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TWO SHORT PAPERS DETAILING ENHANCEMENTS TO FH-ORANI

by

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Preliminary Working Paper No. OP-71 December 1992

ISSN 1031 9034 ISBN 0 642 16660 9

ABSTRACT

This document contains two short papers on the theoretical structure of FH-ORANI. The first paper is concerned with local ownership shares for fixed capital in individual industries. The second is concerned with the taxation of earnings of fixed capital. Each paper identifies shortcomings in the current treatment, proposes a new treatment, describes its computer implementation, and presents illustrative simulation results.

The first paper proposes two changes relating to local ownership of fixed capital.

- In calculating industry shares in aggregate capital stocks, we assume uniformity across industries not in pre-tax rates of return, but in post-tax rates.
- In determining local ownership shares for individual industries, we do not assume changes in shares to be uniform across industries, but do require them to be jointly consistent with the change in the economy-wide average local ownership share.

Illustrative simulation results show that the new treatment greatly increases the sensitivity of foreign income payments to changes in the economy-wide local ownership share.

The second paper proposes several changes relating to taxation of earnings of fixed capital.

- Tax reductions arising from depreciation and investment allowances are not apportioned between fixed capital, working capital, and land, but are allocated entirely to fixed capital.
- The share of tax on earnings of fixed capital in total tax on non-labour income is not fixed, but varies in response to changes in the composition of non-labour income.
- Investors treat the reduction in tax arising from the investment allowance not as an augmentation to their income, but as a partial offset to the purchase cost of capital.

Illustrative simulation results show that the new treatment greatly increases the sensitivity of capital usage to changes in the depreciation and investment allowances.

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THE LOCAL OWNERSHIP SHARE OF LOCAL CAPITAL IN FH-ORANI: A CORRECTION[1]

by

R.A. McDougall

This paper proposes a revision of the modelling of the local ownership share of local capital in FH-ORANI (Dee 1989). Section 1 explains the current treatment, and Section 2 the proposed new treatment. Section 3 reports illustrative simulation results, and Section 4 summarises and concludes.

1. The current treatment

FH-ORANI is based on two earlier versions of ORANI: a so-called long-run closure of ORANI (Horridge 1985) and fiscal ORANI (Dee 1987). The long-run closure of ORANI adds a small long-run module to the standard ORANI model (Dixon, Parmenter, Sutton and Vincent 1982). Fiscal ORANI consists of standard ORANI and a large fiscal extension. FH-ORANI comprises standard ORANI, the fiscal extension, and a modified version of the original long-run module, called the modified Horridge extension. The concern of this paper is with the modified Horridge extension.

The long-run closure was designed to provide a better measure of aggregate welfare in long-run simulations, by recognising the distinction between income generated in Australia — GDP — and income accruing to Australians — GNP. Long-run simulations with standard ORANI had been criticised for ignoring this (Horridge 1985, p. 2):

> ...any rise in GDP — ORANI's nearest approach to a measure of national prosperity — must, since employment was exogenous, imply an increase in the national capital stock. It was unclear how this was to be financed, but if, as seemed likely, an inflow of foreign capital was required, the rentals on this foreign-owned capital would accrue to foreigners. Thus the increase in GDP would be likely to overstate the advantage accruing to Australians from, say, a tariff reform.

[1] The author thanks Alexandra Strzelecki for implementing the revised treatment, Stephen Brown for providing the shocks for the illustrative simulations, and Alan Powell for comments on an earlier draft.

In the long-run closure, gross national product (GNP) is allocated between consumption expenditure and saving. Saving in turn is allocated between local and overseas investment. Investment in local industries, on the other hand, is determined by those industries' demands for physical capital. Any excess demand for funds for local investment, above those supplied by local saving, is supplied by foreign capital inflow.

Local investment by Australians determines Australian equity in local capital, which together with total local capital determines the local ownership share. Capital earnings are assumed to be divided between Australians and foreigners according to their ownership shares. All other income generated in Australia is assumed to accrue to Australians. Then GNP is calculated as local capital earnings accruing to Australians, plus Australian earnings from overseas capital, plus non-capital income.

In ORANI, each industry has its own capital stock. The long-run closure allows for variation in the local ownership share across industries in the initial equilibrium, by using industry-specific data on local ownership shares. But it does not contain variables representing these industry-specific shares. It contains only a variable representing the overall local ownership share.

Another feature of the long-run closure of concern in this paper is the treatment of the aggregate capital stock. The percentage change in the aggregate capital stock is a weighted average of the percentage change in the capital stock of each industry, where the weights are industry shares in the aggregate capital stock. Different approaches are taken to calculating these shares in standard ORANI and the long-run closure.

Standard ORANI derives the industry shares from data on capital stock values by industry (Dixon *et al*. 1982, p. 127). Horridge (1985 p. 29) argues that this is unsatisfactory for long-run analysis. For long-run simulations, the database should represent a long-run equilibrium of the economy, in which 'industry capital stocks earn equilibrium rates of return, which should be equalised (after adjustment for various industry-specific factors). A database founded on statistics for a single year is unlikely to satisfy this requirement.'

Accordingly, the long-run closure uses a new measure of the aggregate capital stock. For this measure, each industry's share in the aggregate capital stock is set equal to its share in aggregate capital earnings. This 'forces stocks to adjust so that they all earn the appropriate rate of return, given fixed rentals' (ibid., loc. cit.).

Similarly, the average creation price of locally owned capital is a weighted average of capital prices in each industry, where the weights are industry shares in the aggregate stock of locally owned capital. In the long-run closure, these shares are set equal to shares in aggregate capital earnings accruing to Australians.

The last feature of the long-run closure of present concern is the determination of the local ownership shares for individual industries. The user is required to provide estimates of local ownership shares by industries, and of certain macroeconomic ratios. From the macroeconomic ratios and input-output data from the standard database, an auxiliary procedure determines the overall local share in local capital earnings. The user-provided estimates of shares for individual industries are then revised, to agree with the overall share. The revision formula is

$$Q_j = (\hat{Q}_j)^P \qquad (1)$$

where $\hat{Q}_j$ denotes the user-provided estimate of the local ownership share for industry j and Q_j the revised share, and P is a parameter set so that the revised industry-specific shares are consistent with the predetermined average ownership share.

The revision formula (1) leaves initial shares of zero or one unchanged, while changing shares lying between zero and one. So all industries described by the user as wholly locally owned or wholly foreign-owned remain so, while the ownership shares for partly foreign-owned industries are revised as necessary. Evidently ownership shares are considered more liable to uncertainty or change in these mixed-ownership industries.

In FH-ORANI, these features of the Horridge extension are reworked to take account of the additional information provided in the fiscal extension. This extension replaces the single concept of capital earnings in standard ORANI with three concepts: factor cost, earnings, and disposable earnings. The factor cost of capital is defined as capital earnings plus property tax. Disposable earnings are equal to earnings less income tax.

The ownership share revision procedure is incorporated into the program, INFDAG, which generates the full form of the database from the condensed form (Strzelecki 1992). The general principle of determining the overall local ownership share, and revising individual industry shares to agree with it, is retained. But the calculation of the overall share is changed. In the original Horridge extension it was calculated as the share of earnings by Australian residents in aggregate capital earnings, but in FH-

ORANI it is calculated as a share in aggregate disposable capital earnings. This reflects a change in the database; in FH-ORANI, data for aggregate earnings of foreign residents from capital located in Australia are provided on a post-tax basis.

In the equation system, the equation defining the aggregate capital stock is formally unchanged. But its real significance does change slightly. Whereas in the original Horridge extension the share of each industry in the aggregate capital stock was set equal to its share in aggregate capital earnings, it is now set equal to its share in the aggregate factor cost of capital (this is done not by changing the formula for the share coefficient but by changing the contents of the database array from which it is calculated). A corresponding change occurs for the equation defining the average creation price of locally owned capital.

The greatest change is made in the equation defining GNP. The original equation, defining GNP as earnings of local capital belonging to Australians, plus earnings from foreign capital belonging to Australians, plus $gnp = \beta_1 gdpe - \beta_2 r_t + \beta_3 r_f$,on-c$r_f$pital earnings, is replaced by a new equation defining GNP as gross domestic product (GDP) less disposable earnings of local capital belonging to foreigners, plus earnings of overseas capital belonging to Australians. In percentage change form,

$$gnp = \beta_1 gdpe - \beta_2 r_t + \beta_3 r_f, \qquad \text{(H4)}$$

where *gnp* denotes the (percentage change in) GNP, *gdpe* GDP, r_t disposable earnings of foreign residents from capital located in Australia, and r_f earnings of Australian residents from property located overseas. The βs are share parameters. Aggregate disposable earnings of local capital belonging to foreigners is calculated as the sum of earnings from each industry:

$$r_t = \sum_{j=1}^{h} S_j^{rt} r_j^t, \qquad \text{(H16)}$$

where r_j^t denotes disposable earnings of foreign residents from capital employed in industry *j*, and S_j^{rt} is a coefficient representing the share of each industry *j* in aggregate disposable earnings from local capital belonging to foreigners. For each industry, disposable earnings of local capital belonging to foreigners depends on disposable earnings from all capital in the industry and on the local ownership share.

This new treatment, in which foreigners' capital earnings are determined not only in aggregate but also for each industry, requires information on changes in the local

ownership share in each industry. But the theory underlying the model is not powerful enough to provide this information. The theory does determine the overall level of local ownership, through a wealth accumulation relation, but cannot explain the allocation of local equity across industries. So it is necessary to introduce some arbitrary assumption to determine the local ownership shares in individual industries.

In FH-ORANI, the general assumption is that the percentage change in the local ownership share in an individual industry is equal to the percentage change in the overall local ownership share. This allows disposable earnings of foreign residents from each industry to be calculated as

$$r_j^t = y_{2j}^d - S_j^Q q, \qquad \text{(H17)}$$

where y_{2j}^d denotes disposable earnings of all capital in industry *j*, q the overall local ownership share, and S_j^Q the ratio of the local to the foreign ownership share in industry j.

For industries in which the local capital share is initially unity, this specification must be modified. In these industries, any finite change in the local ownership share implies an infinite change in the foreign ownership share. Accordingly, the parameter S_j^Q is undefined. This problem is addressed in the implementation of FH-ORANI by setting S_j^Q equal to zero for such industries. Since these industries also have S_j^{rt} equal to zero, they make no contribution to the aggregate change in foreigners' earnings.

Table 1 lists industries with local ownership shares of unity in the ORANI database. As the table shows, they account for almost one half of aggregate disposable capital earnings.

TABLE 1: **Wholly locally owned industries**

Industry		
Number	*Description*	*Share in capital stock*[a] *(Per cent)*
84	Electricity	4.3
85	Gas	0.5
86	Water, sewerage, and drainage	2.4
91	Mechanical repairs	0.4
92	Repairs n.e.c.	0.2
94	Railway transport etc.	0.1
97	Communication	2.6
103	Ownership of dwellings	32.9
104	Public administration	0.1
105	Defence	0.1
106	Health	1.2
107	Education, libraries, etc.	0.1
108	Welfare etc. services	0.1
Total		44.9

[a] Capital factor cost shares

Under certain circumstances this industry-based treatment of local and foreign capital earnings is equivalent to a macroeconomic treatment. If rates of return (after tax) are initially uniform across industries, no relative changes in rates of return occur in the simulation, and no industries are initially wholly locally owned, then it is easy to show that the percentage change in the overall share of foreign residents in disposable capital earnings is equal to the percentage change in the overall share of foreign residents in ownership of capital located in Australia. This result relies on the assumption, incorporated in the FH-ORANI theoretical structure, that taxes on property income do not discriminate between Australian and foreign residents.

2. The proposed new treatment

In a couple of respects, the treatment of local ownership of local capital in the modified Horridge extension leaves room for improvement. A minor concern is that the treatment of the aggregate capital stock in the theoretical structure of the modified Horridge extension is inconsistent with the original reason for the treatment. The original reason for introducing flow-based shares was that in equilibrium rates of return would be equated across industries. Clearly, in the fiscal ORANI context, the rates which should be equated are post-tax rates of return, not pre-tax rates augmented by property taxes. Equating these pre-tax rates implies that post-tax rates of return are not uniform across industries.

This affects the behaviour of the aggregate foreign earnings share. If rates of return are not initially equal, then the share of foreign owners in aggregate capital earnings generally diverges from their share in aggregate capital ownership.

A more serious concern arises from the treatment of local ownership shares in individual industries. While the distribution of changes in local ownership across industries is to some extent arbitrary, there is one condition which it must definitely satisfy. That is that changes in local ownership shares for individual industries must be jointly consistent with the change in the overall local ownership share. Unfortunately the current treatment does not satisfy this condition.

We can derive outside the model an identity equating the percentage change in the overall local ownership share to a weighted average of the percentage changes in local ownership shares for individual industries. The weights are the shares of each industry in the aggregate locally owned capital stock. Now under the current treatment, for industries which are wholly or partly foreign-owned, the percentage change in the local ownership share is equal to the percentage change in the overall local ownership share; while for industries which are wholly locally owned, the percentage change in the local ownership share is zero. But these wholly locally owned industries have positive weight in the identity. So the identity is not satisfied; the average percentage change in the local ownership shares for individual industries is smaller in absolute magnitude than the percentage change in the overall local ownership share.

Because the share of wholly locally owned industries in total local ownership is large in the database, the discrepancy in the identity is liable to be large in simulations. For example, with the 1980-81 database, a one per cent change in the foreign ownership share leads (in the absence of compositional effects) to a change in foreigners' earnings not of one per cent, but only 0.46 per cent. Evidently the modified Horridge extension falls far short of achieving its purpose, of accounting for the effects on GNP of changes in foreign ownership of local capital.

Several courses of action might be considered to rectify this shortcoming. One might considering reverting to a purely aggregate treatment of foreign ownership, as in the original Horridge extension. This would lead to errors in simulations in which relative rates of return vary across industries. One might also consider changing the assumption that local ownership shares are fixed in industries which are initially

wholly locally owned. But this would lead to infeasible results in simulations in which the overall local ownership share rises. Even in simulations in which the local ownership share falls, it might be unrealistic to assume that it would fall as rapidly in those industries which are initially wholly locally owned as in industries of mixed ownership.

The solution proposed here is to assume that local ownership shares in individual industries vary according to some fixed rule, depending on the change in the overall local ownership share and on the initial shares for individual industries. The rule should have the following properties:

(A) shares for all industries should vary in the same direction;

(B) the ordering of industries by ownership share should remain unchanged;

(C) shares should be fixed for industries in which they are initially zero or one; and

(D) changes in individual industry shares should be consistent with changes in the overall share.

A rule which satisfies these conditions is

$$dQ_j = Q_j(1-Q_j)\psi, \tag{2}$$

where Q_j denotes the local ownership share in industry *j*, and ψ denotes the absolute change in Ψ, a shift variable common to all industries. It has an additional property, which may be considered desirable, symmetrical treatment of local and foreign ownership. That is, given any required overall local share, revising foreign ownership shares by this procedure gives the same results as revising local ownership shares.

In percentage change form, we have

$$q_j = (1-Q_j)\psi, \tag{H23}$$

where q_j denotes the percentage change in the local ownership share for industry *j*. For any required percentage change q in the average local ownership share, there is some value of the shift variable ψ which generates jointly consistent changes in the individual shares q_j. We determine this value by the condition that the value of local equity calculated using individual-industry local ownership shares should agree with the value calculated using the aggregate value of equity and the average local ownership share:

$$\sum_{j=1}^{h} S_{2j}^{Q}(q_j + \pi_j + k_j(0)) = q + \sum_{j=1}^{h} S_{2j}(\pi_j + k_j(0)), \qquad \text{(H24)}$$

where π_j denotes the price of capital in industry *j* and $k_j(0)$ the quantity, S_{2j} the share of industry *j* in the aggregate capital stock, and S_{2j}^{Q} its share in aggregate locally owned capital.

Then in equation (H17) we can replace the average by the individual-industry local-ownership share:

$$r_j^t = y_{2j}^d - S_j^Q q_j. \qquad \text{(H17′)}$$

Apart from correcting the underestimation of the sensitivity of the average earnings share to the average ownership share in all simulations, this treatment has another benefit in large-change simulations. By providing feasible results for local ownership shares in individual industries, it enables us to provide formulae for updating the ownership shares in the database.

The revision rule expressed by equation (1) is suitable not only for generating local ownership shares for individual industries in simulations, but also for revising local ownership shares in generating the full form of the database. This is not surprising, since the two procedures perform similar tasks. The only difference is that, whereas the equation system requires the differential form of the rule, the database generation procedure can use the exact form. Integrating equation (1), this is found to be the logistic equation,

$$Q_j = \frac{e^{\Psi}\hat{Q}_j}{1+(e^{\Psi}-1)\hat{Q}_j},$$

or, putting P for e^{Ψ},

$$Q_j = \frac{P.\hat{Q}_j}{1+(P-1)\hat{Q}_j}. \qquad (1′)$$

Compared to the current formula, the use of this formula in the database generation procedure would have one minor advantage, of allowing consistency with the procedure used to update the database in large-change simulations, and no apparent disadvantages.

If both the share parameters for calculating aggregate capital stocks, and the procedure for calculating foreigners' capital earnings, are revised as proposed above, then the equation system will have the property, that a one per cent increase in the foreign ownership share leads (in the absence of compositional effects) to a one per cent increase in foreigners' capital earnings.

In summary, the proposed new treatment of local ownership involves the following elements:

— a new procedure for revising local ownership shares in generating the full form of the database;

— use of disposable earnings rather than factor cost weights in calculating the aggregate capital stock and the average purchase price of Australian-owned capital; and

— a new treatment of local ownership shares in individual industries, which achieves consistency with the overall local ownership share, while at the same time generating feasible changes in local ownership shares in all individual industries.

3. Effects on simulation results: example

To illustrate the effects of the proposed revisions on simulation results, simulations were conducted of a removal of all tariff, import quota, and bounty assistance to non-food manufacturing, using both the current and the proposed revised equation system. The simulations were conducted using a modified version of the standard 1980-81 database and a modified version of the standard long-run closure.

The modifications to the database were:

— specifying all industries, except the dummy industry 'non-competing imports' as endogenous investment industries; and

— introducing fixed factors into mining industries, and changing the CRESH parameters, so as to make the long-run supply elasticities equal to 10.0.

The following modifications were made to the standard long-run closure (Dee 1989, Table 4.10):

— the real government borrowing requirement was made exogenous, and the general income tax shift variable was made endogenous, so as to maintain a constant stance of fiscal policy; and

— the consumption shift variable was made endogenous, and the consumption-saving ratio exogenous, so as to apply the Horridge (1985) rather than the fiscal treatment of the determination of aggregate household consumption expenditure.

Summary results are reported in Table 2.

The comparison shows that the current equation system severely understates the effects of the fall in the local ownership share on foreigners' earnings from local capital. This in turn leads to overestimation of the benefits of assistance reform as measured by real GNP and consumption. But while the proposed corrections greatly increase the estimated cost of the servicing the foreign capital inflows associated with tariff reform, they still leave a substantial net benefit to Australians. The gains from trade flowing from tariff reform lead to an improvement in Australian living standards, even when the estimated increase in income payments to foreigners is revised upwards.

It is also interesting to note that, despite the downwards revision of consumption, the estimated decline in average real after-tax wage rates remains almost unchanged, as a downwards revision of average after-tax money wage rates is almost entirely offset by a downwards revision of consumer prices. So this partial welfare indicator is almost unaffected by the revised local ownership treatment, at least in this simulation.

TABLE 2: **Estimated effects of removing assistance to non-food manufacturing: results with different treatments of local ownership**
(Percentage changes)

	Current	*Revised*	*Difference*
Standard reported macroeconomic variables			
Real GNP	0.27	0.17	-0.11
Real GDP	0.77	0.83	0.06
Real consumption	0.34	0.23	-0.11
Real investment	1.73	1.83	0.10
Export volume	8.40	9.06	0.67
Import volume	7.34	7.30	-0.04
Balance of trade[a]	-0.06	0.04	0.10
Consumer price index	-3.14	-3.28	-0.13
Real after-tax wage rate	-0.26	-0.27	-0.01
Persons employed	0.13	0.13	0.01
Capital stock	1.73	1.83	0.10
General income tax shift	7.53	7.01	-0.52
Additional reported macroeconomic variables			
Disposable non-labour earnings	-2.29	-2.26	0.03
Local ownership share	-1.49	-1.63	-0.14
Foreigners' earnings from local capital	4.27	12.59	8.32
Australians' earnings from overseas capital	-0.95	-1.04	-0.08
GDP	-2.47	-2.56	-0.09
GNP	-2.59	-2.83	-0.24
Activity level, by broad sector			
Agriculture etc.	3.40	3.66	0.26
Mining	6.81	7.51	0.70
Manufacturing	-1.53	-1.35	0.18
Services	0.59	0.57	-0.02

a Change in balance of trade as percentage of GDP.

4. Concluding remarks

The results from the illustrative simulations confirm that the current treatment of local ownership shares for individual industries in FH-ORANI is a significant source of error in simulation results. The current treatment leads to severe understatement of the effects of changes in the overall local ownership share on GNP. The proposed new treatment eliminates these errors, with little increase in the complexity of the model.

The treatment of local ownership shares proposed here has now been incorporated in a restandardised version of FH-ORANI, ORANI-IC92, developed for use in the Industry Commission (McDougall and Skene 1992).

TAXATION OF EARNINGS OF FIXED CAPITAL IN FH-ORANI[1]

by

R.A. McDougall

1. Introduction

This paper proposes a revised treatment of taxation of earnings of fixed capital in FH-ORANI (Dee 1989). Section 2 describes the present treatment, and Section 3 identifies some anomalies in it. Section 4 proposes a new treatment, and Section 5 describes its implementation. Section 6 reports simulation results illustrating the effects of the revised treatment. Section 7 discusses implications for the construction of the fiscal ORANI database, and Section 8 provides a summary.

2. The current treatment

In FH-ORANI each industry uses three or four primary factors: labour, fixed capital, working capital, and, if appropriate, agricultural land. Labour, fixed capital and land are combined in a CRESH function (Hanoch 1971) to form a composite primary factor input. The composite factor, working capital, and intermediate inputs are combined in a Leontief (fixed proportions) function to support the level of activity in the industry.

Primary factor costs include not only factor earnings but also payroll tax (on labour usage) and property taxes (on fixed capital and land usage). Earnings of fixed capital, land, and working capital comprise non-labour income. Depreciation and investment allowances are subtracted from non-labour income to yield taxable non-labour income. Applying the relevant tax rate to this base yields tax on non-labour income.

This theoretical structure defines tax on non-labour income as a whole, but not tax on its individual components. In particular, it does not define tax on earnings of fixed capital; nor, consequently, does it define disposable earnings of fixed capital.

1 The author thanks Alexandra Strzelecki for computing assistance, and Alan Powell for comments on an earlier draft.

This creates a difficulty, since those variables are needed in the model. Disposable earnings of fixed capital appears in the equation defining property income accruing to foreigners (because the theoretical structure allows for foreign ownership of fixed capital, but not of land or working capital). Tax on earnings of fixed capital enters implicitly into the equation defining after-tax rates of return on fixed capital (this equation in FH-ORANI replaces the equation defining pre-tax rates of return in standard ORANI).

In the current theoretical structure, the difficulty is met by imputing to fixed capital, in the equations defining disposable earnings and after-tax rates of return, a fixed share of tax on non-labour income. This share is set equal to the initial share (calculated from the database) of earnings of fixed capital in non-labour income (Dee 1989, pp. 94, 98).

Table 1 lists these two equations, and others required for later reference (not in percentage change form, but in levels). Variables and parameters are listed in table 2. In the first two equations note especially the appearance as a parameter of the initial share of tax on earnings of fixed capital in tax on non-labour income, S_j^Q.

3. Anomalies in the current treatment

The current treatment of taxation of non-labour income contains two anomalies. The first relates to the depreciation and investment allowances. These reduce the tax base, and so generate reductions in tax on non-labour income. The current treatment apportions these tax reductions between earnings of fixed capital and other non-labour income. But only fixed capital is depreciable, and only fixed capital investment attracts investment allowances. So the tax reductions should be allocated entirely to earnings of fixed capital.

The second anomaly arises because the share of tax on earnings of fixed capital in tax on non-labour income is treated not as a variable but as a constant. This gives rise to anomalous results in simulations in which the quantity or the unit cost of fixed capital varies relative to other non-labour factor inputs. In these simulations, changes will occur in the share of earnings of fixed capital in non-labour income. These changes should lead to changes in the share of tax on earnings of fixed capital in tax on non-labour income. Holding the tax share constant while the income share varies entails implicit changes in the rates of tax on fixed capital and other non-labour income. These tax rate changes have no justification.

TABLE 1: **FH-ORANI equations relating to taxation of earnings of fixed capital** (continued)

Identifier	*Equation*	*Description*
Equations requiring revision		
(H18)	$Y_{2j}^{d} = Y_{(g+1,2)j}^{g} - S_j R_j^{YK}$	Disposable earnings of fixed capital
(H20)	$R_j(0) = \frac{P_{(g+1,2)j}^{(1)}}{\Pi_j} - d_j - \frac{R_{2j}^{PK} + S_j R_j^{YK}}{\Pi_j K_j(0)}$	After-tax rate of return
Related equations		
(12.46)	$P_{(g+1,1)j}^{(1)} X_{(g+1,1)j}^{(1)} = \sum_{m=1}^{M} P_{(g+1,1,m)j}^{(1)} X_{(g+1,1,m)j}^{(1)}$	Gross labour cost by industry as sum over occupations of gross labour cost by industry and occupation
(18.2)	$\sum_{i=1}^{g} P_{(i1)}^{(0)} X_{(i1)j}^{(0)} = \sum_{i=1}^{g}\sum_{s=1}^{2} P_{(is)j}^{(1)} X_{(is)j}^{(1)} + \sum_{m=1}^{M} P_{(g+1,1,m)j}^{(1)} X_{(g+1,1,m)j}^{(1)} + \sum_{v=2}^{3} P_{(g+1,v)j}^{(1)} X_{(g+1,v)j}^{(1)} + P_{g+2,j}^{(1)} X_{g}^{(}$	Zero pure profits in production
(20.9)	$K_j(0) = X_{(g+1,2)j}^{(1)}$	Demand equals supply for capital
(F12)	$Y_{(g+1,2)j}^{t} = P_{(g+1,2)j}^{(1)} X_{(g+1,2)j}^{(1)}$	Gross cost of fixed capital
(F13)	$Y_{(g+1,3)j}^{t} = P_{(g+1,3)j}^{(1)} X_{(g+1,3)j}^{(1)}$	Gross cost of land

TABLE 1: **FH-ORANI equations relating to taxation of earnings of fixed capital** (continued)

Identifier	*Equation*	*Description*
(F14)	$Y^{t}_{(g+2)\,j} = P^{(1)}_{wj} X^{(1)}_{g+2,\,j}$	Cost of working capital
(F15)	$R^{PK}_{2\,j} = T^{PK}_{2\,j} \Pi_{j} X^{(1)}_{(g+1,\,2)\,j}$	Property tax on fixed capital
(F17)	$Y^{g}_{(g+1,2)\,j} = Y^{t}_{(g+1,2)\,j} - R^{PK}_{2\,j}$	Earnings of fixed capital
(F18)	$Y^{g}_{(g+1,3)\,j} = Y^{t}_{(g+1,3)\,j} - R^{PK}_{3\,j}$	Earnings of land
(F19)	$Y^{g}_{(g+1)\,j} = Y^{g}_{(g+1,2)\,j} + Y^{g}_{(g+1,3)\,j} + Y^{t}_{(g+2)\,j}$	Non-labour income
(F20)	$R^{YK}_{j} = T^{YK}_{j} (Y^{g}_{(g+1)\,j} - \Delta_{j} \Pi_{j} X^{(1)}_{(g+1,2)\,j} - \mathrm{A}_{j} \Pi_{j} Y_{j})$	Tax on non-labour income
(F21)	$Y^{d}_{(g+1)\,j} = Y^{g}_{(g+1)\,j} - R^{YK}_{j}$	Disposable non-labour income
(F26)	$R^{NI}_{j} = P^{(1)}_{g+2,\,j} X^{(1)}_{g+2,\,j} - P^{(1)}_{wj} X^{(1)}_{g+2,\,j}$	Non-commodity indirect taxes n.e.c.
(H16)	$R_{t} = \sum_{j=1}^{h} R^{t}_{j}$	Property income to overseas

Note: Subscript range for all equations is $j = 1, \ldots, h$.
g Number of commodities; h Number of industries; M Number of occupations; n.e.c. Not elsewhere classified.
Sources: Dixon *et al.* (1982), Dee (1989).

TABLE 2: **Variables and parameters in FH-ORANI equations relating to taxation of earnings of fixed capital**

Variables

A_j	j = 1,...,h.	h	Rate of investment allowance
Δ_j	j = 1,...,h.	h	Rate of depreciation allowance
Π_j	j = 1,...,h.	h	Purchase price of capital
$K_j(0)$	j = 1,...,h.	h	Stock of fixed capital, by industry
$P^{(1)}_{(is)j}$	i = 1,...,g, s = 1,2, j = 1,...,h.	2gh	Purchasers' price of commodity inputs in intermediate usage
$P^{(1)}_{(g+1,v)j}$	v = 1,2,3, j = 1,...,h.	3h	Unit cost of labour, fixed capital, and land
$P^{(1)}_{(g+1,1,m)j}$	m = 1,...,M, j = 1,...,h.	Mh	Unit cost of labour, by occupation
$P^{(0)}_{(i1)}$	i = 1,...,g.	g	Basic prices of domestic commodities
$P^{(1)}_{wj}$	j = 1,...,h.	h	Rental price of working capital
R^{YK}_j	j = 1,...,h.	h	Tax on non-labour income
R^{PK}_{3j}	j = 1,...,h.	h	Property tax on land
$R_j(0)$	j = 1,...,h.	h	Rate of return on fixed capital
R^{NI}_j	j = 1,...,h.	h	Non-commodity indirect taxes n.e.c.
R^{PK}_{2j}	j = 1,...,h.	h	Property tax on fixed capital
R_t		h	Property income to overseas
R^t_j	j = 1,...,h.	h	Property income to overseas, by industry
T^{PK}_{2j}	j = 1,...,h.	h	Rate of property tax on fixed capital
T^{YK}_j	j = 1,...,h.	h	Rate of tax on non-labour income
$X^{(1)}_{(is)j}$	i = 1,...,g, s = 1,2, j = 1,...,h.	2gh	Demand for inputs into current production

TABLE 2: **Variables and Parameters in FH-ORANI equations relating to taxation of earnings of fixed capital** (continued)

$X^{(1)}_{g+2,j}$	$j = 1,...,h.$	h	Demand for 'other cost' tickets
$X^{(1)}_{(g+1,1,m)j}$	$m = 1,...,M,$ $j = 1,...,h.$	Mh	Demand for labour, by occupation
$X^{(1)}_{(g+1,v)j}$	$v = 1, 2, 3,$ $j = 1,...,h.$	$3h$	Demand for labour, fixed capital, and land
$X^{(0)}_{(i1)j}$	$i = 1,...,g,$ $j = 1,...,h.$	gh	Supply of commodities
Y_j	$j = 1,...,h.$	h	Capital creation
Y^d_{2j}	$j = 1,...,h.$	h	Disposable earnings of fixed capital
$Y^g_{(g+1)j}$	$j = 1,...,h.$	h	Non-labour income
$Y^d_{(g+1)j}$	$j = 1,...,h.$	h	Disposable non-labour income
$Y^g_{(g+1,2)j}$	$j = 1,...,h.$	h	Earnings of fixed capital
$Y^g_{(g+1,3)j}$	$j = 1,...,h.$	h	Earnings of land
$Y^t_{(g+2)j}$	$j = 1,...,h.$	h	Cost of working capital
$Y^t_{(g+1,2)j}$	$j = 1,...,h.$	h	Gross cost of fixed capital
$Y^t_{(g+1,3)j}$	$j = 1,...,h.$	h	Gross cost of land
Parameters			
d_j	$j = 1,...,h.$	h	Economic rate of depreciation
S_j	$j = 1,...,h.$	h	Share of tax on earnings of fixed capital in tax on non-labour income

g Number of commodities
h Number of industries
M Number of occupations
n.e.c. Not elsewhere classifiedimplicit changes in the rates of tax on fixed capital and other non-labour income. These tax rate changes have no justification.

4. Derivation of a revised treatment

In this section we derive revised equations for disposable income from fixed capital and after-tax rates of return on fixed capital. Table 3 presents the revised equations together with equations used in deriving them. Table 4 provides descriptions for variables introduced in table 3.

In modelling producer behaviour, producers may either be assumed to rent productive assets and minimise costs, or else to own assets and maximise profits. The two approaches yield identical results (Dixon, Parmenter, Sutton and Vincent 1982, p. 77).

In defining disposable earnings of fixed capital we assume that producers rent assets. Then each industry pays asset rent to three groups of property owners, namely the owners of fixed capital, land, and working capital; and each group is taxed on its rental earnings according to equation (F20) of table 1. Then, assuming that owners of fixed capital and investors in fixed capital are the same group of persons, their disposable income is as defined in equation (H18*), table 3.

In the revised equation, disposable income from fixed capital is equal to income less tax on earnings of fixed capital. Tax on earnings of fixed capital is equal to the non-labour income tax rate multiplied by taxable earnings of fixed capital. Taxable earnings of fixed capital are equal to earnings less depreciation and investment allowances. Since the whole of the depreciation and investment allowances are deducted from taxable earnings of fixed capital, the corresponding tax reductions are imputed entirely to earnings of fixed capital.

In revising the rate-of-return equation we adopt the profit-maximising rather than the cost-minimising approach. This entails some extra complexity, but is more in harmony with the existing FH-ORANI formulation, and is done to remove any doubt that our derivation is consistent with FH-ORANI's theoretical presuppositions.

The rate-of-return equation is a relation between the purchase price, the rate of return, and the rental price of fixed capital, and various other variables. In long-run ORANI simulations, its function is to determine the rental price of capital. Since, under the

TABLE 3: **Revision of FH-ORANI equations relating to taxation of earnings of fixed capital** (continued)

Identifier	*Equation*	*Description*
	Revised FH-ORANI equations	
(H18*)	$Y^{d}_{2j} = Y^{g}_{(g+1,2)j} - T^{YK}_{j}(Y^{g}_{(g+1,2)j} - \Delta_j \Pi_j K_j(0) - \mathrm{A}_j \Pi_j Y_j)$	Disposable earnings of fixed capital
(H20*)	$R_j(0) = [P^{(1)}_{(g+1,2)j} - T^{PK}_{2j}\Pi_j - T^{YK}_{j}(P^{(1)}_{(g+1,2)j} - T^{PK}_{2j}\Pi_j - \Delta_j \Pi_j)]/[(1-T^{YK}_{j}\mathrm{A}_j)\Pi_j] - d_j$	After-tax rate of return
	Equations used in deriving the revised equations	
(T1)	$P^{(1)}_{(g+1,2)j} = \Psi_{(g+1,1)(g+1,2)j} P^{(1)}_{(g+1,1)j}$	Cost minimisation condition
(T2)	$V_j = \int_{t=0}^{\infty} D_j e^{-R_j(0)t} dt$	Present value of stream of future dividends
(T3)	$E_j = \sum_{i=1}^{g} P^{(0)}_{(i1)} X^{(0)}_{(i1)j} - \sum_{i=1}^{g}\sum_{s=1}^{2} P^{(1)}_{(is)j} X^{(1)}_{(is)j} - R^{NI}_{j}$	Gross factor cost
(T4)	$Y^{g}_{(g+1)j} = E_j - P^{(1)}_{(g+1,1)j} X^{(1)}_{(g+1,1)j} - T^{PK}_{2j}\Pi_j K_j(0) - R^{PK}_{3j}$	Non-labour income, calculated as a residual
(T5)	$Y^{d}_{(g+1)j} = (1-T^{YK}_{j})Y^{g}_{(g+1)j} + T^{YK}_{j}\Delta_j \Pi_j K_j(0) + T^{YK}_{j}\mathrm{A}_j \Pi_j Y_j$	Disposable non-labour income
(T6)	$D_j = Y^{d}_{(g+1)j} - \Pi_j Y_j$	Dividends

TABLE 3: **Revision of FH-ORANI equations relating to taxation of earnings of fixed capital** (continued)

Identifier	*Equation*	*Description*
(T7)	$\dot{K}_j\ (0) = -d_j K_j(0) + Y_j$	Time rate of change in stock of fixed capital
(T8)	$D_j = (1 - T_j^{YK}) Y^g_{(g+1)j} + T_j^{YK} \Delta_j \Pi_j K_j(0) - (1 - T_j^{YK} \mathrm{A}_j) \Pi_j (d_j K_j(0) + \dot{K}_j(0))$	Dividends, calculated as a residual
(T9)	$0 = \frac{\partial}{\partial K_j(0)} e^{-R_j(0)t} D_j - \frac{d}{dt} \frac{\partial}{\partial \dot{K}_j(0)} e^{-R_j(0)t} D_j$	Euler equation
(T10)	$(1 - T_j^{YK})(\Psi_{(g+1,1)(g+1,2)j} P^{(1)}_{(g+1,1)j} - T_{2j}^{PK} \Pi_j) + T_j^{YK} \Delta_j \Pi_j + \frac{d}{dt}(1 - T_j^{YK} \mathrm{A}_j) \Pi_j$ $= (1 - T_j^{YK} \mathrm{A}_j)(d_j + R_j(0)) \Pi_j$	Euler equation, after substitution from (T8) and (T4)
(T11)	$(1 - T_j^{YK})(P^{(1)}_{(g+1,2)j} - T_{2j}^{PK} \Pi_j) + T_j^{YK} \Delta_j \Pi_j + \frac{d}{dt}(1 - T_j^{YK} \mathrm{A}_j) \Pi_j$ $= (1 - T_j^{YK} \mathrm{A}_j)(d_j + R_j(0)) \Pi_j$	Euler equation, after substitution from (T1)
(T12)	$\frac{d}{dt}(1 - T_j^{YK} \mathrm{A}_j) \Pi_j = 0$	Zero capital gains

Note: Subscript range for all equations is $j = 1,...,h$.

g Number of commodities
h Number of industries
n.e.c. Not elsewhere classified

TABLE 4: **Variables introduced in deriving the revised equations**

Variable	*Subscript range*	*Number*	*Description*
$\Psi_{(g+1,1)(g+1,2)j}$	$j = 1,...,h.$	h	Marginal rate of technical substitution of labour for fixed capital
D_j	$j = 1,...,h.$	h	Dividends
E_j	$j = 1,...,h.$	h	Gross factor earnings
$\dot{K}_j$ (0)	$j = 1,...,h.$	h	Time rate of change in the stock of fixed capital
V_j	$j = 1,...,h.$	h	Present value of the stream of future dividends

h Number of industries

profit-maximising approach, the rental price is not an observable variable, it may not be obvious whether the rate-of-return equation is determining it correctly.

Besides the rate of return equation, the rental price of capital appears in the primary factor demand equations and in the zero profits condition for domestic production. Its functions in long-run simulations are therefore to help determine factor demands and output prices. Then (assuming no errors elsewhere in the model) the rate of return equation is valid if and only if factor demands and output prices are determined correctly. This gives us two separate necessary conditions for the validity of the rate of return equation.

In long-run simulations, the zero profits condition determines output prices correctly if fixed capital earnings are consistent with asset market equilibrium (where the rate of return variable in the model is interpreted as the rate required by investors). The factor demand equations are valid if the factor input mix is consistent with profit maximisation. Either of these conditions is sufficient to determine the rate of return equation.

In this section we determine the rate of return equation using the condition on the factor input mix. The equation so determined has a simple intuitive interpretation. This interpretation makes it obvious that the equation satisfies the condition on fixed capital earnings.

In the ORANI treatment of production, enterprises substitute between labour, fixed capital, and land, so as to minimise the cost of maintaining a given activity level. A necessary condition for cost minimisation is that factor cost price ratios are equal to marginal rates of technical substitution. This gives rise to a condition involving the wage rate, the rental price of capital, and the marginal rate of technical substitution between capital and labour (table 3 equation T1). This equation is implicit in the standard ORANI equations for demand for primary factors.

We use this condition in deriving a revised rate-of-return equation. Following the profit maximising approach, we first derive a profit-maximising condition involving the purchase price of capital, the rate of return, the marginal rate of technical substitution and the wage rate. Since profit maximisation and cost minimisation are equivalent, we should be able to obtain the same equation by the cost-minimisation approach, by combining equation (T1) with a suitable rate-of-return equation. Conversely, from the profit-maximising condition and equation (T1), we can determine the rate-of-return equation.

We interpret profit maximisation in an intertemporal context as maximisation of the present value of the stream of future dividends (equation T2). The discount rate is the required rate of return $R_j(0)$; for simplicity, we assume that this rate is constant over time.

Since the ORANI production technology exhibits constant returns to scale, the activity level of individual firms is indeterminate. So we cannot use profit maximisation to determine the activity level. Instead we take the time path of activity as exogenous, and maximise the present value of the dividend stream conditional on this time path.

Since the ORANI production technology is Leontief in intermediate inputs, the time path for intermediate usage is determined by the time path for activity. With activity and intermediate usage given, all that remains to be determined is the mix of primary factor inputs. The firm chooses the time paths for employment of primary factors, conditional on the time path for activity, so as to maximise the present value of the stream of future dividends.

Since fiscal ORANI includes direct taxes, we specify the firm's objective in terms of after-tax rather than before-tax dividends. After-tax dividends are given by disposable non-labour income and investment expenditure. Disposable non-labour income is given by gross non-labour income and income tax. Gross non-labour income is

included together with certain indirect taxes (payroll, property, and land taxes) in gross factor cost.

To derive an expression for after-tax dividends in terms of ORANI variables, we begin by expressing gross factor cost as revenue less intermediate usage costs less non-commodity indirect taxes not elsewhere classified (n.e.c.) (T3). Taking as given the time paths for activity, output prices, and intermediate input prices as exogenous, the time path for gross factor cost can also be taken as given in the optimisation problem.

Using equations from standard and FH-ORANI (12.46, 18.2, F12-15, F18-19, F26) we can express non-labour income as gross factor cost less gross labour cost and property tax (T4). For simplicity, we assume that property taxes are fully indexed to property values (this assumption will later be relaxed). Substituting for tax on non-labour income from (F20) into (F21), we obtain a new equation for disposable non-labour income (T5). Dividends are equal to disposable non-labour income less investment expenditure (T6); the time rate of change in the capital stock is equal to gross investment less depreciation (T7). Substituting for disposable income, usage of fixed capital, and investment, from (T5, 20.9, T7) into (T6), we obtain an expression for dividends (T8).

From the calculus of variations, a necessary condition for a solution of the maximisation problem (T2) is the Euler equation (T9). Substituting for dividends and non-labour income from (T8, T4) into (T9), we obtain (T10). We assume for simplicity that land usage, if any, is fixed, and that the firm meets the activity level constraint by substituting between capital and labour.

For the ORANI factor demand equations to be consistent with profit maximisation, (T1) and (T10) must be satisfied simultaneously. This gives us the general form of the rate-of-return equation, (T11). Since ORANI, being a one-period model, cannot determine capital gains, we set them arbitrarily to zero (T12). Hence we obtain the revised rate-of-return equation (H20*).

Although we set up the investment decision problem as an intertemporal optimisation problem, we see in (T11) and (H20*) that the solution involves only current variables. This outcome is usual when the problem does not involve adjustment costs. If the firm can adjust its capital stock costlessly and instantaneously, then the optimal current stock depends only on current circumstances (cf. e.g. Nickell 1978). This allows us to solve the problem without specifying the firm’s expectations of future circumstances.

Equations (T11, H20*) have a simple intuitive interpretation. Tax on fixed capital earnings can be expressed as the difference between the tax that would be payable in the absence of depreciation and investment allowances, and the tax reductions generated by those allowances. But from (T11, H20*) we see that for rate-of-return calculations, firms take a different attitude to the tax reduction generated by the investment allowance. This allowance generates not a continuing reduction in tax, but a one-off reduction, occuring near the time when the investment is made. So instead of having a continuing positive effect on disposable income, the allowance in effect offsets part of the initial capital outlay. In short, the tax reduction generated by the investment allowance is equivalent to an investment subsidy.

Although apparently more complicated, the revised rate-of-return equation is essentially simpler than the original FH-ORANI equation. In the original equation, tax on earnings of fixed capital depend not only on the tax regime, capital earnings, and (because of the investment allowance) investment expenditure, but also implicitly on the other components of non-labour income. This was because changes in these other components lead to changes in tax on non-labour income; and this, under the assumption of fixed tax shares, leads to changes in tax on earnings of fixed capital. In the revised treatment, tax on earnings of capital is not affected by changes in the other components of non-labour income.

This simplifies the behaviour of the model in long-run simulations. In standard 'green-book' ORANI, with rates of return fixed, the rental price of capital is directly proportional to the purchase price. Under the original FH-ORANI treatment, even with a fixed income tax regime, this proportionality does not hold, because the implicit rate of tax on earnings of fixed capital is liable to vary. Under the revised treatment, this variation is eliminated, and the rental price of capital is again proportional to the purchase price.

Equations (H18*, H20*) are presented in table 3 in levels of variables. To be incorporated into the FH-ORANI equation system, they must be converted to percentage change form. This is done in table 5 (corresponding to table 3.1 of Dee

TABLE 5: **Linearisation of the revised equations**

Identifier	*Equation*	*Description*
(H18*)	$y^{d}_{2j} = B^{YK}_{2j}\, y^{g}_{(g+1,2)j} - (B^{YK}_{2j} - 1)[t^{YK}_{j} + G^{YK}_{2j}\, y^{g}_{(g+1,2)j} - D^{YK}_{2j}(\delta_j + \pi_j + k_j(0)) - A^{YK}_{2j}(\alpha_j + \pi_j + y_j)]$	Disposable earnings of fixed capital
(H20*)	$r_j(0) = Q^{FK}_{j}(B^{FK}_{j}\{B^{PK}_{2j}\, p^{(1)}_{(g+1,2)j} - [B^{PK}_{2j} - 1][t^{PK}_{2j} + h^{P}_{j}\pi_j]\}$ $-\{B^{FK}_{j} - 1\}\{t^{YK}_{j} + G^{FK}_{j}[B^{PK}_{2j}\, p^{(1)}_{(g+1,2)j} - (B^{PK}_{2j} - 1)(t^{PK}_{2j} + h^{P}_{j}\pi_j)] - [G^{FK}_{j} - 1][\delta_j + \pi_j]\}$ $+A^{FK}_{j}\{t^{YK}_{j} + \alpha_j\} - \pi_j)$	After-tax rate of return

Note: Subscript range for all equations is $j = 1,...,h$.

1989). The new equations contain no new variables, but several new coefficients; these are defined in table 6 (corresponding to table 3.3). The assumption that property tax on fixed capital is fully indexed to the purchase price of capital is relaxed, so that as in the current theoretical structure the degree of indexation is specified by a parameter h_j^P which is read from the database.

One set of coefficients appearing in another equation must also be changed. These are the coefficients s_j^{rt}, representing shares of industries j in aggregate property income to overseas. These coefficients appear in equation (H16) of the modified Horridge extension, in which aggregate property income to overseas is calculated as the sum of property income to overseas from each individual industry. These shares change because the equations for disposable earnings of fixed capital in individual industries change, not only in percentage changes but also in the levels. We include the revised formula in table 6.

5. Implementation of the revised treatment

For the TABLO implementation of FH-ORANI, the information in tables 5 and 6 is sufficient to specify the implementation of the revised treatment. For the hand-crafted implementation, the equations from the condensed system, involving equations (H18, H20) of the full system, must be revised. The revision of the condensed system is summarised in tables 7 and 8, corresponding to tables 4.2 and 4.4 of Dee (1989).

The new treatment of tax on earnings of fixed capital requires revision not only of the equation system, but also of the program INFDAG which expands the condensed into the full form of the database. INFDAG must be revised for the same reason as the share parameters S^{rt}_j in equation (H16), namely that the new treatment implies new values for disposable earnings of fixed capital in individual industries. This affects the calculation of aggregate disposable earnings of fixed capital, the economy-wide average local ownership share of fixed capital, element 3 of array FH04 in the FID file, and Australian shares of industry capital stocks, array FH01 (new versions of the INFDAG program and the header array structure of the database, incorporating these changes, are described in Strzelecki 1992).

TABLE 6: **Coefficients introduced in the revised equations**

Equation	*Coefficient*	*Description*	*Source (ODB = ORANI database, FDB = fiscal database)*
(H16)	S_j^{rt}	Share of industry *j* in property income to overseas.[a]	FDB and ODB. Property income to overseas from industry *j* divided by aggregate property income to overseas. Property income to overseas from industry *j* calculated as the foreign share (one minus the domestic share) of disposable earnings of fixed capital. For calculation of disposable earnings see B_{2j}^{YK} below.
(H18*)	B_{2j}^{YK}	Ratio of earnings of fixed capital to disposable earnings of fixed capital in industry *j*.	FDB and ODB. *j*th element of $\mathbf{V} - \mathbf{V}_P$ divided by disposable earnings in industry *j*. Disposable earnings in industry *j* is calculated as *j*th element of $\mathbf{V} - \mathbf{V}_P$ - (tax on earnings of fixed capital). Tax on earnings of fixed capital is calculated as tax rate multiplied by *j*th element of $\mathbf{V} - \mathbf{V}_P - \mathbf{V}_D - \mathbf{V}_A$. Tax rate is calculated as *j*th element of $\mathbf{V}_T$ divided by *j*th element of $\mathbf{V} - \mathbf{V}_P + \mathbf{W} - \mathbf{W}_P + \mathbf{X}_W - \mathbf{V}_D - \mathbf{V}_A$.
(H18*)	G_{2j}^{YK}	Ratio of earnings of fixed capital to taxable earnings of fixed capital in industry *j*.	FDB and ODB. *j*th element of $\mathbf{V} - \mathbf{V}_P$ divided by *j*th element of $\mathbf{V} - \mathbf{V}_P - \mathbf{V}_D - \mathbf{V}_A$.
(H18*)	D_{2j}^{YK}	Ratio of depreciation allowance to taxable earnings of fixed capital in industry *j*.	FDB and ODB. *j*th element of $\mathbf{V}_D$ divided by *j*th element of $\mathbf{V} - \mathbf{V}_P - \mathbf{V}_D - \mathbf{V}_A$.
(H18*)	A_{2j}^{YK}	Ratio of investment allowance to taxable earnings of fixed capital in industry *j*.	FDB and ODB. *j*th element of $\mathbf{V}_A$ divided by *j*th element of $\mathbf{V} - \mathbf{V}_P - \mathbf{V}_D - \mathbf{V}_A$.

(Continued)

TABLE 6: **Coefficients introduced in the revised equations**

Equation	*Coefficient*	*Description*	*Source (ODB = ORANI database, FDB = fiscal database)*
(H20*)	Q_j^{FK}	Ratio of rate of return on fixed capital, after tax but before depreciation, to rate of return after tax and depreciation, in industry *j*.	FDB and ODB. Ratio of effective disposable earnings of fixed capital to effective disposable earnings less effective depreciation. For calculation of effective disposable earnings see B_j^{FK} below. Effective depreciation is calculated as power of the implicit investment subsidy multiplied by depreciation. For calculation of power of the implicit subsidy see A_j^{FK} below. Depreciation is calculated as *j*th element of **V** multiplied by $(1/Q_j - 1)$, where Q_j is a standard ORANI investment parameter.
(H20*)	B_j^{FK}	Ratio of earnings of fixed capital to effective disposable earnings of fixed capital in industry *j*.	FDB and ODB. *j*th element of **V** - $\mathbf{V}_P$ divided by effective disposable earnings of fixed capital. Effective disposable earnings is calculated as **V** - $\mathbf{V}_P$ - (effective tax on earnings of fixed capital). Effective tax is calculated as tax rate multiplied by **V** - $\mathbf{V}_P$ - $\mathbf{V}_D$. For calculation of tax rate, see B_{2j}^{YK} above.
(H20*)	G_j^{FK}	Ratio of earnings of fixed capital to effective taxable earnings of fixed capital in industry *j*.	FDB and ODB. *j*th element of **V** - $\mathbf{V}_P$ divided by *j*th element of **V** - $\mathbf{V}_P$ - $\mathbf{V}_D$.
(H20*)	A_j^{FK}	Ratio of implicit investment subsidy to investment at purchasers' prices less subsidy, in industry *j*.	FDB and ODB. Implicit subsidy rate divided by power of the implicit subsidy. Power of the implicit subsidy is calculated as one less implicit subsidy rate. Implicit subsidy rate is calculated as tax rate multiplied by investment allowance rate. For calculation of tax rate, see B_{2j}^{YK} above. Investment allowance rate is calculated as *j*th element of $\mathbf{V}_A$ divided by *j*th column sum of **B** + **G** + $\mathbf{L}_1$ + $\mathbf{Q}_1$ + ... + $\mathbf{L}_{g+1}$ + $\mathbf{Q}_{g+1}$.

a Redefined coefficient appearing in equation (H16).
n.e.c. Not elsewhere classified

TABLE 7: **Revised equations in the condensed equation system for FH-ORANI**

Identifier	*Equation*	*Number*	*Description*
(12″*)	HL01 rt + HL02 kappa0 + HL03 p(g+1,2) + HL04 pi + HL05 t2pk + HL06 delta + HL07 alpha + HL08 y + HL09 fyk + HL10 fk + HL11 fy + HL12 qshr = 0	1	Substitute from (H17), (H18*), (F17), (F12), (F15), (20.9) and (F72) into (H26).
(16″*)	HP01 r0 + HP02 p(g+1,2) + HP03 pi + HP04 t2pk + HP05 delta + HP06 alpha + HP07 fyk + HP08 fk + HP09 fy = 0	*h*	Substitute from (F72) into (H20*).

h Number of industries

TABLE 8: **Coefficient submatrices for revised equations of the condensed FH-ORANI system**

Name	*Dimension*	*Definition*
HL01	1 x 1	Minus identity
HL02	1 x *h*	$HL02(1,j) = S_j^{rt}[B_{2j}^{YK} - (B_{2j}^{YK} - 1)(G_{2j}^{YK} - D_{2j}^{YK})]$
HL03	1 x *h*	$HL03(1,j) = S_j^{rt}[B_{2j}^{YK} - (B_{2j}^{YK} - 1)G_{2j}^{YK}]B_{2j}^{PK}$
HL04	1 x *h*	$HL04(1,j) = S_j^{rt}\{-[B_{2j}^{YK} - (B_{2j}^{YK} - 1)G_{2j}^{YK}](B_{2j}^{PK} - 1)h_j^P + [B_{2j}^{YK} - 1][D_{2j}^{YK} + A_{2j}^{YK}]\}$
HL05	1 x *h*	$HL05(1,j) = -S_j^{rt}[B_{2j}^{YK} - (B_{2j}^{YK} - 1)G_{2j}^{YK}](B_{2j}^{PK} - 1)$
HL06	1 x *h*	$HL06(1,j) = S_j^{rt}(B_{2j}^{YK} - 1)D_{2j}^{YK}$
HL07	1 x *h*	$HL07(1,j) = S_j^{rt}(B_{2j}^{YK} - 1)A_{2j}^{YK}$
HL08	1 x *h*	$HL08(1,j) = S_j^{rt}(B_{2j}^{YK} - 1)A_{2j}^{YK}$
HL09	1 x *h*	$HL09(1,j) = -S_j^{rt}(B_{2j}^{YK} - 1)$
HL10	1 x 1	$HL10 = -\sum_{j=1}^{h} S_j^{rt}(B_{2j}^{YK} - 1)$
HL11	1 x 1	$HL11 = -\sum_{j=1}^{h} S_j^{rt}(B_{2j}^{YK} - 1)$
HL12	1 x 1	$HL12 = -\sum_{j=1}^{h} S_j^{rt} S_j^{Q}$
HP01	*h* x *h*	Minus identity
HP02	*h* x *h*	$HP02(j,j) = Q_j^{FK}[B_j^{FK} - (B_j^{FK} - 1)G_j^{FK}]B_{2j}^{PK}$
HP03	*h* x *h*	$HP03(j,j) = Q_j^{FK}\{-[B_j^{FK} - (B_j^{FK} - 1)G_j^{FK}][B_{2j}^{PK} - 1]h_j^P + [B_j^{FK} - 1][G_j^{FK} - 1] - 1\}$
HP04	*h* x *h*	$HP04(j,j) = -Q_j^{FK}[B_j^{FK} - (B_j^{FK} - 1)G_j^{FK}](B_{2j}^{PK} - 1)$

TABLE 8: **Coefficient submatrices for revised equations of the condensed FH-ORANI system** (continued)

Name	*Dimension*	*Definition*
HP05	*h* x *h*	$HP05(j,j) = Q_j^{FK}\,(B_j^{FK} - 1)(G_j^{FK} - 1)$
HP06	*h* x *h*	$HP06(j,j) = Q_j^{FK} A_j^{FK}$
HP07	*h* x *h*	$HP07(j,j) = -Q_j^{FK}[(B_j^{FK} - 1) - A_j^{FK}]$
HP08	*h* x 1	$HP08(j,1) = -Q_j^{FK}[(B_j^{FK} - 1) - A_j^{FK}]$
HP09	*h* x 1	$HP08(j,1) = -Q_j^{FK}[(B_j^{FK} - 1) - A_j^{FK}]$

h Number of industries

6. Illustration of the effects of the revised treatment

To illustrate the effects of the revised treatment of taxation of fixed capital on simulation results, this section compares results of three taxation change scenarios with the old and the revised treatment. Both versions of the equation system incorporate the revised treatment of local ownership of domestic capital stocks, described in the other paper in this volume.

The three scenarios simulate three ways of redistributing the burden of direct taxation from capital onto labour: lowering rates of tax on property income, increasing depreciation allowance rates, and increasing investment allowance rates. The first-round value of the tax reduction on non-labour income was the same in each scenario: 2.6 per cent of the initial value of tax on non-labour income. This corresponds to a reduction in the company tax rate from 39 to 38 per cent (ignoring any further personal income tax paid). In each scenario, the reduction in tax on non-labour income was made up in the first round by an increase in tax on labour income. This required rates of tax on labour income to rise by 1.1 per cent (of their initial levels).

The simulations were performed using a slightly modified version of the 1980-81 ORANI database. The modifications were:

- specifying all industries, except the dummy industry ‘non-competing imports’ as endogenous investment industries; and
- introducing fixed factors into mining industries, and changing the CRESH parameters, so as to make the long-run supply elasticities equal to 10.0.

The closure was based on the standard long-run closure of FH-ORANI (Dee 1988, table 4.10), with the following modifications:

- the real government borrowing requirement was made exogenous, and the general income tax shift variable was made endogenous, so as to maintain a constant stance of fiscal policy; and
- the consumption shift variable was made endogenous, and the consumption-saving ratio exogenous, so as to apply the Horridge (1985) rather than the fiscal treatment of the determination of aggregate household consumption expenditure.

In each simulation, a shock was applied to the economy-wide expected rate of return, so as to maintain equal percentage changes in aggregate real investment and the aggregate capital stock. Note that shocks to and results from the model represent not changes over time, but deviations from a base case at a fixed point in time.

Simulation results are shown in table 9. From the first, third, and fifth columns, it can be seen that all three redistribution methods have similar macroeconomic effects in the original equation system. The reduction in tax on non-labour income leads to a fall in the rental price of capital, of 0.4 or 0.5 per cent. This leads to an expansion in the aggregate capital stock of 0.7 or 0.8 per cent, supporting a rise in real GDP of 0.2 per cent. This in turn, partly offset by a fall in the local ownership share of 0.6 or 0.7 per cent, translates into a rise in real GNP of 0.1 per cent. Wage rates rise faster than consumer prices, compensating workers to some extent for higher rates of income tax. Property income payments to foreigners rise by 6 or 7 per cent, as expansion in the capital stock is funded mainly by foreign capital inflow.

The results for a reduction in non-labour income tax rates with the revised theoretical structure, shown in the second column, are very similar to those obtained with the old structure. The main difference is that the effect of the property income tax cut on the rental price of capital is weaker. The reason is that the revised structure allocates less property income tax to earnings of fixed capital, and more to the other components of non-labour income. Since the effective rate of tax on earnings of fixed capital is lower, the absolute change in the effective tax rate is smaller, and the effect on the rental price is weaker. This leads in turn to a weaker effect on the aggregate capital stock, and smaller changes in most other variables.

Although the revision of the non-labour tax treatment has little effect on results from the tax rate reduction scenario, it greatly affects results from the depreciation allowance and investment allowance scenarios (columns 4, 6). Whereas the capital stock expands by only 0.7 or 0.8 per cent under the old treatment, it expands by 1.4 or 1.5 per cent under the new treatment. Similarly, real GDP rises only 0.2 per cent under the old treatment, but 0.4 or 0.5 per cent under the new. These differences are broadly as expected, since the new treatment allocates the tax reductions generated by the allowance rate changes entirely to fixed capital, instead of sharing them between fixed and working capital. Tax reductions on fixed capital earnings are expansionary, since they encourage firms to increase their capital-labour ratios, and with an almost fixed

TABLE 9: **Estimated effects of various property income tax reduction options, under standard and revised treatments of taxation of earnings of fixed capital**

	Lower tax rates		*Higher depreciation allowance rates*		*Higher investment allowance rates*	
	Standard	*Revised*	*Standard*	*Revised*	*Standard*	*Revised*
	[1]	*[2]*	*[3]*	*[4]*	*[5]*	*[6]*
Standard reported macroeconomic variables						
Real GNP	0.10	0.08	0.08	0.14	0.10	0.18
Real GDP	0.22	0.18	0.21	0.39	0.24	0.48
Real consumption	0.11	0.09	0.09	0.15	0.11	0.20
Real investment	0.68	0.57	0.73	1.37	0.76	1.53
Export volume	0.10	0.08	0.08	0.16	0.16	0.35
Import volume	0.31	0.26	0.31	0.56	0.37	0.67
Balance of trade[a]	-0.04	-0.03	-0.04	-0.07	-0.04	-0.06
Consumer price index	0.06	0.05	0.02	0.05	0.05	-0.01
Wage rate	0.28	0.25	0.24	0.43	0.26	0.39
Persons employed	0.01	0.01	0.01	0.02	0.01	0.03
Capital stock	0.68	0.57	0.73	1.37	0.76	1.53
General income tax rate shift	0.05	0.07	0.15	0.33	0.20	0.15
Additional reported macroeconomic variables						
Purchase price of capital	0.05	0.06	0.00	0.02	0.04	-0.14
Gross non-labour income	0.29	0.25	0.24	0.47	0.33	0.53
Tax on non-labour income	-2.36	-2.35	-2.65	-2.58	-2.67	-2.22
Rental price of capital	-0.44	-0.36	-0.54	-0.87	-0.45	-1.08
Local ownership share	-0.64	-0.54	-0.70	-1.30	-0.72	-1.42
Property income to overseas	6.42	5.52	6.94	13.24	7.23	14.25
Activity level, by broad sector						
Agriculture etc	-0.12	-0.14	0.03	0.10	-0.10	-0.01
Mining	0.74	0.72	0.34	0.55	0.96	1.33
Manufacturing	0.22	0.17	0.32	0.60	0.25	0.57
Services	0.23	0.19	0.21	0.39	0.24	0.50

[a] Change in balance of trade as percentage of GDP.

supply of labour, this tends to increase output; but tax reductions on working capital earnings have little expansionary effect, because of the assumption in the ORANI theoretical structure that working capital is used in fixed proportion to output. The real GNP results under the revised treatment are also greater than those under the original

treatment, even though much of the rise in GDP is absorbed in higher income payments to foreigners.

In summary, these simulations show that the revised treatment of non-labour income strongly affects results from simulations involving changes in depreciation and investment allowances. They also suggest that it affects only weakly the response of the model to changes in tax rates on non-labour income. It is possible however that it would influence more strongly results for some industry-specific tax rate changes than for the economy-wide change simulated here.

7. Implications for the construction of the fiscal ORANI database

The revised treatment of tax on non-labour income in the theoretical structure has some implications for the construction of the fiscal ORANI database. In constructing the depreciation and investment tax allowances, Australian Tax Office statistics for aggregated industry groups is allocated across ORANI industries on the basis of shares based on other industry-specific quantities. At present, both depreciation and investment allowances are allocated in proportion to industry capital stocks. With the revised theoretical structure, in which investment allowances are equivalent to commodity subsidies on investment, it would be more appropriate to allocate investment allowances in proportion to industry investment expenditures.

8. Summary and conclusions

This paper has identified three deficiencies in the current treatment of tax on non-labour income in FH-ORANI.

- The tax reductions generated by the depreciation and investment allowances are shared across all components of non-labour income, whereas they should be imputed entirely to earnings of fixed capital.
- The share of tax on earnings of fixed capital in tax on non-labour income is treated as fixed, whereas it should be allowed to vary in response to changes in the composition of non-labour income.

- Enterprises are assumed to regard the investment allowance as a source of continuing reductions in tax on non-labour income, instead as a one-off tax reduction.

A new treatment, consistent with intertemporal optimisation by investors, has been developed and implemented. Illustrative simulation results show that the revised treatment slightly reduces the sensitivity of capital formation to the non-labour income tax rate, but greatly increases its sensitivity to changes in the depreciation and investment allowances. Finally, implications of the new treatment for the construction of the fiscal ORANI database have been considered.

The treatment of taxation of earnings of fixed capital proposed here has now been incorporated in a restandardised version of FH-ORANI, ORANI-IC92, developed for use in the Industry Commission (McDougall and Skene 1992).

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