

Industries Assistance Commission

**A GUIDE TO THE IAC's USE OF THE ORANI MODEL**

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## OVERVIEW

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Soon after its inception in 1974, the Commission recognised the need to extend and upgrade its available analytical capacities to meet its statutory obligations in advising governments on industry issues. Together with other government agencies, the Commission sponsored a comprehensive research project, which was designed to provide a consistent analytical framework and data base to be used to support policy analysis in a number of fields and to assist in co-ordination between policies.

The ORANI model was developed as part of this research project. The objective in developing the model was to improve the way in which industry assistance, trade and development issues could be analysed within a comprehensive, economywide framework. That is, it was designed to improve the information that could be brought to bear on the impact of policy and other changes on directly-affected industries, other industries and the economy as a whole.

ORANI is a large-scale multisectoral model of the Australian economy. It is large in scale because it embodies considerable microeconomic detail on the nature of production and demand in the economy. It is called a multisectoral model because it treats the economy as a system of inter-related industry sectors. The model captures the interdependencies between industries that arise from the purchase of each others outputs of goods and services; competition for available resources, such as labour and capital; and other constraints that operate generally (eg the balance of trade). In short, the ORANI model provides considerable detail on individual industries within an economy-wide framework.

Because of this, the model can be used to analyse a vast range of issues; either broad in scope (eg an exchange rate change) or industry-specific (eg a tariff change). It provides information on the effects of policy and other changes on the economy generally, outputs of individual industries, imports and exports of different commodities, employment patterns, commodity prices and so on.

The ORANI framework is especially suited to the analysis of 'what if...' questions. That is, the basic methodology of ORANI simulations corresponds to saying, 'In a given economic environment which abstracts from the multitude of other factors that could affect industry performance, what if (say) tariff assistance to industry X were changed by 10 per cent?' The type of answer provided would not be a forecast of the actual outcome (since this could be influenced by many other factors) but would be a conditional projection of the influence of that policy change alone.

The value of the ORANI model is that it provides a framework for analysing important elements of an issue, rather than a definitive answer. It organises a large body of information in an explicit, systematic way. Modifications can be introduced to enhance the model's suitability for analysing the circumstances of particular industries and/or policy issues. Since the model is laid open for scrutiny, discussion about the appropriateness of ORANI analysis can focus on particular elements of data or particular assumptions as warranting further attention. The important point is that there is a comprehensive and cohesive framework upon which to build improvements and within which to test alternative views.

The ORANI model has gained an international reputation as a valuable contribution to applied economic analysis. But like any economic model, it has certain limitations and simplifications in its data base and underlying assumptions, which must be considered when interpreting results. While precision cannot be claimed, the model results provide useful indicators of the direction and orders of magnitude of responses to some economic change. Qualitative insights from the model usually remain quite robust, even in the light of what might appear to be significant changes in data or assumptions.

The Commission uses the ORANI model to provide insights into the factors which influence economy-wide growth, employment, and the development of individual industries. In the context of individual industry inquiries, ORANI can assist the Commission in formulating policy advice, by (for example) illustrating the effects of different policy options. The economy-wide scope of ORANI means that the model indicates the implications not only for directly-affected industries, but also for the economy as a whole and for the interests of consumers and other producers.

For the Commission, ORANI results usually provide only one source of analytical information. And irrespective of the quality of ORANI-based information in particular cases, the formulation of a policy recommendation continues to require the exercise of considerable judgment.

This guide is designed to promote better understanding of the ORANI model. It provides an overview of its role in the Commission's work; its general nature; the salient features of its structure; and what its results mean.

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## 1. INTRODUCTION

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The ORANI model was developed as part of the IMPACT Project.<sup>1</sup> The composition of supporters of (and contributors to) the Project has evolved since its inception in 1975. Currently, the IAC represents a number of government agencies<sup>2</sup> in an agreement with the University of Melbourne, which in turn represents a number of academic institutions.<sup>3</sup>

The computing system for the ORANI model is publicly available. This feature, together with the flexibility of the model to analyse a wide range of issues, has meant that ORANI has become widely used in government and academic environments.<sup>4</sup> However, the focus of this guide is on the use of ORANI within the Commission. This guide is meant to serve three related purposes:

to clarify the Commission's use of the ORANI framework in its inquiry and general research programs;

to provide a non-technical overview of the model to promote understanding of its structure, strengths and limitations; and

to assist inquiry participants (and other readers) in interpreting simulation results and in offering constructive feedback on the Commission's use of the model.

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1 For a non-technical description of the IMPACT Project models, see Alan A. Powell, *The IMPACT Project: An Overview*, First Progress Report of the IMPACT Project, Vol. 1, AGPS, Canberra, 1977; and Alan A. Powell and Brian R. Parmenter, 'The IMPACT Project as a Tool for Policy Analysis: Brief Overview', *Australian Quarterly*, Vol. 51(1), March 1979, pp. 62-74. Professor Powell has made several other progress reports since 1977; the latest being, 'A Brief Account of Activities Over the Period 1st February 1982 to 28th February 1985 with a Prospectus for Further Developments', *IMPACT Project Report R-05*, University of Melbourne, April 1985.

2 Other participating Commonwealth agencies are the Departments of Arts, Sport, the Environment, Tourism and Territories; Employment, Education and Training; Immigration, Local Government and Ethnic Affairs; Industry, Technology and Commerce (Bureau of Industry Economics); and Primary Industries and Energy (Australian Bureau of Agricultural and Resource Economics). In early 1987, the Treasury joined as an observer.

3 Other participating academic institutions are the Australian National University and La Trobe University. Other universities participate on an informal basis.

4 In fact, ORANI has gained wide acceptance as the preferred method for policy analysis of intersectoral issues. A survey of applications by the IMPACT team, the IAC, other government agencies and by academics can be found in Alan A. Powell and Tony Lawson, 'A Decade of Applied General Equilibrium Modelling For Policy Work', *IMPACT General Paper* No. G-69, Melbourne, November 1986 (available from the IAC - see footnote 5).

With these objectives, this guide cannot cover issues of technical detail of the model. Nor can it adequately describe the enhancements of the model that have been introduced and that are in prospect. Readers with this level of interest are referred to the exhaustive technical documentation by the principal authors of the model and to the set of working papers which describe specific aspects of the standard model, updates of data bases, refinements of parameter estimates, and enhancements in technical scope.<sup>5</sup>

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<sup>5</sup> The centrepiece of the ORANI documentation is Peter B. Dixon, B.R. Parmenter, John Sutton and D.P. Vincent, *ORANI • A Multisectoral Model of the Australian Economy*, North Holland Publishing Co., Amsterdam, 1982 (hereinafter referred to as DPSV). Lists and copies of working papers can be obtained from the IMPACT Information Officer, Industries Assistance Commission, P.O. Box 80, BELCONNEN, A.C.T., 2617.

## 2. THE ROLE OF ORANI IN POLICY ANALYSE

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All economic analysis requires the use of models. A model does not have to take a particular form, such as a set of mathematical expressions. It may be a set of qualitative concepts, perhaps based on intuition, personal experience or reasoning. Irrespective of form, models make a problem manageable by simplifying what is complex in reality. Economic models must therefore abstract from many of the intricacies of a modern economy. Yet to be useful, they must capture the more important features of the system they seek to represent, and leave aside the details that are only of secondary importance.

As Robinson and Eatwell put it,

"Yet, we cannot get on without making models, and models must be simplified. A map on the scale of 1:1 is of no use to a traveller. The art of setting up models is to cut out all complications inessential to the point at issue, without eliminating the features necessary for safe guidance."

The phrase 'to the point at issue' in this quote should be emphasised. It suggests that the nature and adequacy of a model cannot be divorced from its purpose. It is very much a case of 'horses for courses'. Certain policy problems are better analysed with particular types of models and any particular model may be well suited to some policy tasks, but not to others.

This section sets the context for ORANI by outlining the purposes for which the model was designed and for which it has proved to be a useful analytical tool. It does not address the question 'Why use a model?', since the use of a model (be it quantitative or qualitative, explicit or implicit) is inevitable for anyone approaching a policy problem. Rather, it addresses the question, 'Why use a model which takes on an explicit, quantitative form?'

### **2.1 The Role Of A Multisectoral Model**

Being a multisectoral model of the Australian economy, ORANI is mainly used in the context of inter-industry analysis. A useful starting point in assessing the model's role is therefore to address the purpose of inter-industry analysis.

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6 Joan Robinson and John Eatwell, *An Introduction to Modern Economics*, McGraw Hill, Maidenhead, U.K., 1973, p. 54.

**. Why conduct inter-industry analyses?<sup>7</sup>**

Inter-industry analysis is based on the view that, for some purposes, it is important to consider the economy as a complete system of interdependent industrial sectors. This view of the economy emphasises:

- the direct links between industries through purchases and sales of each other's goods and services; and
- indirect links through such mechanisms as collective competition for available labour, capital and other resources and economy-wide constraints that operate on the balance of payments, government budgets and so on.

Interdependencies between industries can be important in a number of areas. First, macroeconomic policies and other events, which affect the economy generally, rarely have an industry-neutral impact. Inter-industry analysis can help determine the implications of macroeconomic policies and events on the pattern of industry development.

Second, a development in one industry sector may have quite pervasive effects, through the direct and indirect links between economic activities. Inter-industry analysis helps identify the wider potential implications of a change and helps ensure that consideration of effects is not confined to directly-affected industries.

Third, in the current economic environment, governments are increasingly constrained in their ability to tackle macroeconomic problems (eg growth, unemployment, inflation, and the balance of payments) through the use of conventional demand management policies. This has generated greater interest in microeconomic policies as a means of addressing macroeconomic problems. Or at least, it has led policymakers to be more concerned about the macroeconomic consequences of policies that are applied at the sector level in the economy. Inter-industry analysis has an important role to play in this regard, in identifying, for example, the macroeconomic implications of industry policies.

**. Why use ORANI?**

Multisectoral analysis therefore has a vital role in addressing important policy issues. Once the role of inter-industry analysis is accepted, the use of a quantitative model such as ORANI becomes indispensable.

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<sup>7</sup> For a more complete overview of the role of inter-industry analysis, see B.R. Parmenter, 'Inter-Industry Analysis: The ORANI Model of Australia's Industrial Structure', in L.R. Webb and R.H. Allan, *Industrial Economics: Australian Studies*, George Allen and Unwin, Sydney, 1982.



Inter-industry analysis requires a detailed picture of the structure of the economy and a set of mechanisms for determining how that picture will change in response to some economic stimulus. The detailed picture covers such elements as the structure of sales and purchase linkages between industries and their employment of labour and capital. The response mechanisms characterise the behaviour of different groups, such as producers, workers, consumers and investors, as they interact with each other in adapting to economic stimuli. The required detail of structural data and response mechanisms is beyond the capacity of intuitive models. A formal quantitative framework is essential, for purely practical reasons.

**The ORANI model embodies considerable detail on the structure of the economy.** The standard ORANI data base identifies about 112 industry sectors which produce a similar number of goods and services. The database provides a breakdown of costs of production in different industries, where outputs are sold (eg to other industries, exports and final consumption) and the composition of imports. (See section 4.1 for more discussion on the database.)

**The design principles of ORANI introduce a substantial body of economic theory** to capture the principal responses of different economic decision makers in adapting to changed economic conditions. These principles are based firmly on conventional microeconomic theory which ascribe standard forms economic behaviour, such as cost minimisation or utility maximisation.

To understand why ORANI is based on these design principles, it is useful to make a broad distinction between causation and correlation. The modelling of the motivation (behaviour) of economic actors corresponds to the causation approach. As an illustration, the pursuit of cost minimisation causes producers to purchase less of a commodity when its price increases relative to possible substitutes. An alternative approach is to model responses as being simply correlated with some set of factors. For example, the output of an industry could be modelled as being correlated with time. The (informal) justification might be that, demand may historically have grown steadily with increases in population size.

A potential problem with the correlation approach is that, whilst it may be satisfactory in predicting events for some time period, circumstances may change in an economy to undermine the correlation that was previously evident. For

example, the cost pressures created by the oil-price shocks of the 1970s upset the correlations between, say, growth in output and growth in population.<sup>8</sup>

The causal modelling approach is much more durable in the sense that it is able to withstand, and indeed explain and predict, changes that occur in the economic environment. In short, it contributes far more to an understanding of how the economy operates and what the full implications of some change might be.

Moreover, a sound theoretical foundation ensures logical consistency within the structure of the model and therefore imposes a discipline of logic on the results. This can be very important in ensuring that spurious results are not produced. Just as one example, the model is structured in such a way that if prices of substitute goods are inflated equally (in percentage terms), consumers will not alter the mix of their purchases.

Because of these characteristics, **ORANI provides a systematic framework for analysing policy and other issues.** It organises a consistent, integrated data base with a set of the important structural relationships of the Australian economy.

The ORANI model provides a framework for tracking the likely responses of many different groups to some change and for weighing up perhaps opposing influences to provide an estimate of what the final outcome might be. In helping to identify the full implications of some policy change, ORANI can therefore contribute to the development of policy that better serves the community generally.

For example, many of the policy recommendations that the Commission considers involve a change in assistance to a particular industry. The effects of the change in assistance on that industry are relatively *easy* to identify. What is often more difficult to assess is the effect that the change may have on using industries, supplying industries, consumers, the general level of prices, wages and so on. ORANI provides a means of assessing all these effects, as well as weighing up all the different responses to suggest what the implications of the change might be for the economy as a whole.

Not only does it help identify the full implications of a policy change, but it can also illustrate how a range of different policies interact. Such insights can assist policy co-ordination.

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<sup>8</sup> Many quantitative macroeconomic models broke down in terms of their predictive abilities in the wake of the oil-price shocks. This was in part because they relied on the correlations between factors which had previously existed at a very broad level. Following the revealed inadequacies of these models, much more attention has been paid to structural, causal models which could incorporate the nature and detail of likely responses to developments such as sudden increases in certain input costs.

In addition, the **ORANI framework can be used flexibly** to address a wide range of problems or the same problem in different ways (see section 4.3). However, the systematic nature of ORANI helps ensure that model experiments are approached in a comprehensive and coherent fashion.

**The structure of ORANI is explicit.** That is, it is a model with high visibility, with a data base and assumptions open to scrutiny. This contributes to an understanding of why the model produces the results it does; and if there is surprise at or disagreement with the results, the focus of debate can be narrowed to the source of differences (be it data or some mechanism of the underlying theory), rather than disputing the analysis as a whole. Indeed, insights provided by participants in Commission inquiries can lead to modifications to the model to improve the way in which it represents particular aspects of interest (see section 4.3).

Although the ORANI framework can be very useful in policy analysis, it is not a substitute for judgment. The user must ensure that the model and the way that it is used are suited to the issue at hand. The limitations of the model in illustrating certain mechanisms must be borne in mind. Professor Powell, in discussing the background to the development of the IMPACT models, said:

"They are not policy studies; nor can they, without the intervention of a policy adviser, produce policy prescriptions. Essentially, they are nothing more nor less than analytical tools designed to assist in reaching a better informed understanding of issues to which judgments must ultimately be applied."<sup>9</sup>

Overall, the ORANI model provides a valuable framework for handling a large body of information to address a range of policy and other issues. It imposes the rigour that results can only be derived from explicit inputs of data and assumptions which reflect the essential features of behaviour suggested by conventional economic theory. ORANI results provide useful indicators of the likely direction and orders of magnitude of responses to economic changes. But inevitable approximations and simplifications in the inputs of data and theory mean that precision cannot be claimed. Consequently, the model serves as an aid to judgment and not as a replacement for it.

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9 Alan A. Powell, *The IMPACT Project: An Overview*, op. cit., p. 1.

## **2.2 The IAC Context**

The Commission's main functions are to advise the Government on the appropriate nature and extent of assistance to Australian industries and to report more generally on trends in industry assistance and its effects on the economy. General policy guidelines for industry inquiries require the Commission to take into account, amongst other things, the effects of its proposals on the interests of other industries, and of consumers.<sup>10</sup>

Inter-industry analysis therefore forms a central part of the Commission's inquiries and research. The ORANI framework often assists the Commission in this regard, by providing a formal, quantitative and 'transparent' way of assessing structural interdependencies in the economy. The model provides information:

to the Commission, which may help the process of making judgments about appropriate policy proposals; and

to decision-makers and the community-at-large, to assist understanding of the implications of policy options.

The model is not treated as a 'black box'; run in a routine and unquestioning way to provide the sole source of analytical information. The importance placed on ORANI-based analysis varies from case to case, depending most importantly on the suitability of the model's assumptions to the issue at hand. Often, modifications are made to the model to enhance its ability to consider particular industries or analytical issues. But in no case would the Commission rely solely on the model as a basis for its judgments. ORANI analysis is but one of a number of sources of information that are normally accessed.

The Commission has always seen that an important, integral part of its work is to provide information on the effects of assistance to industries and changes in these assistance arrangements. Perhaps the most comprehensive discussion of the Commission's approach to reporting on effects of changes in assistance was provided in its 1979-80 Annual Report.<sup>11</sup> It was stated that analysis of three aspects of effects can be influential in the formulation of the Commission's recommendations - although the extent of influence of each aspect varies according to the circumstances of individual inquiries. The three aspects are:

the consideration of effects of assistance changes in isolation from other developments in the economic environment;

assessment of effects from the perspective of the longer term economic and social environment in which the policies would operate; and

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<sup>10</sup> See, for example, IAC, *Annual Report 1984-85*, AGPS Canberra, 1985, p. 26. <sup>11</sup> IAC, *Annual Report 1979-80*, AGPS, Canberra, 1980, Chapter 3.

analysis of the short term consequences of moving from the existing to proposed levels of assistance.

The Commission went on to emphasise the importance of taking an economy-wide approach to assessment of effects and a balanced reporting of potential gains and losses for various groups in the community.

The ORANI model has proved useful to the Commission in exploring the economywide implications of assistance. Moreover, its potential to assist the Commission's reporting functions is expanding.

Following the Uhrig Review of the Commission,<sup>12</sup> additional emphasis has been placed on:

reporting not only on the nature and effects of assistance measures but also on the principal factors affecting the economic performance of assisted industries;

. assessment of forms of assistance other than border protection; and

reporting on other assistance options as well as the Commission's preferred option.

The ORANI model is sufficiently comprehensive and flexible to be able to address these aspects in many cases.

Analysis based on the ORANI model complements the Commission's use of the concepts of nominal and effective rates of assistance.<sup>13</sup> Estimates of nominal and effective rates, which are (partial equilibrium) measures based on the assumption that imported and domestically-produced goods are perfect substitutes, are used as indicators of the relative levels of assistance afforded various industries. These measures are of limited use in assessing the likely effects of changes in assistance. However, ORANI, with its economy-wide perspective (and assumptions of imperfect substitution), can often provide more useful indications of likely effects.

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<sup>12</sup> In October 1984, the Government enacted amendments to the IAC Act following a Review of the IAC conducted by Mr John Uhrig.

<sup>13</sup> See, for example, IAC, *Assistance to Manufacturing Industries*, Information Paper, AGPS, Canberra, June 1987.

### 3. THE GENERAL NATURE OF ORANI

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This section describes the general way in which ORANI has been constructed in order to fulfill its role. In so doing, it explains some of the descriptors that have been applied to the model. This may also help to distinguish ORANI from other classes of quantitative models.

#### . ORANI is a Computable General Equilibrium (CGE) Model

There is no precise definition of a CGE model. However, common characteristics include the following.

The 'computable' part of the descriptor reflects an emphasis on practical application. There may be developments in economic theory, complex mathematical forms for relationships, or scope of structural detail that some analysts may wish to have incorporated in models. But practical considerations, such as the capacity of available computers, rule them out. There is implicit recognition that some (perhaps relatively minor) short cuts on theory have been taken to ensure that the model is tractable and can be applied to analyse policy issues.

The 'general equilibrium' part refers in a broad way to the fact that attention is given to the structural detail of the economy, the inter-relationships between sectors of the economy, and to the notion that demands equal supplies in all markets.<sup>14</sup> One contrast would be with a model which only attempts to describe relationships between macroeconomic aggregates in the economy, and which passes over the industry or workforce structure. Another contrast would be with a partial equilibrium model which would consider, for example, the direct effects of a policy change on demand and supply conditions in one industry, but would overlook the indirect effects transmitted to other industries and feedback from other industries.

There are two main features of CGE models. First, the responses to change that they compute reflect optimising behaviour on the part of producers (profit maximisation or cost minimisation) and consumers (utility maximisation). Second, they take account of constraints, such as availability of factors of production (eg labour, capital, and agricultural land), restrictions on the government budget, the balance of payments and so on. Taking account of such constraints provides a role for prices to induce adjustments in the production and exchange of goods and

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<sup>14</sup> In the CGE class of model, there may be some exceptions to the notion of simultaneous equilibrium between supplies and demands in all input and product markets. For example, depending partly on how simulations are specified, not all markets in the ORANI model clear'. Nevertheless, the CGE label is useful and meaningful in indicating the basic design principles, even if there is not absolute adherence to the concept of general equilibrium.

services. This contrasts with traditional input-output analysis, in which industry output responses are assumed to reflect an historical, average pattern and do not reflect optimising behaviour nor the operation of constraints.<sup>15</sup>

In CGE models, the allocation of resources (labour, capital, material inputs and so on) across industry sectors, as well as the outputs of industries, are determined by the interplay of profit-maximising producers and utility-maximising consumers in competitive markets. Prices and quantities are determined simultaneously to ensure that supplies equal demands in both product and input markets.

**. ORANI is a Comparative Static Model**

The ORANI theory is specified (for the most part) so as to compute equilibrium solutions. That is, the results have the interpretation that all the inter-related adjustments have worked through the economy to (re-)establish balance between demands and supplies. The term 'comparative static' refers to the method of comparing differences in the values of variables between equilibrium solutions.

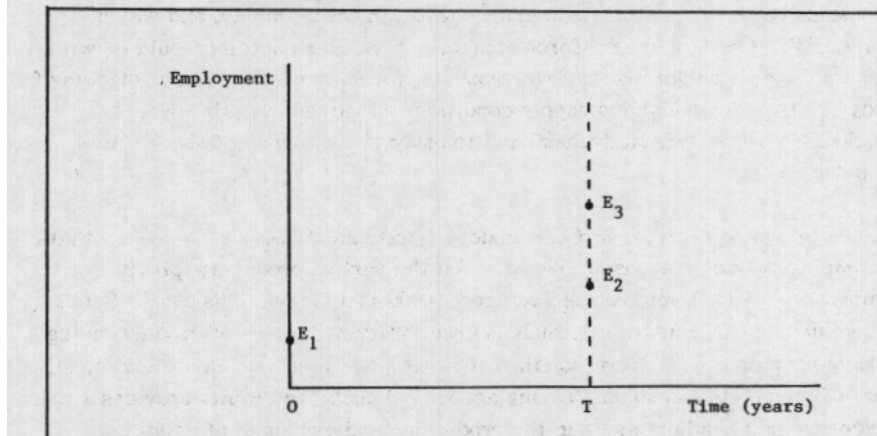
ORANI is a comparative static model and it operates in the following way. Suppose the focus of interest is on employment in industry X. In Figure 3.1, current (equilibrium) employment is represented by  $E_1$ . Suppose that in response to evolving economic conditions employment would be  $E_2$  after a period of T years.  $E_2$  is an equilibrium point and represents the 'control' solution. If a policy change is introduced, the effect might be to raise equilibrium employment to  $E_3$ .

The ORANI methodology is to compare the equilibrium values at the point T. That is, the effect of a policy change is assessed as the change in employment in

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15 See section 4.2 and IAC, 'A Perspective on Input-Output Analysis and Multipliers', *Working Paper*, December 1987.

**FIGURE 3.1 : CURRENT AND FUTURE OUTCOMES FOR EMPLOYMENT IN INDUSTRY X**





equilibrium (represented by  $E_3 - E_2$ ), all other things being equal. For computational ease, the structure of ORANI equations is expressed in terms of percentage changes (see section 4.3). This means that an ORANI result is the difference ( $E_3 - E_2$ ) in period T, expressed as a percentage of the original value

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The ORANI methodology contrasts with dynamic models which attempt to track the movement of variables over time through disequilibria to a new equilibrium solution (provided no new disturbance is introduced to initiate adjustment towards yet another equilibrium). In terms of Figure 3.1, a dynamic model would provide information which could be used to draw in the time paths of employment in moving from  $E_1$  to  $E_2$  and from  $E_1$  to  $E_3$ .

ORANI is not specific in regard to the timing of changes. Rather, timing is inferred from the range of factors which are allowed to adjust in reaching a new 'equilibrium'. The most important determinant in this regard is the stock of capital. In many applications, the capital stock in each ORANI industry is held constant. Under these circumstances, the equilibrium that can be achieved is only short run. The time lapse for the ORANI short run has generally been interpreted to be roughly two years. In applications in which capital stocks are allowed to adjust, ORANI solutions can be given a longer term interpretation (say 5 to 10 years).

#### **. Policy Analysis versus 'Forecasting'**

ORANI can be used to address a host of 'what if' type of questions. What would happen if assistance to a particular industry were changed by a specified amount? What would happen if world prices for certain commodities declined by 10 per cent? What if Australia's currency depreciated by 20 per cent following an adverse movement in the terms of trade?

In the way in which ORANI simulations are normally conducted, the answers to such questions indicate the influence of the policy (or other) change alone. They abstract from the myriad of other factors that would be operating continuously to shape the development of industries and the employment of labour. Thus, in the

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16 Strictly, the difference should be expressed as a percentage of the control value in year T, ie  $E_2$ . However, in practice,  $E_2$  is taken as being equal to  $E_1$ , because (i) the control solution involves no change from the current situation; (ii) the (historical) data base provides a reasonable approximation for the control values because various ratios derived from the data base (eg sales and cost shares) are more important to ORANI solutions than the actual levels; and (iii) sensitivity analyses suggest that comparative static results are not very sensitive to the details of a control solution. See Peter B. Dixon, B.R. Parmenter and Mark Horridge, 'Forecasting Versus Policy Analysis With the ORANI Model', *IMPACT Working Paper* No. OP-56, Melbourne, June 1986. An intuitive example might be that the effects (eg the pattern of percentage changes in outputs) resulting from a change in industry assistance -would be similar whether calculated on the basis of 1986 or 1988 data.

analysis of policies, ORANI does not attempt to forecast the actual outcome but abstracts from other economic influences to focus on the likely effects attributable to the policy change alone.

The above discussion on comparative statics showed that, for policy analysis, ORANI assesses the sole influence of a policy on the likely value of certain variables at some time in the future. All factors, other than the policy change, are held constant in the comparison of future values.<sup>17</sup> Hence, in policy analysis, ORANI projects the effects on future levels of output and employment and so on above or below what they would otherwise be.

To illustrate further, suppose that the influence of a policy was projected to raise industry output in about two years time by 2 per cent. This result would not represent a forecast of the actual outcome. There will be other factors at play, such as shifts in demand and changes in world commodity prices which, in the absence of a policy change, may lead to an actual outcome of a reduction of 5 per cent in industry output. Since the influence of the policy was assessed to be to raise output by 2 per cent above what it would otherwise be, a forecast of the outcome after the introduction of the policy change would be that industry output would decline by 3 per cent.

For forecasting, the comparison is not between two equilibria at a future point in time. Rather, forecasting is concerned with a comparison between current values and likely future values. There has been some work to adapt ORANI along these lines for making projections of future values.<sup>18</sup> These projections are conditional upon scenarios for the future course of certain variables that must be supplied as inputs to the model.

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<sup>17</sup> In practice, the only change introduced into the ORANI simulations is the policy change under consideration. In terms of Figure 3.1, this means that  $E_2$  equals  $E_1$ .

<sup>18</sup> See Peter B. Dixon, 'Prospects for Australian Industries and Occupations, 1985 to 1990', *Australian Economic Review*, 1st Quarter, 1986, pp. 3-28.

#### 4. THE STRUCTURE OF THE ORANI MODEL

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This section covers the specifics of what is in the ORANI model. It is structured so as to illustrate three salient features:

- the detailed information in the ORANI data base;
- its foundation in conventional microeconomic theory; and its
- operational flexibility.

##### **4.1 The Data Base**

The simulation results of any quantitative model reflect a combination of two key components: its data base and the theoretical structure embodied in its system of equations that describe how various economic decision makers are likely to react to changing circumstances. The information content of the data is given and is quite independent of the explanatory approach taken by the model builder (except perhaps in a purely organisational sense).

The foundation of the ORANI data base is input-output information which, amongst other things, captures the sales and purchase patterns of industry sectors within the economy. In essence, input-output statistics show:

- the distribution of industry outputs to satisfy the input requirements of other industries (termed 'intermediate demands') and to satisfy the final demands by households (consumption), by government, by investors (for capital formation purposes) and by foreigners (exports); and

- the cost structures of industries in terms of intermediate inputs of commodities (goods and services supplied by other domestic industries and by imports), primary factors of production (labour, capital) and certain taxes and subsidies.

The starting point for the construction of the ORANI data base is the Australian Bureau of Statistics' (ABS) Input-Output Tables.<sup>19</sup> These show demands for and supplies of 108 commodities and industries. Further detail is obtained from the ABS on particular aspects of these data such as imports of different commodities and the use of 'margins' (eg wholesale trade, retail trade, transport) in transferring goods and services from producers to consumers. The data base is also modified

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<sup>19</sup> For the published form of the Input-Output Tables see, for example, ABS, *Australian National Accounts, Input-Output Tables 1978-79* (Catalogue No. 5209.0), Canberra, 1984.

(based on survey data from the (former) Bureau of Agricultural Economics) to reflect a special treatment of the agricultural sector (see 'Commodity Supplies' below).<sup>20</sup>

With all this information, the ORANI data base in itself provides considerable detail on the structure of production and demand in the Australian economy, the allocation of primary factors of production (capital, agricultural land and different types of labour), the commodity composition and destination of imports, and the breakdown of other costs of production such as margins and taxes.

A number of aspects of the data base may influence the interpretation of ORANI simulation results. First, although the lags have been diminishing, the ABS releases input-output information which references some previous year. For example the 1987 release of input-output data refers to 1979-80 and 1980-81. This raises the question of whether the ORANI data base is 'out-of-date'.

A second aspect concerns the interpretation of the data base as representing an initial equilibrium. In the last section, the comparative static methodology was described as involving comparisons between equilibria. Although the ORANI data base is 'balanced' to match demands for and supplies of commodities in the reference year, some industries may not be in equilibrium in the sense of, for example, fully adjusting their production patterns to then existing demand patterns or having their desired levels of capital stock installed. This aspect is similar to the first in that it is suggesting that the desirable 'equilibrium' data base to serve as the initial point of departure would be somewhat different to the ORANI data base derived from historical input-output statistics.

Do these deficiencies matter? The answer is not entirely categorical.

The model's input-output data base is relied upon to supply appropriate values for key shares: eg the shares of different commodities and primary factors in an industry's total costs, and the relative importance of different purchasers of the output(s) of each industry. Experience and various studies have shown that the values of many of these shares shift only gradually over time. Furthermore, even what may appear to be significant errors in some share values will not necessarily

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<sup>20</sup> For a description of modifications made to the ABS Input-Output Tables in constructing the ORANI data base, see DPSV, *op. cit.*, pp. 170-175. For an update with reference to the 1977-78 Input-Output Tables, see Ian Bruce, 'The ORANI 78 Input-Output and Parameter Files for 1977-78', *IMPACT Working Paper* No. OP-51, IMPACT Research Centre, Melbourne, February 1985.

have a dramatic impact upon the broad representation of the structure of the economy 21

Consequently, an input-output information base that is somewhat dated can still be used to provide a reasonable picture of economy-wide inter-relationships. Thus ORANI estimates of effects on broad aggregates would be sound, as would estimates of the feedbacks from the rest of the economy to individual industries. However, some qualification may be required if attention is focussed on particular industries in which the detail of production processes has changed significantly over the intervening period. In these circumstances, the Commission usually attempts to update the data referring to particular industries of interest.

#### **4.2 Theoretical Structure**

The input-output data base could be used (without extensive recourse to behavioural assumptions about the way various economic actors are likely to respond to change) to trace through the implications of some disturbance, eg a policy-induced increase in the output of an industry. For example, the input-output relationships could be used in a mechanistic way to generate estimates of consequential effects on other industries, demands for primary factors and so on.

This approach corresponds to traditional types of input-output analysis.<sup>22</sup> The main weakness, from a theoretical point of view, is that such analyses are based on the assumption that producer and purchaser responses (at the margin) reflect the historically-observed average patterns, for example in the purchase and sale of goods between industries and demands for factors of production.<sup>23</sup> As a consequence, it is assumed implicitly that the outputs of industries comprise inputs which are all combined in fixed proportions and that final buyers purchase commodities in fixed proportions. Such an approach makes no allowance for what might happen in reality; namely, that producers might adjust their input mixes and that final buyers might adjust the composition of their purchases in response to pressures, such as an increase in the cost of a commodity, triggered by the change.

The ORANI model substantially overcomes this kind of weakness by incorporating explicit mechanisms to capture certain of the likely adjustment processes of producers and consumers faced with some change in the economic environment. It

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<sup>21</sup> For example, suppose there is a 20 per cent error in the estimate of an industry's use of a commodity. If that commodity represents 20 per cent of the industry's costs, the error in the industry's total costs is about 4 per cent. This might then pass on to a subsequent purchasing industry as a 1 per cent error in its costs. Thus, the economy-wide implications rapidly become relatively insignificant.

<sup>22</sup> For a description of the techniques of input-output analysis see IAC, 'A Perspective on Input Output Analysis and Multipliers', Working Paper, December 1987.

<sup>23</sup> Parmenter, *op.cit.*, and IAC, *op.cit.* provide discussions of the limitations of this type of input-output analysis.

does this by overlaying the data base with a system of equations aimed at describing the economic behaviour of relevant groups. The type of behaviour reflected in these equations is derived from conventional microeconomic theory, and in essence it portrays producers as seeking to minimise costs (within certain constraints) and consumers as seeking (again, within limits) to maximise utility (or, to minimise the cost of achieving a certain level of benefit from consumption).

Details of the various behavioural assumptions embodied in ORANI are now discussed briefly.

#### **42\_1 Direct demands for and supplies of commodities Input**

##### **demands**

Producers are assumed to minimise the costs of producing a given level of output, within certain constraints imposed by the assumed technology of production. A brief digression should illustrate the meaning of this statement.

The fixed proportions production technology discussed above (in relation to inputoutput analysis) represents an assumption at one extreme. This implies a complete lack of flexibility available to producers to adjust input mixes to minimise costs. At the other extreme is complete flexibility which would imply that producers would use only one type of input - that which is cheapest. This extreme is obviously also unrealistic in that most production processes require some minimum levels of certain materials, labour and capital input.

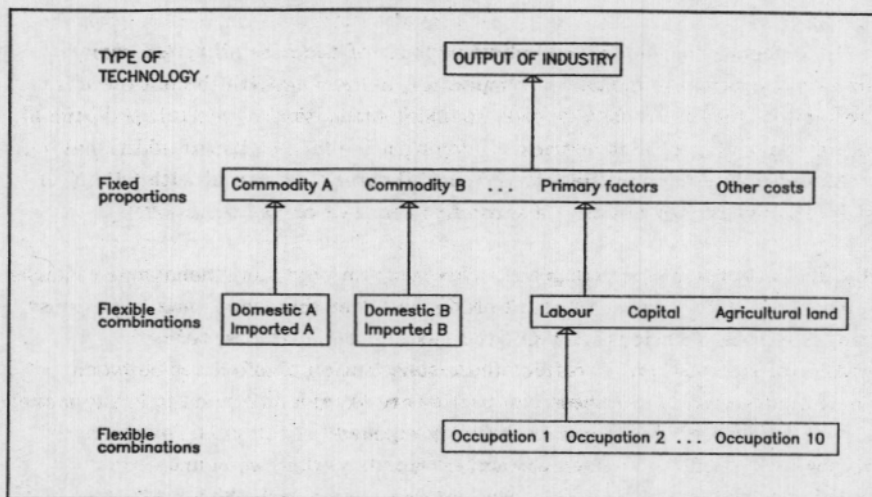
Some position, intermediate between these extremes, is a more accurate reflection of what happens in reality. Producers have a degree of flexibility to adjust input mixes in response to changes in the relative prices of inputs. For example, an increase in the cost of labour relative to capital might induce producers to utilise labour-saving capital equipment more intensively. The degree of flexibility (ie the possibilities for substitution between inputs) is likely to vary between industries, depending on technical production requirements.

The ORANI theory captures what are considered to be the most important areas of flexibility for producers by introducing input substitution possibilities at different notional levels of the production process. The production technology inherent in the ORANI theory is represented in schematic form in Figure 4.1. This shows producers as being able:

- to substitute different types of labour to minimise the costs of achieving given requirements for labour services in general;
- to substitute land (in the case of agricultural industries), total labour services, and capital to minimise the costs of achieving a given requirement for so-called primary factors of production;

- to substitute between domestic and import sources in satisfying their requirements for commodities; but
- to combine commodities (representing flexible combinations of import and domestic sources), total primary factors (representing flexible combinations of agricultural land, labour and capital) and other cost factors (such as working capital) only in fixed proportions.

**FIGURE 4.1 : SCHEMATIC REPRESENTATION OF ASSUMED PRODUCTION TECHNOLOGY IN ORANI**



The ORANI theory therefore allows for degrees of flexibility in some but not all areas of the production process. It does not allow for substitution between different materials (eg plastics for metals) or between materials and primary factors. This stance reflects a strategy which acknowledges the more important substitution possibilities, whilst recognising that data and computational complexities militate against allowing for general flexibility.<sup>24</sup>

The assumption of fixed proportions at the last level described above does not mean that the input-output coefficients are necessarily forced to remain constant in ORANI simulations. The effects of changes in the coefficients (reflecting technological change) can be analysed, but the origins of the changes are not generated or explained within the model, but are selected by the analyst and imposed as input to the model.

<sup>24</sup> Modifications of this stance can be introduced in specific instances. For a case of substitution possibilities between fuels in input demands, see Truong P. Truong, 'ORANI FUEL : Incorporating Interfuel Substitution into the Standard ORANI System', *IMPACT WorkingPaper No. OP-58*, September 1986.



Another assumption implied in the production technology in ORANI is the characteristic of constant returns to scale. That is, increases (decreases) in output bring about equi-proportionate increases (decreases) in total costs. Constant returns to scale are incorporated in the model for practical reasons (to do with the possibilities for arriving at a model solution).<sup>25</sup> ORANI cannot therefore capture any potential for increasing returns to scale (lower unit costs at higher rates of output) in some industries. The influence of scale effects can nevertheless be assessed within the ORANI framework in the manner suggested above (ie by imposing pre-determined changes in the technical coefficients of the model).<sup>26</sup>

The ORANI theory does not take explicit account of the possibility for variations in capacity utilisation in industries. Implicitly, in keeping with the notion of equilibrium, it is assumed that there is no under-utilisation of capital. Additional output can be achieved by industries employing more labour, but at additional unit cost. A situation of under-utilisation of capital can be simulated with ORANI if desired; although it may not have a substantial impact on the results.<sup>27</sup>

Finally, the inclusion of some degree of flexibility in producers' behaviour requires some measures of the extent to which producers alter their input mix in response to changes in relative prices. The ORANI model uses measures, termed elasticities of substitution, to reflect these substitution possibilities between different inputs. Values for these elasticities are provided from outside the model and constitute part of the 'parameter file' component of the model's data base. Where possible, values have been estimated by independent econometric estimation techniques that are as consistent as possible with the ORANI theory.<sup>28</sup>

#### **. Commodity supplies**

The same commodity (good or service) can be produced by different, but (usually) related industries. Similarly, one industry can produce more than one commodity.

As an example, ABS input-output statistics<sup>29</sup> show that the commodity 'Bags and containers' is produced by (among others) the industries 'Bags and containers',

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25 The development program for the ORANI model includes a project to take account of increasing returns to scale. See Peter Cory and Mark Horridge, 'A Harris-Style Miniature Version of ORAN1', *IMPACT Working Paper* No. OP-54, Melbourne, June 1985.

26 This was done, for example, in Appendix 12 to IAC, *Passenger Motor Vehicles and Components - Post 1984 Assistance Arrangements*, Report No. 267, AGPS, Canberra, June 1981.

27 See Peter B. Dixon, Alan A. Powell and Brian R. Parmenter, *Structural Adaptation in an Ailing Macroeconomy* Melbourne University Press, 1979, section 3.5.

28 The mathematical form of the substitution relationships is not discussed here. For an overview of the parameter estimation, see DPSV, *op. cit.*, pp. 181-198. For an update, see Bruce, *op. cit.*. 29 ABS, *op. cit.*.

`Paper products nec' and `Printing, stationery, etc'. On the other hand, the industry `Paper products nec' comprises a number of firms which produce the commodities `Pulp, paper and paperboard', `Bags and containers', `Paper products nec' and `Printing, stationery etc.

In the ORANI theory, producers can select a mix of outputs (commodities produced) to maximise their revenue. They are constrained, however, in their ability to do this by technical production relationships, which govern the flexibility of their production processes to switch from producing one commodity to another. For example, the relative prices of `Bags and containers' and `Printing, stationery, etc' may change in a way which increases the incentives to produce more bags and containers. However, the ability to switch from one commodity to another is likely to be constrained, since production processes of some firms will be more or less dedicated to printing and stationery activities.

Thus, just as producers are assumed to have a degree of flexibility in selecting their input mixes, they are assumed to have a degree of flexibility in selecting their output mixes. Whereas the flexibility of producers to alter their input mixes was termed `(input) substitution possibilities', the flexibility of producers to alter their output mixes is termed `(output) transformation possibilities'.

The principle, according to the ORANI theory, is that producers are able to alter the mix of commodities across a wide range in order to maximise their revenue. In practice, ie in the computer implementation of the standard ORANI model, transformation possibilities are only represented in the agricultural sector. In all other industries, the mix of commodity outputs is produced in fixed proportions. However, modifications can be made to allow transformation possibilities in particular industries if desired.<sup>30</sup>

#### **. Investment demands**

There are two parts to the ORANI investment theory. The first part describes the technology for creating units of capital in an industry in terms of its commodity composition. The composition of capital varies from industry to industry, so that ORANI is able to recognise, for example, that a dollar of investment in agriculture induces a greater increase in demand for tractors than does investment in other industries. Similarly, a dollar investment in transport is likely to bring forth greater demand for motor vehicles.

It is assumed that commodities are combined in fixed proportions to produce a unit of capital in each industry. Investing producers do, however, have some

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<sup>30</sup> For example, transformation possibilities were allowed among textiles, clothing and footwear (TCF) industries in the ORANI modelling work for the IAC inquiry into TCF industries. See Appendix W to IAC, *The Textile, Clothing and Footwear Industries*, Vol. 3 (Appendixes), Report No. 386, AGPS, Canberra, May 1986.

flexibility in choosing between domestic and import sources. It is assumed that they minimise investment costs by substituting in favour of the cheaper source of commodities (subject to technical constraints); but they purchase the different commodities that make up their investment bundle in fixed proportions.

The second part of the theory describes how many units of capital will be created in each industry. This part is primarily concerned with the (relative) allocation of investment across industries. In many short-run applications, aggregate investment is set according to macroeconomic factors outside the model. ORANI determines how this given aggregate investment is allocated to individual industries.

Stated most simply,<sup>31</sup> this second part of the ORANI investment theory assumes that aggregate private investment is allocated across industries so as to equate expected rates of return.<sup>32</sup> The expected rate of return in each industry takes account of current returns on capital, varies inversely with the level of investment and makes some allowance for risk.

The adjustment mechanism in the theory is the level of industry investment. If the current rate of return in an industry is high relative to other industries, it will account for a relatively larger share of total investment. Doing so, however, will tend to reduce the expected rate of return (below what it would otherwise be). Thus, the level of investment regulates expected rates of return in industries, so that these expected rates can be equated across industries.

For some industries (eg those dominated by public enterprises) the rate-of-return theory is considered inappropriate, and investment in these cases is usually set by a direct link to aggregate real investment.

#### **Household demands**

The consumption theory in ORANI is expressed in terms of an average *household*. It assumes that the aggregate consumer budget (or consumption expenditure) will be allocated so as to maximise the utility gained from the consumption of commodities.

Consumers are assumed to alter the allocation of their expenditure on different commodities, depending on the responsiveness of the demands for different commodities to changes in:

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31 For a more complete description, see DPSV, *op. cit.*, pp. 118-122.

32 It is assumed that capital takes one period (which does not need to be specified in units of time) to install. The allocation of investment, more strictly speaking, is made so as to equate expected rates of return in the following period.

the aggregate consumption budget (eg if the budget expands, consumers are likely to devote a smaller proportion of total expenditure to certain goods (eg so-called necessities) than to others (eg luxuries); and

- relative prices of commodities.

The responsiveness of consumer demands to changes in total budgets is measured by what is termed an 'expenditure elasticity'; and the responsiveness to changes in relative prices is measured by a 'price elasticity'. Values of these elasticities are estimated outside the ORANI model (via a framework consistent with ORANI theory).

There is a further aspect to the consumer decision-making process incorporated in the model. It is assumed that, as part of their assessment of prices and allocation of expenditure, consumers attempt to minimise their expenditure on a commodity by substituting between domestic and import sources. The degree to which such substitution takes place is limited by consumers' perceptions of quality or other attributes that differ between domestically produced and imported commodities.

The consumption theory also allows for changes in tastes. These, however, must be imposed on the model, rather than being determined within the ORANI framework.

The behaviour currently embodied in the standard ORANI framework assumes that consumers' preferences for one type of commodity are independent of their preferences for another type of commodity. This means, for example, that consumers' purchases of motor vehicles do not depend directly on how many household appliances they buy. (indirectly, there is a link in that all consumption goods compete for available funds within the consumption budget).

Whilst this assumption is reasonable for many commodities (particularly when commodities are broadly defined), there may be some instances in which specific substitution and complementarity relationships are important. The standard ORANI stance would not allow for specific substitution relationships between, say, beer and wine nor the complementarity between, say, television sets and video cassette recorders.

These specific consumption relationships are more important when dealing with disaggregated commodity groups. Modifications can be made to the ORANI model in these cases <sup>33</sup>

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<sup>33</sup> For example, specific substitution relationships between beer, wine and spirits have been analysed by G.A. Meagher, B.R. Parmenter, R.J. Rimmer and Kenneth W. Clements in 'Special Purpose Versions of a General Purpose Multisectoral Model: Tax Issues and the Australian Wine Industry', *IMPACT Working Paper* No. OP-41, Melbourne, September 1983.

#### . Export **demands**

Demands by foreigners for Australian commodities (exports) are assumed to respond to changes in prices denominated in foreign currencies. The responsiveness of export demands is measured by what are termed 'export demand elasticities'.

Values for the export demand elasticities are supplied from outside the model. If Australia supplies a very small proportion of the world market for a particular commodity, variations in its export volumes are unlikely to have much influence on the world price. This can be handled in the ORANI model by setting the values for the export demand elasticities for such commodities to a large value, say 20. This corresponds to what is commonly referred to as 'the small country' assumption. However, Australia cannot be regarded as a small country in relation to certain commodity exports (eg wool) and in such cases increases in the volume of exports are assumed to place downward pressure on world prices.

#### 'Other' demands

The remaining final demand category is 'other', which essentially comprises government demands for commodities. In keeping with the input-output conventions, government bodies are viewed as buying only goods and services and do not directly demand labour and other primary factors. They purchase the outputs of the defence industry, the public administration industry and so on; and it is these latter industries which employ primary factors of production.

There is no formal theory underlying the way in which 'other' demands are handled in ORANI. Rather, changes in other demands are linked to changes in household consumption expenditure. There is freedom to select whether the link is equi-proportionate (which is the usual practice) or exhibits some other relationship.

#### **4.22 Indirect demands, prices, market clearing and other relationships .**

##### **Demands for margins**

The demands for commodities by producers, consumers, foreigners and governments create indirect demands for margins. Parmenter<sup>34</sup> likened margins to frictions - both geographical and institutional - which must be overcome in facilitating flows of commodities from producers to consumers. The services of various trade (eg wholesale and insurance) and transport industries are often required for the transfer of goods and services between producers and purchasers. In ORANI, there are eight margins:

wholesale trade; -  
retail trade; - road  
transport;

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<sup>34</sup> Parmenter, *op. cit.*, pp. **70-71**.

- rail and other transport;
- water transport; -
- air transport;
- marine insurance; and
- restaurants, hotels and clubs.

The demands for margins are assumed to arise in proportion to the direct demand (in quantity terms) for a commodity. The proportion can, however, be varied if desired by imposing the desired relationship on the model.

#### **. Pricing**

ORANI uses several sets of commodity prices, depending on whether reference is being made to the amount paid by purchasers, the amount received by producers, the price of capital, the foreign currency price of exports or the foreign currency price of imports. The model contains a system of equations which sets out the relationships between the different sets of prices.

In so doing, an assumption of competitive pricing behaviour is invoked. This has two aspects:

- prices are set to just cover costs (of production, importing, exporting, transporting, etc), where costs include a component to allow for a return on capital; and
- prices may differ between users only in so far as different amounts of margins and certain taxes apply to the purchases of different users <sup>35</sup>

#### **Market clearing**

The model contains sets of equations to ensure that:

- demand for domestically-produced commodities equals their supply; -
- demand for labour of each type across all industries is satisfied; - demand
- for capital in each industry is equal to supply; and - demand for agricultural
- land in each industry equals its supply.

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<sup>35</sup> For example, consumers may pay more for a commodity than domestic producers on account of an additional retail margin.

#### . **Miscellaneous**

There are also equations in the model which define:

- aggregate imports, exports and the balance of trade;
- macroeconomic indexes such as consumer and capital-goods prices, aggregate employment and aggregate capital stock; and
- the degree of wage indexation.

#### 4.3 Solution Procedures And Operational **Flexibility**

This sub-section explains two of the major steps taken to develop a workable computing system to obtain ORANI solutions. It goes on to show how the ORANI model can be used flexibly for a range of policy investigations.

#### . **Linearisation**

The mathematical form of many of the equations in the ORANI model - especially those which express, for example, the technological relationships of production processes - are highly non-linear. This creates considerable practical difficulties in computing a set of values that will simultaneously satisfy all the equations of the model.

To circumvent this difficulty, the equations from the ORANI theory are manipulated to formulate relationships as linear combinations of proportional (or percentage) changes in variables. The techniques which are currently available for obtaining ORANI solutions avoid or minimise, the approximation errors of this linearisation process.

#### Closure

In the complete ORANI system there are many more variables than there are equations. Under these circumstances, it is mathematically impossible to compute a solution; that is, to find a set of values for all variables that will simultaneously satisfy all equations.

The practice, therefore, in computing ORANI solutions is to reduce the number of variables for which the model is required to compute solution values. This is achieved by declaring a number of variables as being exogenous. That is, values for a number of variables are selected by the model user and are supplied as inputs to the model. The values of exogenous variables are not determined by the model. With sufficient variables declared exogenous, it is then possible to solve the model to yield values for the remaining (endogenous) variables.

The process of declaring certain variables as exogenous determines the 'closure' of the model. This is not a mechanistic process since the appropriateness of a closure depends on the circumstances of an application. Some variables are

relatively obvious candidates to be declared exogenous. For example, the foreign currency prices of imports, technological change and change-in-taste terms are normally fixed. Also, aggregate consumption, investment and government expenditure are normally set exogenously in short-run applications, reflecting the potentially greater impact in the short run of macroeconomic initiatives that are outside the scope of the model.

The form of closure can be an important influence on the results, as it determines the constraints under which different groups in the economy are deemed to be operating. For example, the influence of a policy change on industry outputs can vary, depending on whether (say) a predetermined level of aggregate consumption or a balance of trade constraint has to be satisfied.

#### **. Operational flexibility**

The ability to partition variables into a range of alternative exogenous and endogenous sets gives the model a high degree of operational flexibility. For any given closure, a range of policy or other changes can be simulated by changing a number of exogenous variables singly (to determine the effects of one policy change alone), severally (eg to assess aspects of co-ordination between policies), or en masse (for a 'forecasting' type of application).

Whilst some variables are usually always classed as exogenous, others can switch freely between the exogenous and endogenous sets (again, with care, depending on the circumstance of the application). This provides for a high degree of flexibility in the range of policy questions that the ORANI model can address.

As one simple example, the model can be used to address the following type of question, 'What would happen to imports of commodity X if the relevant tariff were changed by Y per cent?' In this case, tariff rates would be exogenous and imports would be endogenous. On the other hand, the question might be, 'How would the tariffs for industry X have to change for imports of X to be maintained at a pre-existing level (given some other change in the economic environment)?' In this case, imports would be exogenous, leaving the values for tariff rates to be determined by the model.

Model users also have the freedom to use different settings for parameters such as elasticities of substitution and demand elasticities. Most of the standard values of parameters used in ORANI simulations are based on independent econometric evidence, while others have been derived by more ad hoc methods. Parameter values can be altered from standard settings:

- to test the sensitivity of results;
- if new evidence on parameter values comes to light; or



- if it is desired to impose alternative judgments about parameter values.

Special-purpose versions of ORANI are often constructed for particular Commission inquiries and may involve:

- the modification of the input-output data base to disaggregate the standard, input-output industries into more narrowly-defined industries which produce goods and services under reference (and perhaps to group other industries not under reference into a smaller number of sectors);
- the re-specification of the production technology for particular industries of interest; and
- the introduction of separate regional activities within an industry under reference, where there are important regional differences in cost structures and patterns of sales to other industries and/or where regional employment implications form a particular point of focus.

#### **4.4 Modifications To The Standard ORANI Theory**

The theoretical structure of ORANI can be modified in many ways to enhance analysis of particular problems. Just two of the major modifications which are coming into more common use in Commission applications are introduced here.

##### **. Lang-nm Version**

This guide concentrates on the standard short-run version of ORANI. In this version, industry-specific capital stocks are held fixed; and usually aggregate consumption, aggregate investment (but not the industry allocation of total investment) and total government expenditures are set exogenously. Results have the interpretation that they show the adjustment by producers to some change within the constraint of maintaining currently installed capital stocks.

But in the longer term, producers would also adjust their capital stocks in response to some change by revising their levels of investment. Long-term output responses to some change can be expected to be greater than those in the short term, because producers are less constrained.

In a long-run version of ORANI, capital stocks are allowed to vary and the view is taken that investment shifts to relatively profitable sectors until expected rates of return are equated across industries. This is achieved by setting rates of return exogenously and allowing the model to determine the levels of capital stocks that are consistent with those rates. Values of aggregate consumption, investment and government expenditures are usually determined by the model in a long-run version, subject to some constraints, eg on the balance of trade.

In standard ORANI applications, there is no role for foreigners to finance some investment in capital, repatriate some returns and draw away income that would otherwise be available for domestic consumption. Given the potential importance

of these issues in longer-term applications, a separate long-run version of ORANI has been constructed.<sup>36</sup> Briefly, its main features are:

- a distinction is made between income generated in Australia (GDP) and income accruing to Australians (GNP);
- aggregate consumption and investment are endogenous (determined by the model) and are linked to income, and GNP is divided between consumption and net savings;
- net savings determines the extent of Australian equity in capital stocks; and
- the level of capital stocks are linked to the flows of investment in the long-term adjustment period.

#### **. ORANNI-FISCAL**

The standard version of ORANI is not complete in its representation of government revenues and expenditures. This limits the model's ability to assess the fiscal dimensions to a policy change (eg adjustment in tariff rates), and its ability to analyse the effects of changes in some fiscal instruments (such as a change in income tax rates). It also means that constraints on overall government revenues and expenditures cannot be taken into account in model experiments.

A fiscal extension to the ORANI model has been constructed to overcome these limitations.<sup>37</sup> A starting point to view the fiscal extension is the breakdown of government revenue and expenditure displayed in Table 4.1. The central task of ORANI-FISCAL is to explain in detail how all the revenue and expenditure items might vary with and feed back on industry activity.

The standard ORANI computations of payments to factors of production provide an important starting point, since they define taxable incomes. Payroll or property tax rates and direct tax rates are applied in turn to these income bases to provide estimates of direct tax collections.

Since transfer (ie social welfare) payments depend on population and workforce characteristics, the fiscal extension first explains movements in labour force status (employed, unemployed, not in the workforce). The different types of transfer payment (unemployment benefits, means-tested benefits and other transfers not subject to means testing or workforce status) can then be estimated.

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<sup>36</sup> See Mark Horridge, 'Long-run Closure of ORANI: First Implementation', *IMPACT Working Paper* No. OP-50, February 1985.

<sup>37</sup> See Philippa Dee, 'The Theoretical Structure of Fiscal ORANI', *LAC Research Memorandum*, April 1987.

TABLE 4.1 : DECOMPOSITION OF GOVERNMENT REVENUE AND EXPENDITURE IN ORANI-FISCAL

Government revenue	Government expenditure
Direct taxes on labour income (progressive) - non-labour income (proportional)	Consumption expenditure -
Payroll taxes	Investment expenditure
Property taxes	Unemployment benefits
Commodity taxes	Means-tested transfers <sup>a</sup>
	Other transfers <sup>b</sup>
Other indirect taxes	'Other' outlays
'Other' revenue	
<u>Total revenue</u>	<u>Total expenditure</u>

a. Available to those not in the workforce.

b. Not means tested, available irrespective of workforce status.

After-tax incomes, plus government transfer payments, equal personal disposable incomes. Disposable incomes play an important role in ORANI-FISCAL, in that they influence both consumption levels and decisions to enter the workforce. Thus ORANI-FISCAL closes the income-consumption link, which is left open in standard ORANI.

Other items of revenue and expenditure are calculated in relatively straightforward fashion. Finally, government revenues are totalled, as are government expenditures. ORANI-FISCAL can then be run 'passively' to compute the implications of some economic change for government revenue, expenditure and their composition. On the other hand, it can be run 'actively' to impose a constraint on government revenue and/or expenditure or to analyse in detail the effects of a change in some fiscal instruments such as tax rates.

## 5. INTERPRETING ORANI RESULTS

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The basic methodology in using ORANI corresponds to addressing the type of question, 'Given a particular economic environment (closure of the model), what would be the effect of a policy change alone on a set of variables, which might include aggregate employment, inflation, industry-specific output and employment?' As outlined previously, the model used in this way would abstract from the multitude of factors, other than the policy change under consideration, that would affect the development of industries and the economy as a whole.

Because there are various possible economic environments, as well as a multitude of possible policy or other changes which could be simulated, there are too many types of ORANI results to discuss in this paper. However, the general flavour of ORANI results can be illustrated through one example of a simulation experiment in which assistance to an industry is reduced. This should identify the major ORANI mechanisms which are common in many of the Commission's applications. These include:

- input-output linkages between industries;
- competition between industries for available resources;
- other constraints on the economy as a whole (eg on aggregate expenditure or the balance of trade);
- wage indexation which links labour costs to movements in consumer prices; and
- real exchange rate movements which alter the prospects of traded goods in comparison with non-traded goods.

The explanation of results will proceed in a number of steps. Whilst this may mirror the actual sequencing of events in some cases, it should be remembered that the outcomes of all the different mechanisms in ORANI are determined simultaneously.

### **5.1 The Assumed Economic Environment**

ORANI results must be assessed in the context of the economic environment assumed for the simulations (ie the closure of the model). The most frequently used environment is the standard short-run closure. The main elements usually assumed for such simulations are as follows.

- Capital stocks (and agricultural land) available to each industry are fixed. This defines the short-run nature of the specification.

Real aggregate domestic expenditure for consumption and investment purposes and by government are held fixed.<sup>38</sup> It is implicitly assumed that (macroeconomic) factors, outside the province of ORANI, determine these aggregates in the short run.

The balance of trade (exports minus imports) is free to adjust. Since domestic expenditure is fixed, the balance of trade carries the burden of adjusting total expenditure (including exports) to match total income.

Production technology and consumers' preferences are fixed. (Some exogenous change could equally have been specified.)

There are no constraints on supplies of labour in each occupation at prevailing wage rates. Employment levels are then demand determined.

Nominal wages are fully indexed to the ORANI consumer price index. This implies constant real labour costs - often described as real wages. (Some discounting of real wages can equally be specified.)

The (nominal) exchange rate is fixed. This means that all other prices are measured relative to the price of foreign exchange, and domestic prices relative to foreign prices are reflected in the results as changes in domestic price indexes, rather than as changes in the exchange rate. Changes in the domestic price level therefore can be interpreted as movements in the real exchange rate (the nominal exchange rate adjusted for differences between domestic and overseas inflation rates).

## **5.2 Effects On Product Markets**

In ORANI, the demands for commodities, whether they be final demands by households or for investment, or demands by producers for use in current production, are sourced from both domestic production and imports. The initial impact of a reduction in tariff assistance to an industry will be to induce users and consumers to substitute greater purchases of the imported good for the domestically produced good.

The extent of this substitution effect will depend on the extent to which relative prices are altered by the policy change, and the perceptions of purchasers of the differences between goods from local and overseas sources. Existing market shares of imports and domestic production are also important. If the import share is small, then a large percentage increase in import demand may have relatively little impact on domestic production.

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<sup>38</sup> This is not the only possibility. Aggregate consumption and investment could be made endogenous, as in the long-run version of ORANI reported in section 4.4.

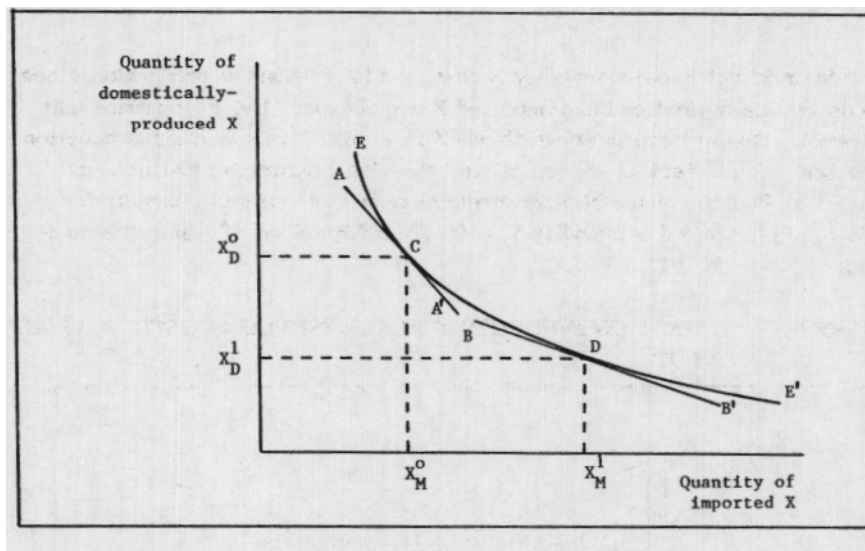
These effects are illustrated in Figure 5.1 where the change in the relative prices between imported and domestically produced goods, induced by the tariff change, is reflected as a change in the relative-price line from  $AA^A$  to  $BB^B$ . The users and consumers who wish to maintain their effective demand for good X shift their bundle of purchases along the effective demand curve  $EE^C$ , from the point C to the point D. As a result, sales of domestically-produced commodity X fall from  $X_D^0$  to  $X_D^1$ , whereas sales of imports increase from  $X_M^0$  to  $X_M^1$ .

From Figure 5.1, it can be seen that even greater substitution of imported for domestically-produced X would occur if:

there were a large change in import prices (reflected in a shift in the relative-price line to a position flatter than  $BB^B$ ); and/or if

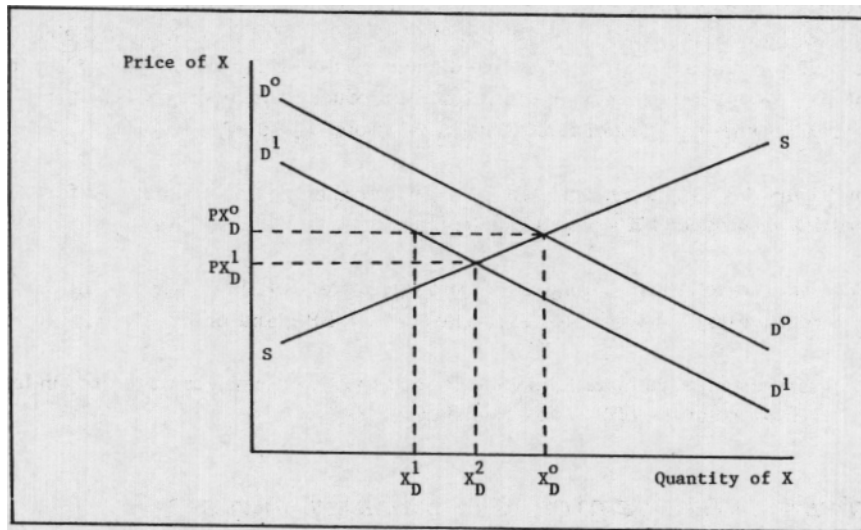
purchasers were more responsive to relative price changes (reflected in less curvature in the effective demand curve  $EE$ ).

FIGURE 6.1 : RESPONSE TO CHANGING PRICE RELATIVES



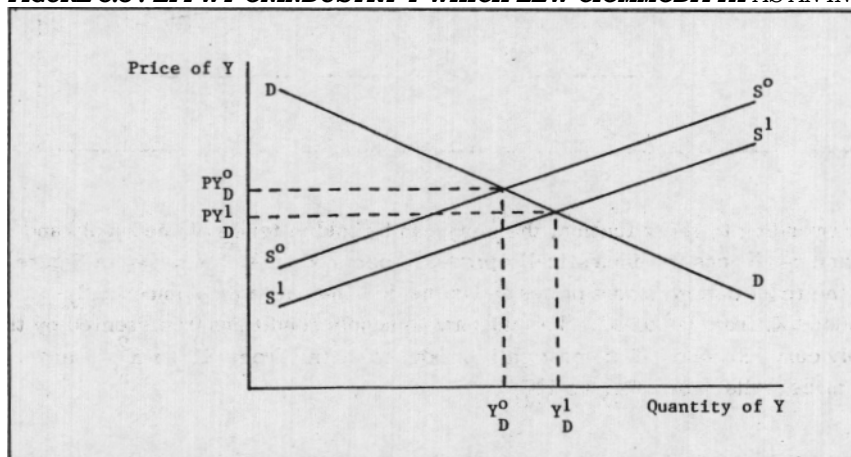
Corresponding to this situation, the story can be told in terms of the supply and demand conditions for domestically-produced commodity X. As shown in Figure 5.2, the reduction in import prices shifts the demand curve for domestically-produced X from  $D^0$  to  $D^1$ . With unchanged supply conditions (represented by the supply curve S), sales of domestically-produced X fall from  $X_D^0$  to  $X_D^1$ , and the price falls from  $P_D^0$  to  $P_X$ .

FIGURE 5.2 : SUPPLY AND DEMAND RESPONSES FOR DOMESTICALLY-PRODUCED COMMODITY X



The industries which use commodity X now have lower costs of production, **since** both domestically-produced and imported X are cheaper. Using industries that will benefit the most are those which use X most intensively in their production processes. The effect on a representative using industry is illustrated in Figure 5.3. Because of the cheaper availability of X, the supply schedule for domestically-produced commodity Y shifts down from  $S^0$  to  $S^1$ , and sales and output increase from  $Y_D^0$  to  $Y_D^1$ .

FIGURE 5.3 : EFFWT ON INDUSTRY Y WHICH LEW COMMODITY X AS AN INPUT





These direct effects on industry X and its main users are likely to be the most important. Depending on how widely commodity X is used, however, the effects on different commodities could be quite pervasive.

First, consumers may alter the mix of their bundle of purchases to favour cheaper items. In terms of Figure 5.1, this would correspond to a shift outward in the curve  $EE^c$ . That is, demand for both domestically-produced and imported goods could increase.

Second, industries which use good X as an input will have lower production costs. Purchasers of commodities produced by these using industries may be induced to buy more domestically-produced items that are now cheaper than imported alternatives. Competitiveness on export markets may also be improved.

Third, a reduction in prices will lead to a reduction in labour costs through the link between the consumer price index and wage indexation. A reduction in labour costs will be of general benefit to producing industries, and more so to those that are relatively labour-intensive.

The effects of a reduction in costs depends on the responsiveness of supply and demand curves. Referring to Figure 5.3, it can be seen that increases in production will not be great in some industries, following a reduction in one cost item, if producers cannot increase output without a significant increase in total production costs; ie, if the slope of the supply curve is steep (supply is inelastic). On the other hand, if the supply curve is flat (highly elastic), the reduction in costs will translate predominantly into output increases. For given supply conditions, output responses will predominate if demand is elastic; but if demand is inelastic, price decreases will be the main result.

There are further mechanisms that will influence the outcome. More of the total investment will be allocated to those industries which are prospering relative to others. This will, in turn, favour those industries which produce goods used intensively in capital formation in the prospering industries.

Also, the pattern and total usage of margins - such as transport, wholesale and retail trade - is likely to alter. Again, the outcome will depend on the mix of industries that grow and decline as a result of the policy change and their intensity of use of the different margins.

One potentially important factor, which is not accounted for, should be mentioned. It was stated above that lower prices to consumers may induce them to alter the mixture of their

bundle of purchases in favour of goods that have become relatively cheaper. However, in standard short-run simulations, there is no mechanism to capture the possibility that consumers might raise their aggregate level of expenditure in response to generally lower prices. (Aggregate consumption expenditure has been fixed exogenously in this notional application).

In summary, a change of assistance to one industry sets in train a detailed set of mechanisms in the ORANI framework. The industry producing commodity X is affected not only by an initial reduction in sales, due to greater competition from imports that are made cheaper, but also by other consumer and user responses, the effect on labour costs through wage indexation and so on. Other industries would prosper from the change through cheaper inputs of X (and other goods), lower labour costs and/or greater investment demands. Some industries may be made worse off if they relied heavily on sales to industry X, or if adjustments to consumption or investment demands did not favour them.

The final outcome on industry outputs, individually and in aggregate, depends on a myriad of factors. These change according to the nature of the industries most affected, but some of the important factors mentioned here, have been:

the degree to which purchasers substitute between alternative sources of supply (ie between imports and local production) in response to changes in relative prices;<sup>39</sup>

the importance of different goods and services in total purchases by consumers, in investment and by government;

. the strength of forward and backward linkages between industries;

the degree of wage indexation and labour intensity of production in different industries;

the ability of industries to pass on cost increases/decreases or to alter production levels in response to changes in costs.

### **5.3 Effects On Employment**

There will be three general influences on the employment of labour:

industries which contract will employ less labour due to reduced output levels;

expanding industries will employ more labour to service increased levels of output; and

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39 Pagan and Shannon have reviewed criticisms of the ORANI model, and in particular the sensitivity of results to certain parameter values. In the context of tariff experiments, they find sensitivity to export supply elasticities (and not so much to export demand and import substitution parameters, as is frequently charged). See A.R. Pagan and J.H. Shannon, 'How Reliable are ORANI Conclusions?', *Economic Record*, v.63 (180), March 1987, pp. 33-45.

industries may generally substitute labour for capital (depending on what happens to factor prices), since labour has become relatively cheaper through the CPI-wage-indexation link.

Unless some factor is introduced into the simulations to allow for a change in wage relativities between occupations, there will be no switching of labour demands between occupations. Nevertheless, total employment of different occupations is likely to alter due to the relative expansions and contractions in industries which are more intensive in their employment of different occupational types.