A GENERAL EQUILIBRIUM APPROACH TO EXAMINING FORESTRY ISSUES IN THE TASMANIAN ECONOMY[1]

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ABSTRACT A computable general equilibrium model of the Tasmanian economy, TASFOR, has been constructed to examine the industry-level effects and state-wide effects of state forestry policies. The theoretical structure of TASFOR is based on the ORANI model (Dixon *et al.* 1982) and ORANI-NT (Parmenter and Meagher 1990). The paper reports the results of an illustrative application; an increase in the price of output of the forestry sector. It illustrates the extent to which previously reported results from the national ORANI models are not applicable for Tasmania.

I. INTRODUCTION

This paper provides a new general equilibrium (GE) analysis of forestry-related issues within Tasmania. Forestry and forest-related industries are major sectors in the Tasmanian economy, providing directly and indirectly approximately 12 per cent of the State's employment, according to CREA (1991). Disagreement over forestry policies, such as resource security, woodchip exports and the logging of old growth forests, has been intense for the last decade. This debate has largely been ideological; there has been little scientific modelling of the forestry sector in Tasmania or in Australia as a whole upon which to base objective analysis. One exception is Bruce's study (1988) using the ORANI model, which reports the results of economic shocks within the Australian forestry sector.

A general equilibrium approach has been adopted in this paper due to its strength in capturing interindustry links and its ability to include macro-economic aggregates such as real wages (or the level of employment), trade balances and the level of income, consumption, and investment. In addition, these models allow for price-induced substitution for both industrial inputs and outputs and for final demands. Finally, these models are highly flexible and capable of analysing a variety of shocks under different economic environments. The author's model, known as TASFOR, is based closely on the ORANI model developed in the late 1970's by the IMPACT Project, and the ORANI-NT model of the Northern Territory. A full account of the ORANI model is given in Dixon *et al.* (1982); ORANI-NT is described in Meagher and Parmenter (1990).

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[1] Research reported in this paper forms part of the author's Ph.D topic. The assistance of Dr John Madden and an anonymous referee is gratefully acknowledged.

The structure of the paper is as follows: first there is a brief description of TASFOR and of construction of the database, then the effects of an illustrative shock are discussed at both the state-wide and industry level, the effects of wage indexation are examined, and finally TASFOR's results are compared with those from Bruce's earlier study.

2. THE TASFOR MODEL

2.1 Model Description

TASFOR is a stand-alone model of the Tasmanian economy. For many purposes there are advantages in developing a 2-region model, such as FEDERAL (Madden 1990), which specifies the two-way links between Tasmania and mainland Australia. However, the relatively small size of Tasmania within Australia makes it suitable for a stand-alone model. TASFOR treats mainland commodity prices as exogenous, implying that they are unaffected by changes in the Tasmanian economy.[2]

The theoretical structure of TASFOR is based closely on ORANI-NT, which in turn is an extension of the original ORANI model. In brief, these GE models have strong neo-classical foundations; for example, they assume that industries are profit-maximising, competitive and efficient, and that households are utility-maximising. The model's equations are derived from the assumptions of the behaviour of economic agents and from their constraints. In the levels of the variables, ORANI models are non-linear but linear approximations are computed by using percentage changes of these variables. A list of the variables in TASFOR is contained in the Appendix.

In TASFOR, there are two separate export destinations, namely interstate Australia and overseas, and three sources of supply (Tasmania, interstate and international) for commodity buyers in Tasmania, which comprise industries, households and government. Tasmania is assumed to be a price-taker for its imported commodities.

TASFOR differs from ORANI -NT in the following ways:

1. The current version of TASFOR includes a single government sector; no distinction is made between Federal and State government.
2. For simplicity, labour is treated as homogenous and perfectly mobile between industries.[3]

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[2] A justification for treating mainland prices as exogenous can be found in some simulations in Dixon *et al.* (1990). They report the results of reducing Tasmanian government expenditure using the FEDERAL(TASMAIN) model. This caused the Tasmanian CPI to fall by 0.00595 per cent, whilst the mainland CPI fell by only 0.00035 per cent; the change in the Australian mainland CPI was approximately one twentieth of the change in the Tasmanian CPI.

[3] Land has not been included as a separate factor of production. Ideally, TASFOR should allow for price-induced substitution between private forestry and agriculture, as, for example, in Dee's Indonesian forestry model (Dee 1991). The author is unaware of any data on Australian land substitution elasticities. Approximately one half of Tasmania's multiple use forest zones are on Crown land, for which there is no price-induced substitution.

3. TASFOR has fourteen single-commodity industries. The disaggregation concentrates on the forestry industries and those closely related to forestry, e.g. construction. There are two margin industries, transport and other margins (retail and wholesale trade, some financial services, etc.).
4. There is no explicit modelling of the fiscal sector in TASFOR. The model includes direct and indirect taxes and transfer payments to the unemployed.
5. Unlike ORANI-NT, local savings need not equal local investment. TASFOR allows for a proportion of Tasmanian investment to be financed by capital inflows from mainland Australia (or overseas). This breaks the link between real investment and real consumption and enables the interest rate on loanable funds to be set exogenously.
6. Household demand elasticities are derived from both Australian and Tasmanian consumption data.[4]
7. TASFOR's variables include nominal and real Gross State Product calculated by expenditure at market prices.

Industries in TASFOR are classified as export industries with respect to either the interstate or the overseas market if the sales allocated to that export destination exceeds 10 per cent of total sales. Exports of the non-export industries are treated as exogenous.

The current version of the model has 6,742 equations and 8,177 variables, requiring 1,435 variables to be made exogenous. The selection of the exogenous variables will depend on the environment required for each application. For short run experiments the exogenous variables typically include capital stocks, overseas and interstate import prices, export demands of non-export industries, tariff rates, income taxes and payroll taxes, the average propensity to consume and the number of households. Finally, the exchange rate is exogenous in all applications and acts as the numeraire, i.e. it determines the absolute price level.

2.2 Data Sources

The principal data sources for constructing the input-output data files were the 1985-86 Tasmanian Input-Output (TIO) table, and the 1986-87 ORANI national data files. AGGREG, the IMPACT Project's large change aggregation program, (Sutton 1981), was used to convert the standard ORANI 115 commodity, 113 industry database into the required 14 single-commodity industry classification.

The TIO data, which has a 63-industry classification, were not initially in a suitable form for aggregation into the fourteen industries for several reasons. Firstly, TIO includes tourist demand (from interstate and overseas visitors) as a separate final demand category. Tourist expenditure for each commodity was therefore allocated to interstate and overseas exports according to the weights derived from data supplied in CREA (1989). Secondly, stock changes are entered in the TIO as a component of final demand. As ORANI models do not treat stocks explicitly, stock changes were removed

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[4] As in ORANI a Stone-Geary, additive utility function is assumed. Expenditure elasticities are taken from ORANI data files and own and cross-price elasticities are derived from Tasmanian consumption data.

and the input-output table was rebalanced using the RAS method as described in O'Connor and Henry (1975). Finally, in order to define margin industries, some TIO industries had to be allocated to two different TASFOR industries, using shares derived from the ABS Australian National Accounts (1990). For example, TIO's recreation and entertainment industry had to be partitioned into other margins and private services. The adjusted TIO database was then aggregated to the 14-industry classification.

TASFOR's input-output database was completed by calculating the remaining matrices (such as margin demands, the composition of investment demand and overseas import demand, and the allocation of taxes and miscellaneous costs) using shares from the national ORANI data applied to the TIO database. Most of the procedures were developed by Madden (1990) although for some calculations, such as the removal of margin flows from direct flows for margin commodities, a more detailed method was adopted.[5] Parameters, such as elasticities of substitution and investment risk values, were taken directly from the ORANI files. Export demand elasticities were taken from the ORANI file values and from revised estimates proposed by Wittwer and Connolly (1993).[6]

3. AN ILLUSTRATIVE SHOCK: A 10 PER CENT INCREASE IN THE PRICE OF OUTPUT FROM THE FORESTRY AND LOGGING SECTOR

3.1 Introduction

This simulation examines the short-term state-wide and industry-specific effects on the Tasmanian economy of a 10 per cent increase in the basic price of whole logs to all industrial and household purchasers.[7] Results obtained are expressed in terms of the percentage change in the variables from the values that would have occurred in the absence of this price change.

3.2 Economic Environment

This experiment was run under the following conditions:

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[5] For example, in order to remove the margins from the direct flows in the TIO table, Madden (1991) assumed that the ratio of margin flows to direct flows was the same for Tasmania as was the case nationally. In TASFOR, margins were removed by estimating margin flows for each commodity into each industry, using the ORANI shares, and subtracting this total from the TIO table.

[6] The GEMPACK suite of computer software (Codsi and Pearson 1988), supplied by the IMPACT Research Centre, was used to prepare the database, write the equations and run the experiments.

[7] The shock imposed is an increase in the returns to working capital, which raises the industry's costs. This variable was selected in preference to an industry tax as the latter is not part of disposable income and has the disadvantage of being immediately leaked from the circular income flow.

- wages are fully indexed to the Tasmanian consumer price index;[8] labour market changes are shown as changes in employment levels;
- the real level of domestic demand and the balance of trade are both endogenous;
- the average propensity to consume is exogenous;
- capital stocks are fixed; investment occurs but the capital created does not become operational until the following period;
- tariff rates, and mainland and interstate import prices, are exogenous;
- government demand for commodities and investment in state-run industries are also exogenous.

3.3 Results

Some macro-economic projections are shown in Table 1. The cost-induced log price rise has a depressing effect on all the major economic indicators, such as real private consumption, investment and employment. There is a net decline in aggregate demand which exerts downward pressure on the general price level and, due to full wage indexation, on the nominal wage rate. Tasmania's external trade balance deteriorates as the decline in export revenue is greater than the fall in the import bill. There is a reduced inflow of capital funds because the fall in private investment spending is greater than the fall in domestic savings. The decline in employment of 0.4 per cent represents the loss of approximately 700 Tasmanian jobs. A more detailed explanation of these results is provided in Section 3.3.2.

Table 1. State-Wide Results of a 10 Per Cent Increase in the Price of Forestry and Logging (% change)

Tasmanian savings	- 0.362
Capital inflow	- 1.164
Wage rate	- 0.193
Total import bill	- 0.340
Total export revenue	- 0.471
Total labour employment	- 0.403
Total nominal household spending	- 0.362
Total real household spending	- 0.169
Total nominal private investment	- 0.843
Total real private investment	- 0.697
Nominal gross state domestic product*	- 0.478
Real gross state domestic product*	- 0.298
Total disposable real income	- 0.169
Consumer price index	- 0.193

* calculated by expenditure at market prices[9]

[8] Unemployment benefits are also fully indexed.

[9] TASFOR generates gross state product deflators calculated at both factor cost and market prices. For the simulations described, changes in these indices are very similar to those in the consumer price index. For this reason they are not reported separately.

Table 2. Industry Level Results of a 10 Per Cent Increase in the Price of Forestry and Logging (% change)

Industry	Output	Employment	Investment	Export Price*	
				Mainland	Overseas
Agriculture	0.165	0.279	1.113	- 0.089	- 0.084
Forestry	- 4.808	- 6.470	- 13.802	N/A	N/A
Mining	0.438	0.551	0.515	- 0.083	- 0.078
Sawlogs/ woodchips	- 6.060	- 11.210	- 6.300	0.890	0.933
Wood products	- 0.642	- 0.970	- 0.842	0.235	N/A
Pulp and paper	- 0.878	- 1.222	- 1.264	0.189	N/A
Export manufactures	0.269	0.388	0.383	- 0.063	- 0.056
Import-comp manufactures	0.003	0.004	- 0.016	- 0.130	- 0.124
Utilities	- 0.132	- 0.252	- 0.517	N/A	N/A
Construction	- 0.349	- 0.552	- 0.503	N/A	N/A
Transport	- 0.261	- 0.298	- 0.501	N/A	N/A
Other margins	- 0.216	- 0.276	- 0.290	N/A	N/A
Government services	- 0.057	- 0.060	0.000	N/A	N/A
Private services	- 0.167	- 0.386	- 0.508	N/A	N/A

* Export industries only

Table 2 shows the effects on Tasmanian industries. The two industries most adversely affected by the log price rise are forestry and sawlogs/woodchips, where output falls by approximately 5 per cent and 6 per cent respectively. Relative to the output decline, employment falls by more for the latter industry due to its higher initial capital/labour intensity, using values derived from the Tasmanian input-output data.[10,11,12]

In comparison with the forestry and logging industry, the sawlogs/woodchips industry is modelled as relatively high risk; investors are more cautious about adjusting their investment spending in response to changes in expected rates of return. For this

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[10] Most database share coefficients and simulation results have not been tabulated due to space constraints.

[11] Some caution is required when interpreting TASFOR's results that refer to capital. Firstly, in common with agriculture, the TIO value of gross operating surplus (G.O.S.) for the forest industry, from which capital stock is determined, includes the return to land. Secondly, in input-output analysis, public trading enterprises, such as the Forestry Commission of Tasmania, are recorded as having a zero G.O.S. Furthermore, royalties paid to the Commission for purchases of Crown logs are recorded as part of the G.O.S. of the purchasing industries, rather than as an intermediate cost paid to the forestry and logging sector.

[12] It can be shown that for the production functions in TASFOR, in the short run, $\rho = z / S_L$ where, for any industry, ρ and z represent the percentage change in labour demand and output respectively, and S_L is the share of labour in total costs (see, for example Madden 1990. pp 310-11). Therefore, for a given change in output in the short run, the lower the initial labour share (or the higher the capital/labour ratio) the greater the percentage change in labour demand.

reason, investment spending in the sawlogs/woodchips industry declines by less than in forestry and logging. The other forest-related industries, wood products (which includes resawn timber, furniture, and veneers), and paper, pulp and plasterboard, are much less affected by the log price change. Reasons for the variations in results are discussed in more detail in the following section.

Remaining export industries (agriculture, mining and manufactures) benefit from the log price rise. The contractionary effects of the decline in domestic demand are outweighed by the favourable external trade effects arising from lower export prices. Investment increases in these industries in response to higher capital rental rates.

Import-substituting manufactures face three separate influences. Although predominantly import-competing, this industry is classed as an export industry and benefits from extra export demand following from the price fall. In addition, the relative price of imported manufactures has risen, due to the CPI fall, providing a further stimulus to domestic demand. These effects are marginally greater than the contraction in household and industry demand resulting from the lower level of overall economic activity.

Results are unfavourable for the last six industries listed, all of which rely heavily on Tasmanian industrial and household demand. These industries do not benefit from the external trade-related gains, and sell a relatively small proportion of their output to those industries that do.

3.3.1 The Forestry-Related Industry Results

The effects of the price rise on the forestry sector can be explained by looking at the industries' cost structure and at the demand for whole logs. The sawlogs/ woodchips industry is most vulnerable to changes in whole log prices. Part of the explanation is revealed in Table 3 which shows the input cost structure for the four forest industries.

Table 3 reveals that whole log purchases form almost one half of total costs for the sawlogs/woodchips industry, whilst for the other two industries the share, including purchases via the sawlog industry, is approximately 10 per cent.[13] Buyers of whole logs have limited opportunities for substitution away from Tasmanian logs for two reasons. Firstly, TASFOR's input demand equations do not allow inter-commodity substitution; it is not possible, for example, to substitute steel for timber in construction. Secondly, although they do allow for substitution between sources for each commodity, the extent to which this is possible depends on sales shares and substitution elasticities. For both legal and cost reasons, there are virtually no imports of whole logs into Tasmania. The buyers, therefore, have to incur the higher log costs imposed by the domestic forestry industry.

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[13] For example, in the case of wood products, the direct share of whole log costs is 7.1 per cent. As sawlogs/woodchips, which spends 44 per cent of costs on whole logs, comprises 10 per cent of wood product costs, the full share of log costs for wood products is 0.071 + (0.1)(.44) = 0.115 or 11.5 per cent.

Table 3. Forestry Industries' Input Cost Shares Derived From the TASFOR Input-Output Database

Inputs	Industry			
	Forestry and Logging	Sawlogs and Woodchips	Wood Products	Pulp and Paper
Forestry and logging	0.00	0.44	0.07.	0.06
Sawlogs and woodchips	0.00	0.01	0.10	0.06
Wood products	0.00	0.01	0.01	0.01
Pulp and paper	0.00	0.00	0.00	0.04
Other intermediate inputs	0.25	0.08	0.20	0.22
Primary factors	0.54	0.32	0.40	0.34
Imports	0.19	0.13	0.23	0.28
Indirect tax	0.02	0.01	- 0.01	- 0.01
Total	1.00	1.00	1.00	1.00

The effects of the higher log costs are partially offset by the decline in other input costs resulting from the overall contraction in aggregate demand. The net effect is an increase in basic prices for all forestry-related industries,[14] the impact of which depends upon the industries' demand structure. *Ceteris paribus*, in cases where a major proportion of output is bought by industries for which the commodity comprises a small part of total costs, demand will be relatively price inelastic. However, demand will be very elastic for those industries that rely heavily on competitive external markets. Table 4 reveals that the three log processing industries are heavily export-oriented.

Export demand is modelled as elastic in all cases as the forestry industries face strong competitive pressure in mainland and overseas markets.[15] This accounts for the relatively small changes in export prices shown in Table 2. The wood products industry is the least export-oriented. However, two thirds of its domestic sales are to the

Table 4. Forestry Industries' Sales Shares Derived From the TASFOR Input-Output Database

Supplying Industry	Purchaser							
	For. Log.	Saw/ Wood	Wood Prod.	Pulp/ Paper	Other Ind[a]	Export (main)	Export (over)	Other F.D's[b]
For & log	0.00	0.65	0.04	0.14	0.03	-[c]	-	0.14
Saw/wood	0.00	0.01	0.05	0.10	0.11	0.16	0.58	-
Wood prod	0.00	-	-	0.01	0.36	0.55	0.02	0.06
Pulp/paper	0.00	0.00	0.00	0.04	0.03	0.87	0.05	0.01

[a] other industry purchasers for current production

[b] other final demands (households, government, and investment expenditure)

[c] less than 0.01

[14] The presence of diminishing returns in production reduces the extent of the basic price increase: the decline in output exerts some downward pressure on costs.

[15] For example, Wittwer and Connolly (1993) propose a value of -10 for the demand elasticity for Australia's woodchip exports.

construction industry, which, of all the non-forest industries, is most adversely affected by the log price increase.

3.3.2 Separating the Primary Effects From the Consumption-Induced Effects

In analysing the impact of a shock, it is often useful to separate the primary or industrial effects on the economy from those caused by changes in aggregate demand. This improves the explanatory powers of the model and also provides an estimate of some multipliers. The state-wide and industry-specific results of this analysis are shown in Tables 5 and 6 respectively.

Values in the first column of Tables 5 and 6 are obtained by running the experiment as before but with two changes; the level of real domestic consumption expenditure is made exogenous (and held constant) and the average propensity to consume (APC) becomes endogenous. In effect, the APC is forced to adjust to maintain the initial level of real consumption. Industries are modelled to respond to the log price increase in an environment where domestic consumption is unchanged.

The second column values in Tables 5 and 6 are found by introducing a single shock, namely the reduction in real consumption that occurred in the original experiment (i.e., a fall of 0.169 per cent). Results of this simulation are due solely to the decline in consumption. The state-wide and industry output results from the original simulation are reproduced in the third column of Tables 5 and 6 respectively; it can be seen that these original results are equal to those obtained by combining the effects of the primary and consumption-induced shocks.

For both statewide and industry variables, the consumption-induced effects generally take the same sign as the primary effects. The difference in signs for total export revenue is due to the level of aggregate demand in the two simulations. Household expenditure is the largest component of aggregate demand; imposing a

Table 5. State-wide Effects of a 10 Per Cent Increase in the Price of Forestry and Logging Under Different Closures (% change)

	Primary Effects	Consumption-Induced Effects	Final Effects
Tasmanian savings	- 0.081	- 0.280	- 0.362
Capital inflow	- 0.969	- 0.196	- 1.164
Wage rate	- 0.081	- 0.111	- 0.193
Total import bill	- 0.286	- 0.054	- 0.340
Total export revenue	- 0.586	0.115	- 0.471
Total labour employment	- 0.370	- 0.033	- 0.403
Average propensity to consume	0.123	- 0.123	-
Total nominal household spending	- 0.081	- 0.280	- 0.362
Total real household spending	-	- 0.169	- 0.169
Total nominal private investment	- 0.614	- 0.230	- 0.843
Total real private investment	- 0.568	- 0.129	- 0.697
Real gross state domestic product*	- 0.263	- 0.034	- 0.298
Total disposable real income	- 0.123	- 0.046	- 0.169
Consumer price index	- 0.081	- 0.111	- 0.193

* calculated by expenditure at market prices

Table 6. The Effects on Industry Output of a 10 Per Cent Increase in the Price of Forestry and Logging Under Different Closures (% change)

	Primary Effects (i)	Consumption-Induced Effects (ii)	Final Effects (i)+(ii)
Agriculture	0.072	0.094	0.165
Forestry	- 4.931	0.123	- 4.808
Mining	0.193	0.245	0.438
Sawlogs/woodchips	- 6.204	0.144	- 6.060
Wood products	- 0.718	0.076	- 0.642
Pulp and paper	- 1.038	0.159	- 0.798
Export manufactures	0.121	0.147	0.269
Import-comp manufactures	- 0.010	0.012	- 0.003
Utilities	- 0.114	- 0.018	- 0.132
Construction	- 0.198	- 0.151	- 0.349
Transport	- 0.267	- 0.006	- 0.261
Other margins	- 0.133	- 0.083	- 0.216
Government services	- 0.003	- 0.053	- 0.057
Private services	- 0.075	- 0.091	- 0.167

constant level of this expenditure constrains the decline in consumer and producer prices. For forestry-related industries, this reduces the extent to which the log price rise is offset by reductions in the prices of other inputs. The subsequent export price increases have a severe impact on volumes traded in the competitive export markets.

There is relatively little downward pressure on the prices of the other export industries, leading to small demand increases. The net effect of these price changes is a decrease in export revenue, which is to be expected as forest products account for almost 25 per cent of Tasmania's export income. In the second simulation, the reduction in aggregate demand exerts further depresses the price level, stimulating all export industries and partially offsetting the decline in export revenue.

Table 6 reveals that for all forest-related industries the unfavourable primary effects outweigh the positive consumption-induced effects. Non-traded commodities including construction, other margins and private services are shown to be most vulnerable to the decline in domestic aggregate demand.

The fall in employment arising from the log price rise is captured almost entirely in the primary effect, rather than in the consumption-induced effect. Table 6 shows that with exception of government and private services, all industries are more adversely, or less favourably, affected when household spending is held constant. In effect, the decline in export prices resulting from the reduction in real consumption acts as an exchange rate depreciation, with the subsequent stimulation of all export and import substitution industries.

The consumption induced multiplier[16] can be estimated by comparing variables before and after the decline in consumption. In this application, the real GSP multiplier value is 1.13 and the employment multiplier is 1.09.[17]

3.3.3 Wage Indexation

The simulations reported above assumed that wages were fully indexed to the Tasmanian CPI. An alternative scenario is to remove all local wage indexation. As the mainland CPI is treated as exogenous in TASFOR, this is roughly equivalent to indexing wages to the national CPI. This additional simulation allows us to examine the difference in the results attributable to removing local wage indexation;[18] the results reported below compare the effects of the log price rise without wage indexation with those obtained under the full indexation environment.

The statewide effects, shown in Table 7 are broadly similar to those obtained earlier. One key difference is that by retaining the money wage rate, the general price level has fallen by less, leading to an increase in real wages and a larger fall in employment.[19] The only labour substitution possibilities in TASFOR are between labour and capital; as the latter is held exogenous in the short run,[20] TASFOR effectively allows no price-induced substitution from labour to other inputs. This decline in employment is therefore due solely to the relatively lower level of the industries' output and not to the higher price of labour, relative to other inputs.

Despite the larger decline in output and employment in this simulation, there is a smaller decline in disposable real income. This is due to the increase in both real wages and the value of unemployment benefits.

Without indexation, exports are less price competitive and export revenue experiences a greater decline. Domestic prices fall by less, reducing the relative price of imports. It might be expected that this result, combined with the smaller decline in nominal state domestic product, would lead to a smaller decline in the import bill. The reverse occurs for the following reason. With wage indexation removed, output of almost all industries is relatively lower and export industries are most adversely

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[16] Input-output analysis defines three effects, each of which have a corresponding multiplier; the initial effect, the first round/industrial support effect, and the consumption induced effect. The primary effect reported above is equivalent to the first round/industrial support effect.

[17] TASFOR's Keynesian multiplier is estimated at 0.59. This is obtained by examining the effect on real gross state product of a increase in real government expenditure. The relatively low multiplier value is due to Tasmania's strong exposure to interstate and international trade and also due to the presence of unemployment benefits, which act as an automatic stabiliser.

[18] In this simulation, indexation was also removed from unemployment benefits.

[19] Compared with the full indexation simulation, output and employment are lower in almost all industries: they rise by less in non-forest-related export industries and decline by more in all the remaining industries except government services.

[20] The production function specification for primary inputs is CES rather than Leontief, implying that the marginal product of capital remains positive. There is excess capacity only in the sense that capital levels are above those that minimise long run average costs.

Table 7. State-Wide Results of a 10 Per Cent Increase in the Price of Forestry and Logging Under Different Indexation Settings (% change)

	Full Indexation	No Indexation
Tasmanian savings	- 0.362	- 0.247
Capital inflow	- 1.164	- 1.194
Wage rate	- 1.193	0.000
Total import bill	- 0.340	- 0.371
Total export revenue	- 0.471	- 0.606
Total labour employment	- 0.403	- 0.485
Total nominal household spending	- 0.362	- 0.247
Total real household spending	- 0.169	- 0.135
Total nominal private investment	- 0.843	- 0.815
Total real private investment	- 0.697	- 0.739
Nominal gross state domestic product*	- 0.471	- 0.402
Real gross state domestic product*	- 0.298	- 0.349
Total disposable real income	- 0.169	- 0.135
Consumer price index	- 0.193	- 0.112

* calculated by expenditure at market prices

affected. These industries are relatively import-intensive[21] and although they account for only 28 per cent of all imports, they are responsible for most of the decline in industrial import demand. The greater decline in imports is due to the dominance of these industrial output effects over the disposable income effect and price substitution effects.

4. COMPARISON OF TASFOR RESULTS WITH THOSE FROM BRUCE'S ORANI STUDY

Bruce (1988) used the ORANI model to examine the short-term effects of several economic changes affecting the Australian forestry sector. Among these was a 10 per cent increase in forestry and logging costs, which is formally equivalent to a whole log price increase of 10 per cent. His study drew on the 1980-1981 Australian input-output tables. The economic environment in Bruce's study differed from that used in the TASFOR simulations in two respects; the level of real domestic demand, comprising household consumption, investment demand and government demand, was set as exogenous, and, due to an anomaly in the original investment theory reported by Johnson (1985), investment in the forestry and logging sector was also made exogenous.

For comparative purposes, the TASFOR simulation was repeated with the same economic environment as that used by Bruce.[22] The results of the two simulations are shown in Table 8.

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[21] Import costs, as a percentage of total costs, average 26.3 per cent for export industries and 19.3 per cent for non-export industries.

[22] Unemployment benefits are not included in the ORANI model and therefore have been removed from TASFOR in this simulation.

Table 8. TASFOR and ORANI Simulation Results for a 10 Per Cent Increase in Forestry and Logging Costs (% change)

Variable/Industry	ORANI	TASFOR
Short Term Macro-Economic Projections		
Real gross domestic product*	- 0.01	- 0.23
Aggregate employment	- 0.02	- 0.34
Consumer price index	0.02	- 0.07
Aggregate exports	- 0.03	- 0.62
Aggregate imports	0.04	- 0.14
Short Term Output Projections for Forest Related Industries		
Forestry and logging	- 0.04	- 4.57
Sawlogs/woodchips	- 0.61	- 6.32
Wood products	- 0.10	- 0.71
Pulp and paper	- 0.23	- 1.07

* calculated at factor cost

There are some significant differences in the results. For Australia as a whole, the forestry and logging industry is very small, comprising approximately 0.2 per cent of total value added (ABS 1983). Therefore, as expected, the absolute size of the macro-economic changes in the ORANI simulation is much smaller than that in TASFOR.

The CPI rises in the ORANI study whereas it falls in TASFOR. This difference is due to the classification of export industries in the two simulations. The primary user of forestry and logging output, the sawlogs/woodchips industry, together with the other forestry-related industries, wood products and pulp and paper, are treated as non-export industries in ORANI (i.e. exports are set exogenously). Consequently, there is little direct decline in aggregate demand due to the initial price increase. The CPI rises because the overall level of economic activity is almost unchanged and the initial price increase is absorbed into the national economy. This contrasts with the TASFOR simulation where the exposure of the forest industries to external trade reduces aggregate demand and Tasmania's CPI.

Australia experiences an increase in aggregate imports as a result of the relative decline in import prices. Australia's export revenue declines due to reduced sales of non-forest-related exports as a result of the CPI increase. By contrast, Tasmanian import spending falls, due to the relatively higher price of imports and the decline in aggregate demand. Interstate and overseas exports sales of Tasmanian non-forest-related industries, such as agriculture, mining and manufactures, increase slightly, due to the lower export prices: the converse of the Australia-wide simulation

Output of ORANI's forestry and logging industry falls only slightly because there are no Australian import-competing or export industries in which a significant share of costs is allocated to whole logs or sawlogs/woodchips. Furthermore, as more than 99 per cent of Australia's demand for whole logs is locally sourced, there is little price-induced substitution from Australian logs to overseas logs. In Bruce's simulation, with exogenous domestic consumption, the demand for output of the Australian forestry and logging industry is very insensitive to price changes.

The situation in Tasmania is very different. In common with Australia as a whole, the primary buyer of forestry and logging output is the sawlog/woodchip industry, and there is limited scope for imports of whole logs. However, as Section 3.3.1 shows,

external trade is highly significant for the sawlog/woodchip industry. In the TASFOR simulation, the price increase for sawlogs/woodchips reduces export demand by approximately 10 per cent. The export price of other forestry-related commodities also increases, which also further depresses demand for Tasmanian whole logs. On the basis of these results, Tasmania's forest industry is revealed to be more than ten times more sensitive than the national forest industry to cost-induced price increases.

5. CONCLUDING COMMENTS

Although TASFOR is a relatively simple general equilibrium model, it is capable of analysing the impact of economic changes under a range of different environments and providing consistent explanations for the results obtained. It shows, for example, that results obtained from Bruce's Australia-wide ORANI study are not applicable to the Tasmanian economy. This strengthens the case for the development of regional economic models or multi-regional models in cases where the issues in question are at state or regional level.

There is much scope for further research in combining natural resource economics with general equilibrium modelling. ORANI has some shortcomings in its treatment of the forestry sector that limit its usefulness for detailed study in this area. In many cases, forestry sectors produce two types of wood, hardwood (mostly eucalypts) and softwood (mostly radiata pine). This wood can be obtained from very different management regimes ranging from old growth/regrowth harvesting to plantation development. The two wood types have different end uses; in Tasmania for example, hardwood's predominant use is for woodchip exports, whereas softwood is used mostly for construction. Finally, the market structure of the forestry and logging sector and some downstream industries is different from the competitive model assumed in the ORANI model; in particular the state's Forestry Commissions often play a dominant role in setting wood prices.

An additional problem relates to the ORANI investment equations, which fail to incorporate the renewable natural resource features of the forestry sector. Investment is treated as the construction of man-made capital goods to realise a future rate of return, and this abstracts from the fact that deferred harvesting of a growing resource also constitutes investment. In short, the forestry intertemporal optimisation issue is not addressed[23] and capital is inadequately specified for the task as it only includes man-made capital and not 'biological' capital.[24]

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[23] There has been much recent work on developing dynamics in ORANI models, for example, MONASH (Adams and Parmenter, 1993)) and ORANI-INT (Malakellis, 1993). To this author's knowledge, the dynamics of natural resource management have not been specifically addressed.

[24] Most states require forest services to earn a 3 or 4 per cent real rate of return on capital, which, according to some sources, is expected to include some valuation of forest inventory (Industries Commission, 1991). Forestry Tasmania, which was formerly the Forestry Commission of Tasmania, is required, under the State Authorities Financial Management Act (1990), to achieve a real rate of return of at least 4 per cent on assets, including forest inventory.

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APPENDIX. Variables in TASFOR (% change)

Variable Name	Description
AGGCONSNOM	aggregate nominal household spending
AGGCONSREAL	aggregate real household spending
APC	average propensity to consume
CAPITAL(j)	capital stock
CONSPRICE	consumer price index
DISPINCNOM	total nominal disposable real income
DISPINCREAL	total real disposable real income
DUTY(i,overseas)	import duty
EXPREV(e)	export revenue from either source
EXPREVT	total export revenue
EXPSUB(i,e)	export subsidy
EXRATE	exchange rate
EXPPRICE	export price index
FEXPQ(i,e)	export demand shifter
FEXPTAX(i,e)	export tax shifter
FGOVTAX(i,s)	government commodity tax shifter
FHOUSTAX(i,s)	household commodity tax shifter
FINDTAX(i,s,j,k)	industry commodity tax shifter
FOCTP(j)	other cost ticket price shifter
FULLINVINDEX	full investment price index
FULLNOMINV	total investment spending
FWAGE	wage shifter
FWORKC	working capital return shifter
GOVPRICE	government price index
GOVSPNOM	nominal government spending
GOVTAX(i,s)	government commodity tax
GSPNOM	nominal gross state product (gsp) at factor cost
GSPREAL	real gsp at factor cost
HOUS	number of households
HOUSTAX(i,s)	household commodity tax
IMPREV(e)	import bill from either source
IMPINDEX	import price index
IMPREVT	total import bill
INCTAXF(f)	factor income tax
INDCOMTAX(i,s,j,k)	industry commodity tax
INTEREST	interest earned on loanable funds
INVPRICE	investment price index
JACT(j)	industry activity level
LABTAX(j)	payroll tax
NOMGSPE	nominal gsp (by expenditure) at market prices

PCAPITAL(j)	cost of installing a capital unit
PCOMB(i,s)	basic price of commodity i from any source
PCOMEXP(i,e)	export price (in foreign currency if relevant)
PCOMIMPF(i,overseas)	foreign import price
PCOMPGOV(i,s)	government purchase price
PCOMPH(i,s)	household purchase price
PCOMPHGEN(i)	general household commodity purchase price
PCOMPIND(i,s,j,k)	industry purchase price
PFACIND(f,j)	primary factor cost
POCTJ(j)	price of other costs (incl. prod taxes, misc. inputs)
PRENTJ(p)	net rate of return on private capital
PUNEMP	unemployment benefit
PWAGE	wage rate
PWORKC(j)	return to working capital
QCOMEXP(i,e)	export commodity demand
QCOMGOV(i,s)	government commodity demand
QCOMH(i,s)	household commodity demand
QCOMHG(i)	general household commodity demand
QCOMIMP(i,e)	import demand
QCOMIND(i,s,j,k)	industry demand for commodities
QFACIND(f,j)	primary factor demand
QINVJ(j)	investment
QINVT	total private nominal investment
QLABT	total labour employment
QMARGEXP(m,i,e)	export margin demand
QMARGGOV(m,i,s)	government margin demand
QMARGH(m,i,s)	household margin demand
QMARGIND(m,i,s,j,k)	industry margin demand
QOCTJ(j)	demand for other cost tickets
QUNEMP	unemployment rate
QWORKC(j)	working capital
REALEXP	real export spending
REALFULLINV	real investment spending
REALGSPE	real gross state product (by expenditure) at market prices
REALGOV	real government expenditure
REALIMP	real import spending
REALINV	real total private investment
TRADBAL(e)	trade balance for each source
TRADBALT	aggregate trade balance
SAVA	net flow of savings from interstate to Tasmania
SAVT	retained savings by Tasmanians

Range	**Description**.
i	commodities (14)
j	industries (14)
s	sources (Tasmania, interstate,overseas)
k	production (current, capital)
e	export destination/import source (interstate,overseas)
m	margin industries (transport,others)
p	private industries (13)
f	primary factors (labour, capital)