
(29),(38)	s _B , s _Ê	Shares of beginning-of-period level, and within-period change, of government bonds in total end-of-period stock of government bonds outstanding. Source: See note 7.
(29)	s _{dB} , s _{fB} , s _{DB} , s _{DB}	Shares of domestic and foreign end-of-period private holdings, beginning-of-period level, and within-period change, of central bank holdings of government bonds in total end-of-period stock of government bonds out- standing. Source: See note 7.
(30)	R, F	Base year changes in reserves and external debt. Source: IFS.
(31)	M [*] ₁₂ , M ^{N*}	Shares of individual competing and non-competing import commodities in total import bill, imports valued at domestic currency value of foreign prices (ex tariffs). Source: Input-Output.
(32)	E [*] i	Shares of individual export commodities in total value of exports, exports valued at domestic currency value of foreign prices (ex subsidies). Source: Input-Output.
(33)	E*, M*	Total base year values of exports and imports, exclu- sive of tariffs and subsidies. Source: Input-Output.
(34)	PT _{B*} ,PT _{K*} , PT _{Bf} ,PT _{Kf}	Total base year receipts of foreign interest and divi- dends by domestic residents, payments of domestic in- terest and dividends to foreigners. Source: Balance of payments accounts, central bank publications.
(37)	s ⁽⁵⁾ is	Nominal shares of individual domestic and imported commodities in total government commodity expenditure. Source: Input-Output.
(39)	M_{i2}, M_{ℓ}^{N}	Shares of individual competing and non-competing import commodities in total import bill, imports valued at do- mestic prices (including tariffs). Source: Input-Out- put.

Table C3 - Continued

Equation	Parameter	Description
(40)	Ei	Shares of individual export commodities in total value of exports, exports valued at domestic prices (includ- ing subsidies). Source: Input-Output.
(41)	Q _{MTR} , Q _{M*TR}	Ratios of import bill including tariffs and import bill excluding tariffs to total tariff revenue. Source: Input-Output.
(42)	Q _{EES} , Q _{E*ES}	Ratios of exports including subsidies and exports ex- cluding subsidies to total export subsidy expenditure. Source: Input-Output.
(43)	Q _{TTR} , Q _{ETR}	Ratios of total tariff revenue and total export subsi- dies to net trade revenue. Source: Input-Output.
(44)	Q _{GGD} , Q _{PGD} , Q _{TGD} , Q _{NGD}	Ratios of government commodity expenditure,debt service payments, direct taxation and net trade revenue to to- tal government budget deficit. Source: Government ac- counts, central bank publications.
(46)	Gj	Ratio of net to gross real capital formation in indus- try j. Source: Econometric.
(46)	^a j	Elasticity of real net industry investment with respect to price ratio between existing and new capital in that industry. Source: Econometric - see note 8.
(47)	T _j	Share of aggregate gross nominal investment accounted for by industry j. Source: Input-Output.

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Notes on Parameter Equations

1. If long run equilibrium can be assumed for the base year, then $S_{kj} = \psi_{2j}$, a share parameter defined in ORANI and used to aggregate industry physical capital stocks to give the economy's physical capital stock.

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- 2. The parameters which appear in the structural equations for net real returns on nominal assets follow from the level form definitions of those net real returns, definitions which depend on nominal market interest rates and expected rates of inflation and depreciation. Nominal interest rates on money, domestic and foreign bonds, actual inflation rates of the domestic and foreign consumer price indices (CPI) and actual rates of exchange depreciation are available from "International Financial Statistics" (IFS) and central bank publications. If we assume expectations in the base year are rational, then the associated net real returns on nominal assets can be calculated as a residual.
- 3. The parameters in the structural equations for net real returns on real assets follow from the level form definitions of those net real returns, definitions which depend on real market dividend yields and expected rates of inflation and depreciation. As before, actual inflation rates of domestic and foreign CPI

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and share price indices and actual rates of exchange depreciation are readily available from IFS and central bank publications. There are two potential methods of obtaining estimates of real dividend yields. If long run equilibrium can be assumed in the base year, real dividend yields equal real rates of return to capital, available from econometric sources. Alternatively, nominal dividends yields can be deflated by subtracting the rate of share price inflation. In situations where liabilities form a significant portion of corporate balance sheets, nominal bank lending rates can be deflated by the wholesale price index or capital goods price index. The associated net real returns can be calculated as a residual.

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Asset Demand Parameters:

Asset	Argument of Demand Function						
	r _M	r _B	r <mark>*</mark>	r _K	r <mark>*</mark>	У _R	
Money	+.	-	_	_	_	+	
Domestic Bonds	-	+	-	-	-	+	
Foreign Bonds	-	-	+		—	+	
Domestic Capital	_	-	_	+	-	+	
Foreign Capital	_	-	_	_	+	+	

The signs imputed to the elasticity parameters reflect the standard assumption of gross substitutability between assets, that is, own effects are positive and cross effects are negative. Another assumption commonly made is that all asset demand functions have a unitary elasticity with respect to disposable income. In addition, the following intuitively appealing conditions can be imposed on the partial derivatives of the demand functions:

- (i) For each rate of return, if the positive effect exceeds the sum of the negative cross effects, then an increase in any rate of return will ceteris paribus lead to an increase in saving.
- (ii) If money is a better substitute for bonds than for capital goods, then the partial derivative of money with respect to r_B will exceed that with respect to r_K . Similar conditions can be imposed to capture greater substitutability between

domestic assets than between domestic and foreign assets. Thus we might order the cross partial derivatives of the money demand function L as follows: $L_{r_B} > L_{r_K} > L_{r_K} > L_{r_K}$ in absolute value terms.

(iii) Bonds B and real capital K might be seen as good substitutes, but still react more strongly to their own yield than to the yield of the other asset. Thus we might impose the condition that the partial derivatives B_{r_K} and K_{r_B} both exceed L_{r_B} , but that $|B_{r_B}| > |B_{r_K}|$ and $|K_{r_K}| > |K_{r_B}|$. Again, judgements can be made on a priori grounds about the substitutability of foreign bonds and capital relative to domestic bonds and capital.

These conditions on partial derivatives can be converted to associated conditions on elasticities by standardizing according to base year asset stocks and returns. Within this framework of a priori consistency conditions, some elasticities can be chosen so as to lie within the range of available published estimates.

5. In Section 3.2.b we noted the similarity between our definition of personal disposable income and the standard national accounting definition. However, there will be obvious divergences. What we have called dividend income corresponds to the sum of the national accounting concepts of dividends and pre-tax corporate profits. In addition, it may only be possible to obtain estimates for sums of parameters, for example, $S_{LY} + S_{NY}$ or $S_{MY} + S_{BY} + S_{B*Y}$ or $S_{KY} + S_{K*Y}$. The same might apply to the parameters of the tax equation. In this case, judgements will have to be made about the division of these sums into their separate components.

- 6. Although these shares are real shares, some indication might be gained by considering the proportion of total domestic dividends that is paid to foreigners, or by considering the ratio of direct foreign investment to total domestic investment.
- 7. The IFS contains some figures on government deficits, financing, and total debt outstanding. However, it will need to be established whether these figures relate only to internal debt, as required by our parameters, or to the sum of internal and external government debt. Other sources include government accounts and central bank publications.
- 8. In Section 3.6 we noted that α_j is alternatively the elasticity of real net industry investment with respect to the ratio of the real rate of return on capital to the real dividend return. If we assume that α_j is the same for each industry, then this

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common value is also the elasticity of aggregate real net investment with respect to "the" real interest rate, or dividend return. A value for α can therefore be obtained from published estimates of the interest elasticity of aggregate investment.

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