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How Reliable are ORANI Conclusions?*

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This paper seeks to systematically review the main criticisms of the ORANI model by developing a graphical version of a two-sector (exportables and nonexportables) miniature ORANI model. This model shows that ORANI results occur because while supply curves in both sectors have similar slopes, the slopes of the demand curves are polar opposites. Furthermore this model shows that results will tend to be more sensitive to variations in supply rather than demand parameters. Experiments using the ORANI model itself verified these findings. These results indicate that some form of sensitivity analysis with respect to assigned parameter values should form an integral part of any ORANI experiment.

I Introduction

In 1975 the Whitlam government decided to fund an ambitious modelling project. Mindful of the fact that the impact of any policy change can only be adequately assessed in a systems framework, it was decided to construct a suite of models to explore the impact of economic, technological and demographic changes upon the Australian economy. Professor A. A. Powell was nominated as Director of what became known as the IMPACT project, and an intensive research endeavour over the past decade has seen a large part of the original vision come to fruition.

Perhaps the best known product of the IMPACT project has been the ORANI model of the Australian economy. This represents a large-scale general equilibrium model designed to assess a wide variety of questions concerning commercial and industrial policy. To gain a good appreciation of the range of issues that have been addressed by the ORANI model, the interested reader is referred to the summary provided by Parmenter and Meagher (1985).

Not only is the ORANI model the best known of the IMPACT suite, it is also probably the most controversial. Since the first documentation in 1977 there have been a number of conflicts over the nature of the model, the assumptions underlying it, and its utility. Criticisms have come from a number of different sources. Initially the debate was largely academic, with strong dissenting judgements being delivered by those closely associated with the IMP model. But soon the argument extended to the bureaucracy. In particular, the Bureau of Industry Economics (BIE) has had several heated exchanges with the Industries Assistance Commission (IAC) over the use of the ORANI model in tariff enquiries, while individual officers such as Cronin (1984a and 1984b) have continued to argue against the utility of certain variants of the ORANI model.[1]

*We are grateful to Russell Rimmer for performing the sensitivity experiments on ORANI reported in this paper, and to Peter Dixon and an unknown referee for their detailed comments on an earlier version of this paper. This work was done as part of the IMPACT work programme.

[1]Specifically what is referred to as 'short-run' ORANI, whose central feature is that capital stocks are fixed in each industry. This contrasts with 'long-run' ORANI which works with a fixed rate of return across industries. Many of the criticisms advanced regarding the former also apply to the latter, but we will not be directly concerned with long-run ORANI in this paper.

These controversies have been largely 'in-house'. But the appointment of Professor P. B. Dixon – perhaps the major figure in the construction of ORANI – as head of the Institute of Applied Economic and Social Research has moved the dissension much more into the public domain. Partly this shift arises from the belief that the ORANI model is no longer to be restricted to examining allocation issues such as arise with tariffs, but also stabilization and distributional ones. Many of the critics find it implausible that a single model can adequately serve all of these purposes, and it is a viewpoint with which one can sympathize. Of course it is doubtful if the builders of ORANI do maintain that the model can be successfully used to address problems that fall in all of the three areas above. Certainly the original design of the IMPACT project called for a suite of models rather than reliance on an exclusive one. It was envisaged that ORANI would need to be supplemented by MACRO – a macroeconomic model – if it was to effectively deal with stabilization issues.

Critiques of the ORANI model may be divided into three major categories. The first of these denies the neoclassical economics that provides the theoretical framework for ORANI. There are really two parts to this complaint. One rejects the use of optimization of profits, utility etc. to derive demand and supply curves. This rejection could be applied to almost any macroeconomic model or analysis done by economists, and it is therefore directed more generally at economic theorizing than ORANI itself. In fact, if ORANI is thought of as a system of demand and supply curves allied with a market-clearing assumption, the purpose of economic theory is to provide some restrictions upon the shapes of these curves.

The second part of this criticism relates to the requirement that markets clear. Cronin (1984b) argues that prices are not very sensitive to demand conditions and cites a number of macroeconomic studies in support of his case. While that evidence is by no means clear-cut, it is more important to ask whether it is incompatible with market-clearing. The answer must be in the negative. Lack of sensitivity to demand shifts may not signify that markets do not clear; it may just indicate that supply is relatively elastic. Price changes induced by demand shifts vary inversely with the elasticity of supply. Consequently, a wide range of responses is possible from ORANI depending on the precise slopes assigned to the supply curves.[2]

The second of the three general types of criticism focuses upon the closure of ORANI. Most computable general equilibrium models have supply and demand curves not only for local industries but also for the labour market and the 'rest of the world'. Furthermore, demands are forced to sum to aggregate income, making the balance of trade zero. Because of these modifications, world prices and incomes are determined jointly with their domestic equivalents. By contrast, ORANI treats many foreign variables and real wages as fixed and, in its short-run mode, treats aggregate expenditure as exogenous, and so independent of aggregate incomes. Treating the foreign sector as given does not seem an unreasonable strategy. Although conceptually it is nicer to determine all outputs and prices, it is almost inevitable that the 'rest of the world' is unlikely to be quantified with the same precision as the domestic sector, i.e. the slopes of the foreign demand and supply curves will be chosen somewhat more arbitrarily.

Treating aggregate expenditure as fixed may indeed be a serious deficiency. It is hard to envisage this action as a reasonable description of behaviour for any period over six months, whereas short-run ORANI is frequently asserted to be based upon a one- to two-year period – see Cooper *et al.* (1985). To some extent this closure was just one of convenience, as the MACRO module was to endogenize aggregate expenditure (absorption). In some instances the assumption seems a reasonable simplification. For example, when the resource allocation effects of tariff changes are under study, it is useful to abstract from the macroeconomic environment. But for other simulations in which the effects of policy actions upon saving behaviour become paramount, it is clearly unsatisfactory. Beginning with Dixon *et al.* (1984) and culminating in Horridge and Powell (1984), the IMPACT team has developed an approach to make absorption endogenous in long-run ORANI simulations, and this formulation could profitably be applied to the short-run model as well. In the next section we illustrate how this closure can influence conclusions by looking at a miniature model of ORANI. A similar story applies to the labour market. ORANI has a perfectly elastic supply of labour at a wage rate determined solely by the degree of indexation set by the user. Accordingly, either real or nominal wages are fixed independently of the state of the labour market. Endogenizing the wage rates was to be done through BACHUROO and MACRO, but recent experience of the Phillips curve in Australia would indicate that keeping real wages constant is an acceptable approximation to labour market outcomes.

Much of the comment above relates indirectly to the shapes of the demand and supply curves employed in ORANI. Lastly, we come to evaluations which concentrate indirectly upon the parameters which determine those shapes. Most attention has been paid to the trade parameters – export demand and import substitution elasticities – with the ORANI team devoting a paper, Dixon *et al.* (1985), to rebutting that criticism. Our paper is essentially devoted to this issue, as it is quite fundamental to a proper assessment of the reliability of ORANI results. Moreover, as observed above in connection with the 'neoclassical' critique, many of the reservations expressed about ORANI can be interpreted as debates over the sensitivity of ORANI to the particular parameter values chosen to calibrate it. Indeed, we feel that the debate over the utility of the ORANI model would have been much more productive if it had recognized that the ORANI framework is capable of generating a wide range of responses as the calibrating parameters are changed. What is important then, is a proper understanding of the issues of sensitivity.[3]

In this paper we concentrate upon the question of how sensitive the conclusions reached with ORANI are to the parameter values embodied in it. An overall perspective is available from a miniature version of ORANI designed to replicate, reasonably closely, the conclusions of the large-scale model. A study of the smaller model yields valuable insights about the larger one and guides the design of experiments to assess the sensitivity of the latter. As the construction and use of miniatures has long been a feature of the IMPACT project, there are good reasons for continuing this tradition.

Section II lays out this miniature in graphical form, showing how typical ORANI conclusions stem from the shapes of demand and supply curves present in the model. Section III then looks at how variations in demand curve shapes affect outcomes, reviewing criticisms made about ORANI assumptions in this area. Section IV follows the same strategy but for the supply side. Finally, the concluding section takes cognizance of some recent developments that aim to provide greater information to ORANI users about the robustness of their results.

TABLE 1
Own Price Elasticities of Demand and Supply, BOTE Model

Sector	Demand	Supply
Export	– infinity	1.27
Non-export	– .1	1.12

II The Miniature Model

Fairly recently, when faced with the need to understand the impact of oil price movements upon the agricultural sector, Dixon *et al.* (1982) provided a two-sector model that was quite successful in duplicating the aggregate outcomes of the very much larger ORANI model. This representation was termed the back-of-the-envelope or BOTE model. It distinguishes only two sectors, identified by whether they are oriented towards export (e) or non-export (n) activities, but the behavioural relations embodied in it are of the same type as ORANI. We believe that this miniature is very good for understanding the mechanisms which produce ORANI's distinctive results, and it also provides a useful way of classifying the reservations expressed about ORANI.

Fundamentally, all computable general equilibrium models aim to determine industry prices and outputs consistent with the condition that all markets clear. Consequently, the demand and supply curves need to be specified, and it is the movements in these curves, along with their shapes, which determine the responses to any shock. It is useful therefore to look at these schedules in the case of the BOTE model, with the expectation that a study of them will highlight the principal ORANI results.

Table 1 presents the demand and supply own price elasticities for each of the two sectors in BOTE, while Figures 1 and 2 supply a typical

[2]Of course, neoclassical theory relates these slopes to factor substitution elasticities, and it is impossible to change one without the other in ORANI. This means that changes in the supply curve slope have implications for factor demand curves. It is possible that some of the critics are actually objecting to this connection, but we know of no specific claim to that effect.

[3]This is also true for some criticisms that we don't specifically deal with. For example, Cronin (1984b) is unhappy with the investment theory in ORANI. His objections relate to the magnitude of the investment response to profitability.

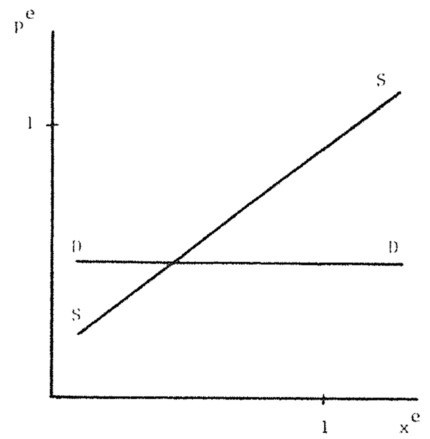

FIGURE 1
Export Industry

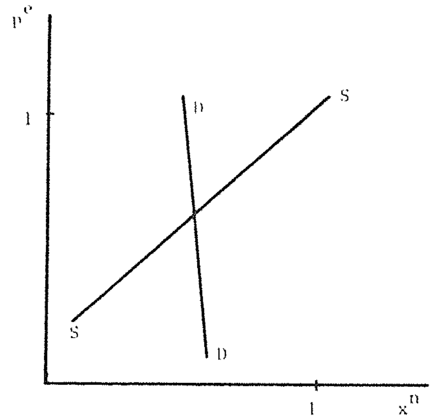

FIGURE 2
Non-Export Industry

graphical format when the values of exogenous variables have been changed; the curves are drawn with their exact slopes and the axes represent rates of change in prices and quantities in accordance with the ORANI convention of measuring variables as percentage deviations from an equilibrium position. The derivation of the slopes, along with a mathematical statement of the BOTE equations, is given in Appendix 1.

It is interesting to observe immediately that the supply elasticities are similar in both sectors, but the demand elasticities are virtually polar opposites. The position of each of these curves depends upon a number of different factors. For goods that are not exported, i.e. those in the non-traded and import-competing parts of the economy, the level

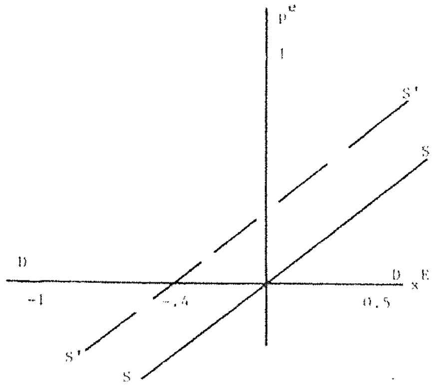

FIGURE 3
Export Industry

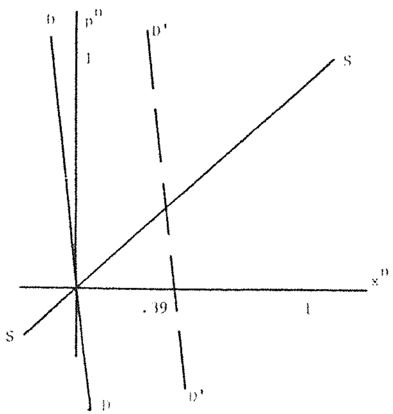

FIGURE 4
Non-Export Industry

of demand depends upon import good prices (in domestic currency) and the aggregate level of expenditure (absorption). Obviously, under the standard short-run ORANI closure in which absorption and foreign prices are exogenous, the position of the demand curve is fixed by policy and external events. Export demand levels also depend on exogenous foreign factors – the levels of income and competitors' prices. Supply curves depend upon foreign prices through the cost of imported raw materials and also the level of nominal wages.

Figures 3 and 4 may be employed to obtain some of the characteristic ORANI responses to an aggregate demand shock and a rise in tariffs. Dashed lines in the figures indicate new equilibrium positions after the postulated disturbance.

Aggregate Demand Shock

A rise in domestic absorption shifts the non-export industry demand curve to the right, thereby raising prices and output in that industry. As exporters use some of the commodities produced by the non-export sector as inputs in the production process, these price rises increase their cost structure, shifting the export supply curve to the left. After this 'first round', holding nominal wages constant, the non-export sector has grown and the export sector has contracted. Probably this effect is not very large. For the BOTE model a rise of .45 per cent in absorption, with fixed nominal wages, increases output in the non-export sector by 0.39 per cent, while it reduces output in the export sector by 0.40 per cent.

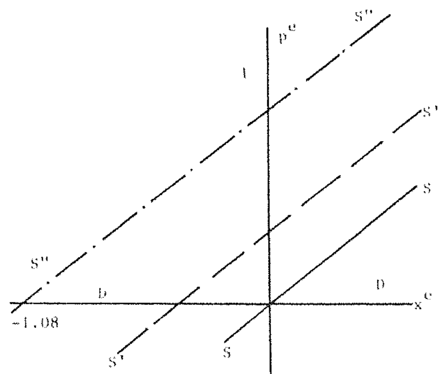

FIGURE 5
Export Industry

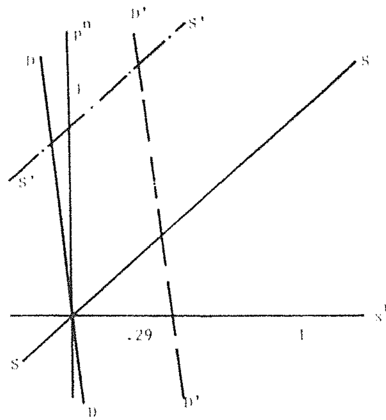

FIGURE 6
Non-Export Industry

The second round effects depend upon the labour market closure. If nominal wages rise in line with the aggregate price level, this will shift the supply curves of both industries further to the left (see Figures 5 and 6), further reducing output in the export sector and offsetting part of the positive impact of demand expansion on the non-export sector. The rise in nominal wages will actually be less than that for the price of the non-export commodity, as the aggregate price level includes contributions from export and import prices, both remaining constant. In fact, with a .45 per cent rise in aggregate demand and full indexation to the consumer price index, output in the non-export industry rises by 0.29 per cent, while it falls by 1.08 per cent in the export sector.[4]

Obviously the final outcomes depend significantly upon the wage indexation rule in force, as that determines the magnitude of any shift in the supply curves. But, as is clear from the steep slope of the demand curve in the non-export sector, there will be very little offset to the positive effects of the demand expansion there; most of the impact is felt on prices and not quantities. By contrast, the infinite elasticity for export demand ensures a strong output contraction. This is a key ORANI

[4] The experiments considered in this paper are discussed in Dixon *et al.* (1982) who examined four different policy shocks each of which produced a 1 per cent decrease in the exchange rate when used in ORANI simulations.

characteristic and Figures 1 and 2 show it follows from the relative shapes of demand curves in the two sectors. Notice that a shock such as an oil price rise will also have a much smaller effect on the non-export sector then on exports. The same movement in supply curves translates into different output responses because of differing demand curve slopes – the actual responses in BOTE to a 26 per cent rise in local oil prices being −.14 per cent for the non-export sector and −1.25 per cent for the export sextor.

A Tariff Increase

The sequence is exactly the same as above, except that the demand expansion for non-export commodities stems from the assistance provided to one of their components, import-competing goods. There are however additional unfavourable supply-side effects, with tariffs directly increasing the cost of production in the export sector because of imported inputs, while the CPI response is now much greater than in the previous experiment as both non-export and imported goods exhibit price movements. Overall the outcome is clouded. From the demand function for non-export commodities in BOTE, a 10.7 per cent increase in tariffs generates a 1.85 per cent rise in demand, which is offset by large movements in wages. Again, given the steepness of the demand curve in this sector, it is unlikely that some expansion would not be forthcoming, and indeed the non-export sector does increase its supply by .03 per cent. Exports are reduced by 1.28 per cent.

A number of points may be made on the basis of a study of the miniature model. First, whilst the shapes of the demand and supply curves are potentially very important for conclusions, their exact impact will depend upon the type of experiment being conducted. Thus, for a rise in foreign demand – a shift in the export demand curve – it is only the shape of the export supply curve that is crucial; the fact that the export demand curve is taken to be infinitely elastic is irrelevant. Hence, it will never be possible to conclude that ORANI is sensitive to particular parameters; it will all depend upon the context. Furthermore, it would be a grave mistake to conclude that, because ORANI results might be sensitive to particular parameters in one context, they will always exhibit such sensitivity. It is not possible to base a general acceptance or dismissal of the ORANI model upon how sensitive its conclusions are in a specific situation.

Second, closures are also vital to results. Such a fact is apparent for the labour market in the form of 'second round' effects mentioned above, but it is also true regarding the endogeneity of absorption. If absorption is made to depend upon national income, then an expansion in foreign demand, for example, would shift the demand curves of both the export and non-export industries, and the shapes of both supply curves then become critical. As an example of this phenomenon we added to BOTE a primitive absorption/income relation of the type employed in Horridge and Powell (1984). A 10.7 per cent rise in tariffs under this augmented specification gives a 0.52 per cent reduction in aggregate employment compared to the standard one of 0.21 per cent.

III Criticisms From the Demand Side

The Non-Export Industries

For the non-export industry the shape of the demand curve is determined by the own price elasticity. Under the ORANI specifications, and for import-competers, the latter is the product of the import share in total expenditure and a substitution parameter indicating how competitive imports and non-export goods are. Most of the controversy over demand curves in this sector relates to the magnitude of the substitution parameter.

Two themes may be identified. The first relates to the origin of the import substitution values employed in ORANI. Both the ORANI modellers and the Industries Assistance Commission (1983b) profess considerable confidence in them; Dixon *et al.* (1983, p. 284) for example, saying, regarding their construction and reliability,

> A detailed econometric study using newly mobilised data was conducted and the results are regarded as one of the strongest parts of the current ORANI parameter file. It is unlikely that a convincing case could be made for large variations in the standard ORANI values.

Doubts must exist about such a strong interpretation of the pioneering study of Alaouze *et al.* (1977). Cronin (1984a) for example has pointed to problems arising from aggregation when there is substantial variation in quality by country of origin. Both Walker (1981) and Ng (1983) have tried to assess whether the econometric estimates should be treated with caution, by asking if the specifications underlying the econometric work were adequate. Unless one is convinced of the adequacy of the specification, the actual numbers derived from the exercise would seem to have little more validity than if arbitrarily assigned. Ng finds strong evidence of mis-specification of the relationship in a number of industries, particularly when he investigates the question of the constancy of the underlying substitution parameter over time. For example, he finds that both ASIC industries 2835 and 3211 (Asbestos and Cement Products, and Motor Vehicles, respectively) fail the cusums squared test for coefficient stability of Brown, Durbin and Evans (1975). Recursive estimation shows that the point estimate of the elasticity of substitution varies greatly over the sample period. When only the first half of the sample is used the elasticity is estimated as 0.37, whereas it is 1.15 over the whole period.

Revealed preference provides another test of the reliability of the parameter values contained in ORANI. Despite a strong defence of these estimates in their reply to the Bureau of Industry Economics – IAC (1983b) – the IAC during the Enquiry into the Steel Industry raised the import substitution parameters for 'steel' products from one to six (IAC, 1983a, p. 309).[5] Their comment at that time was: 'The Commission has been unable to assemble time series . . . on which econometric estimates of these parameters could be based'.

For the purpose of analyzing the second part of Dixon *et al.*'s contention cited above, let us suppose that the econometric estimates have emerged from an acceptable modelling strategy. Such estimates nevertheless have a degree of uncertainty about them induced by random elements in the data, and it is customary to recognize this uncertainty by considering the range of values covered by two standard deviations on either side of the point estimate. Denoting the point estimate by b, and the standard deviation by s, the range would be $(b-2s, b+2s)$. The potential proportional change in the estimate is therefore $\pm 2s/b = \pm 2/t$, where t is the t statistic given in regression analysis. Clearly the uncertainty about the value coming from the data – summarized by t – determines how large a variation in the parameter it will be necessary to consider. Few econometric studies have t values greater than six, so that a 33 per cent change in the estimates would need to be contemplated in most circumstances.[6] Potentially large changes in the parameters are the norm rather than the exception where estimates are culled from data.

But all this concern over magnitudes would be irrelevant if the model itself – or, as we emphasized above, specific configurations of it – was not very sensitive to variations in the parameters. Elsewhere, Pagan and Shannon (1985a), we have proposed a convenient way to summarize evidence on the degree of sensitivity. This involved computing a sensitivity or S elasticity for each parameter of interest. Let γ be a solution value for a model output and assume it is a function of a parameter θ. Then the S elasticity for γ with respect to θ is $(\partial y/\partial\theta)(\theta/y)$, and it is calculated for a given θ^* (and associated γ^*). For models such as ORANI it is possible to provide explicit expressions for $\partial y/\partial\theta$, but we have instead approximated that quantity by $\Delta y/\Delta\theta$, where Δy is the change in γ from varying θ from θ^* by an amount $\Delta\theta$. This was the simplest way of computing the requisite derivative with the current ORANI software.

There is no problem in computing the S elasticities for the BOTE model, as it features only three parameters. However, the ORANI model has an enormous number of parameters and therefore a very large number of potential S elasticities. Conceptually there is no difficulty, but the procedure of computing $\partial y/\partial\theta$ by $\Delta y/\Delta\theta$ becomes infeasible (from a cost viewpoint) if S elasticities are computed for every parameter. Furthermore, since we wish to compare the BOTE and ORANI models, it would be necessary to weight the S elasticities for each coefficient in ORANI to enable a ready comparison to the 'aggregate' S elasticities of BOTE. Hence, some simplification of the problem is necessary. Here we followed Dixon *et al.* (1985) in varying all parameters in a defined set by 10 per cent simultaneously, so that the S elasticities reported later are to variations in a group of parameters.

Table 2 gives the S elasticities associated with a 1 per cent change in all the import substitution parameters in ORANI for the 25 per cent tariff increase experiment. Details of the groupings employed in forming the export, import-competing and non-traded goods sectors are presented in Appendix 2. Detailed industry results also are

[5] It is interesting to observe that the substitution elasticities for the steel industry were not rated as having high reliability in the book documenting the ORANI model – see Dixon, Parmenter, Sutton and Vincent (1982, pp. 185-7).

[6] The t values tabled by Alaouze *et al.* (1977) refer only to the estimated magnitude of substitution parameters applying one quarter after relative prices have changed, whereas what is wanted are those relating to a two-year period. Ng (1983), using a technique due to Bewley (1979), computes the latter for a number of industries, finding a maximum t statistic of 4.8.

available in Pagan and Shannon (1985b) and there is a wide divergence in sensitivity of industry output, with some very high S elasticities. However, for industries exhibiting this feature, the output change stemming from the imposition of a tariff is very low. Accordingly, in absolute terms the output solution under a new parameter setting is small, even though the proportional change is large. To avoid giving a false impression on sensitivity, Table 2 gives the median of the S elasticities across industries.

To apply the results of Table 2 to any assessment of the ORANI model it needs to be borne in mind that the output from ORANI (γ) is already expressed as a rate of change. Consequently, an S elasticity represents the extent to which the growth rate in a variable will be modified as parameter values are revised. Bearing this point in mind, it is apparent from Table 2 that output growth in the import-competing industries, following the imposition of a tariff, improves dramatically as the import substitution parameters increase. In fact, the implication of the S elasticities in Table 2 is that a 33 per cent rise in all of these parameters roughly provides a 33 per cent stimulus to output growth in import-competing industry, and it would tend to lift aggregate employment growth by about 22 per cent over the ORANI prediction. On balance, however, it seems fair to conclude that, whilst plausible alternative import substitution terms can significantly ameliorate any conclusion that tariff increases reduce aggregate employment, it cannot, by itself, reverse such a judgement.[7]

Export Sector Demand

Possibly more heat has been generated over the size of export demand elasticities than over any other aspect of the ORANI model. Whilst Cronin (1979) has been the most vociferous critic, many other observers have expressed some doubts about

TABLE 2
Sensitivity (S) *Elasticities for the Import Substitution Parameters, ORANI*(a)

Agg. Emp.	Output-Export	Output-Non Traded	Output-Import competing
−.67	.11	.10	.93

(a) The S elasticity here shows the percentage change in solution values to a 1 per cent change in the parameter.

the ORANI assumption of a very elastic demand curve for exports.[8] For example, it has been pointed out that the demand elasticities used to calibrate short-run ORANI are actually those described by Freebairn (1978) as applicable to the long run.

Dixon *et al.* devote most of their 1985 paper to an analysis of ORANI responses to export demand elasticities, concluding that it is only when demand elasticities become less than two that any major qualifications would need to be entered:

> . . . if we are satisfied that export demand elasticities are, on average, greater than two, then the exact values we choose for them between two and infinity do not have critical implications for ORANI [p. 345].

Exactly why this should be so can be appreciated from Figures 7 and 8. Although the transition from an elasticity of infinity to one of two looks a major shift, it translates into a very limited alteration in demand curve shapes. Hence, any movements in the supply curve (as in the dashed line) are felt largely as output changes. Below unity though, the demand curve shifts rapidly to the vertical position and inflation rather than output becomes the dominant response.

Dixon *et al* make a strong case against inelastic demand curves, arguing that the acquisition of this characteristic would make it profitable for Australian producers to form cartels and exploit their monopoly power.[9] Implicitly the ORANI modellers argue their case in terms of the predicted

[7]Peter Dixon has pointed out to us that sensitivity of this conclusion to the parameter values has been recognized by the ORANI team, e.g. in Dixon *et al.* (1979, p. 19). He argues that what is important is not the sign of the employment response in this ORANI run, but the fact that it is small. We would agree that this is probably the best way to interpret the outcome of the tariff experiment, but we also feel that it was the sign of the response which many would cite as the major, and most striking, conclusion. Indeed, we believe that 'counter-intuitive' results such as this are often regarded as an 'ORANI characteristic'. Consequently, here and in the remainder of the paper, we focus upon the question of how robust such sharp conclusions are.

[8]In BOTE the sole export elasticity is infinite but, in ORANI, there is a range of elasticities between −1.3 and −20, with a tendency to congregate around −10.0.

[9]One objection to this, presented by Cronin (1984b), that an inelastic industry demand curve does not confer monopoly power on individuals firms, seems to miss the point. Dixon *et al.*'s argument hinges on the incentives to collude.

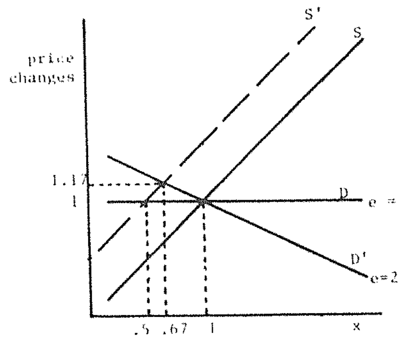

FIGURE 7
Elastic Curves

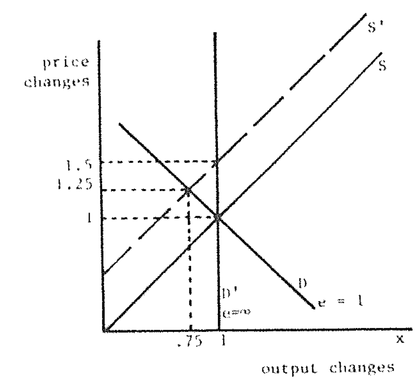

FIGURE 8
Inelastic Curves

price increments following on a reduction in Australian exports, and it is indeed hard to believe that these would be major. By contrast, Cronin is more concerned with the revenue flow from a price cut in Australian exports. Because of the existence of various non-price barriers to trade, he doubts if these price reductions would stimulate much extra effective demand. Both of these arguments have merit, and reconciliation between them demands that an asymetric response be recognized; the demand elasticity appropriate to a price rise being much greater than that for a price deline. If one accedes to this proposition, it follows that the export elasticities to be used depend directly upon the scenario under examination. Unfortunately, at the moment ORANI users do not have a facility whereby such asymetric behaviour could be encompassed.

It is worth looking at how important the export demand elasticity parameters are to ORANI solutions. When we examine Table 3 we see that the S elasticity for aggregate employment to a 1 per cent change in these coefficients is 0.32. Once again, although there is a query about reliability, quite large variations in export demand elasticities – of the order of 300 per cent – would be needed to reverse employment results from the tariff experiment.

TABLE 3
Sensitivity (S) *Elasticities for the Export Demand Parameters, ORANI*(a)

Agg. Emp.	Output-Export	Output-Non Traded	Output-Import competing
.32	.20	.14	.10

(a) The S elasticity shows the percentage change in solution values to a 1 per cent change in the parameter.

IV Sensitivity to the Supply Side

As seen in Figure 1 above, at around unity the elasticity of supply is approximately the same for both the export and non-export sectors in the BOTE model. Dissenting judgements have been made to both this equivalence and magnitude of supply elasticities. Cronin (1984b) has done this indirectly through an objection to the responsiveness of prices to demand an ORANI. He feels that, at least for the non-export sector, prices should not be greatly influenced by demand conditions, and he posits a very elastic supply curve. Lloyd (1983) believes that the agricultural supply elasticities are overstated.

Once again the issue is one of sensitivity; are the ORANI solutions very sensitive to plausible alternative values for these supply functions? Investigations by others – Harrison and Kimbell (1983) – have shown that supply elasticities are very important parameters in numerical general equilibrium models, and it would be surprising if this were not also true of ORANI. To gain some insight into this topic we have computed the S elasticities separately for 1 per cent changes in the

TABLE 4
Sensitivity Elasticities, Supply Side Parameters, ORANI[(a)]

Effect on Solution Values	Sector Supply Elasticity		
	Non-Traded	Import-Competing	Export
Output, *NT*	.21	−.03	.30
Output, *IC*	.05	.15	.10
Output, *E*	.16	.02	.65
Agg. Emp.	.38	−.16	1.03

(a) For the output variables the S elasticities are the median values for all industries in the referenced classification.

supply elasticities in the non-traded (*NT*), export (*E*) and import-competing (*IC*) sectors (under the tariff experiment). Table 4 presents these results. Pagan and Shannon (1985b) provide industry-specific S elasticities.

Table 4 demonstrates that, of the three types of supply elasticity, it is the export category which is crucial to the ORANI outcomes. The aggregate employment S elasticity is extremely large, making modifications to any sharp conclusions probable if these elasticities are not known with any precision. It is also noticeable that the employment S elasticity to export supply coefficients is much larger than for the two parameters considered on the demand side, and this lends support to the hypothesis that it is on the supply side that the key parameters of ORANI are encountered.

V Conclusion

A number of points emerge from the above analysis. The likely variation in parameter values is such that ORANI results should always be subjected to some sensitivity analysis. Deciding on exactly what this should be is a different matter. Our solution was to advance the idea of sensitivity elasticities, which show the effect of a 1 per cent change in parameter values upon model solutions. With this tool we demonstrated that, at least when looking at tariff changes, it was the export supply elasticities which were probably the most important set of parameters in ORANI. In fact, the ORANI solutions were almost twice as sensitive to this parameter as to any from the demand side. Yet it is interesting that most of the doubts about ORANI concentrate upon the latter, particularly in respect of the 'trade parameters'.

Our methodology is also capable of delivering other insights. First among them is the possibility of looking at combinations of changes in parameters. Using the S elasticities earlier, a 50 per cent increase in all import substitution parameters, combined with a 50 per cent decrease in export supply and demand elasticities gives a 100 per cent reduction in the aggregate employment reaction, i.e. a reversal of the sharp conclusion that a 25 per cent tariff increase reduces employment. To put this remark in perspective, a 50 per cent change in parameter values is by no means implausible, being consistent with a regression t statistic of anything less than four. Thus, despite the fact that no single set of parameters could be plausibly varied to extract a reversal of outcomes, a combination of changes might.

Our analysis has shown how important various parameter values (and closures) can be to the conclusions drawn from a computable general equilibrium model such as ORANI. What should be our response to this? One solution is to provide an alternative set of parameter values to those currently adopted as standard in ORANI. We doubt that this can be accomplished in any satisfactory way, without far greater knowledge of industry structure than we (or most users) have. It seems unlikely that any user would have the confidence to override standard settings for more than a few industries. Thus it seems desirable that a facility exist whereby a choice can be made to either run ORANI with standard parameter values (the default option) or to easily modify the existing parameter file to exploit special knowledge. It clearly is imperative that any person seeking to override the normal parameter values should state quite clearly what changes were made, just as current runs have to describe the chosen environment. During 1986 a software package known as GEMPACK is being developed at the University of Melbourne to enable ORANI users to run a variety of experiments rather than just the standard ORANI experiments. A description of this software package is given in Pearson (1986).

But we also feel that it is important to know which parameters are critical to the answers from a given simulation. Users may then concentrate upon the reliability of those parameters, perhaps obtaining new evidence that would enable a more precise determination of their values. To this end, we believe it is useful to provide the sensitivity elasticities described in Section III of this paper. On-going research by Shannon aims at providing the software that would generate such information for the ORANI model.

APPENDIX 1

A Mathematical Statement of the BOTE Model

Statement of the Model

The BOTE model contains an export sector (e) and a nonexport sector (n). In each sector there is: a zero pure profits condition; a labour demand equation; an output function; and a factor income function. The model also includes the CPI function, and the demand function for nonexportables. (Other equations are incorporated into the model when we attempt to close the model in alternative ways.)

Export sector

(zero pure profits) $p^e = S_l^e(\omega+\xi) + S_k^e q^e + S_i^e \xi$ (1)

(labour demand) $l^e = \sigma^e(q^e - \omega - \xi)$ (2)

(output) $x^e = V_l^e l^e$ (3)

(factor income) $r^e = V_l^e(l^e+\omega) + V_k^e(q^e-\xi)$ (4)

Non-export sector

(zero pure profits) $p^n = S_l^n(\omega+\xi) + S_k^n q^n + S_o^n p_o + S_e^n p^e + S_m^n p_m^n + S_i^n \xi$ (5)

(labour demand) $l^n = \sigma^n(q^n - \omega - \xi)$ (6)

(output) $x^n = V_l^n l^n$ (7)

(factor income) $r^n = V_l^n(l^n+\omega) + V_k^n(q^n-\xi)$ (8)

In the nonexport sector there is also a

(demand function) $x^n = \eta_1 a + (1-\eta_1)x^e - \eta_2[p^n - (Q_m^n p_m^n + Q_m^c p_m^c)]$. (9)

The CPI fucntion for the model is

$$\xi = W_n p^n + W_m p_m^c + W_o p_o + W_e p_e. \quad (10)$$

Variables

ξ percentage change in the CPI

ω percentage change in the real wage rate

p^e, p^n percentage change in the domestic price of exportable and nonexportable goods

q^e, q^n percentage change in the nominal rental value (profit) per unit of capital in the exporting and nonexporting sectors

l^e, l^n percentage change in employment in the exporting and nonexporting sectors

x^e, x^n percentage change in the volume of output in the exporting and nonexporting sectors

r^e, r^n percentage change in real primary factor income in the exporting and nonexporting sectors

a percentage change in aggregate absorption

p_o percentage change in the domestic price of oil

p_m^n, p_m^c percentage change in the domestic price of imported inputs and imported consumer goods

Derivation of Supply and Demand Equations

The derivation of the graphical version of BOTE is straightforward. Starting with the export sector we make the usual small-country assumption that export prices are exogeneous or $p^e = \bar{p}^e$ which gives us the horizontal demand curve in Figure 1. We then take our output or supply function given in (3) and substitute expressions for l^e and q^e obtained from (2) and (1) respectively. By substituting the appropriate parameter values we obtain the supply curve

$$x^e = 1.27p^e - .775\omega - 1.27\xi$$

shown in Figure 1.

Similar procedures are used when deriving the nonexporting sector's curves shown in Figure 2. By substituting the parameter values into (10) we obtain the demand curve

$$x^n = -.1p^n + .96a + .04x^e + .075p_m^n + .025p_m^c.$$

Using the same procedure as was used in the export sector we obtain the supply curve

$$x^n = 1.12p^n - .8\omega - .007p_o - .09p^e - .1p_m^n - .93\xi.$$

*Incorporating an Absorption Income Relation**

The simple absorption/income relation which was appended to BOTE was

$$a = \psi_1[(.88)(\omega+l^n) + (.12)(\omega+l^e)] + \psi_2[(.88)(q^n-\xi) + (.12)(q^e-\xi)].$$

In this function absorption is equal to labour's income and capital's income (there is no provision for savings in BOTE).

The values .88 and .12 represent the shares of total output which Dixon *et al.* (1982, p. 29) attribute to the nonexport and export sectors. The new parameters are ψ_1, labour's share in domestic income = .7, and ψ_2, capital's share in domestic income = .3

In the standard BOTE experiments the exogenous variables were

$$p^e,\ \omega,\ p_o,\ p_m^n,\ p_m^c \text{ and } a.$$

When the absorption/income relation is included 'a' now becomes an endogenous variable and the exogenous variables are

$$p^e,\ \omega,\ p_o,\ p_m^n \text{ and } p_m^c.$$

*A more detailed explanation is available on requeset.

Appendix 2

Construction of Sensitivity Elasticities

Dixon *et al.* (1985) have provided ORANI solutions when import substitution parameters are reduced by 10 per cent and when export demand elasticities are changed by 50 per cent. We compute the *S* elasticities to these changes assuming that the effect of a *k* per cent change is the same as *k* times a 1 per cent change. This is only true if the model response is linear, but experience with the BOTE model suggests that this assumption is reasonable provided extreme values are not being considered. An example of the last is when export demand elasticities go below two. In Pagan and Shannon (1985a) we present a method of obtaining exact values of these elasticities for any size change.

To obtain the supply elasticity impacts, the ORANI model elasticities file was modified for us by Russell Rimmer to enable to 10 per cent reduction in the standard parameter values. This information was used to compute the *S* elasticities.

Finally, it seemed sensible to divide the industries according to whether they were primarily oriented towards export, import-competing or non-traded categories. The classification we have used is essentially that in Higgs *et al.* (1984) and is given below with industry number.

Exports	1,2,3,4,5,6,8,9,11-14,18,25,30,49,63, 70,76,93,94,95.
Import-Competing	16,21,24,28,29,31-48,50,52-58,62, 65-69,71-75,77-83,96
Non-Traded	7,10,15,17,19,20,22,23,26,27,51,59, 60,61,64,84-92,97-112.

REFERENCES

Alaouze, C.M., Marsden, J.S. and Zeitsch, J. (1977), 'Estimates of the Elasticity of Substitution Between Imported and Domestically Produced Commodities at the Four Digit ASIC Level', IMPACT Working Paper No. 0-11.

Bewley, R. A. (1979), 'The Direct Estimation of the Equilibrium Response in a Linear Dynamic Model', *Economic Letters*, **3**, 357-61.

Brown, R.L. Durbin, J. and Evans, J.M. (1975), 'Techniques for Testing the Consistency of Regression Relationships over Time', *Journal of the Royal Statistical Association*, Series B, **37**, 149-63.

Cooper, R.J., McLaren, K.R. and Powell, A.A. (1985), 'Short-Run Macroeconomic Closure in Applied General Equilibrium Modelling', in J. Piggott and J. Whalley (eds), *New Developments in Applied General Equilibrium Analysis*, Cambridge University Press.

Cronin, M.R. (1979), 'Export Demand Elasticities with Less Than Perfect Markets', *The Australian Journal of Agricultural Economics*, **23**, 69-72.

—— (1984a), 'The Effects of Tariff Cuts Upon the Export Sector in Some Long Term Applications of ORANI', in *The ORANI Trade Parameters*, Industries Assistance Commission, 67-96.

—— (1984b), 'Conjecture and Refutation', paper presented to the Bureau of Industry Economics seminar, August.

Dixon, P.B., Parmenter, B.R. and Rimmer R.J. (1984), 'Extending to the ORANI Model of the Australian Economy: Adding Foreign Investment to a Miniature Version', in H.E. Scarf and J.B. Shoven (eds), *Applied General Equilibrium Analysis*, Cambridge University Press, New York.

—— (1983), 'The Sensitivity of ORANI Projections of the Short-Run Effects of Increases in Protection to Variations in the Values Adopted for Export Demand Elasticities', in R. Dixon (ed.), *The Agricultural Sector and Economy-Wide Modelling*, Institute of Applied Economic and Social Research, University of Melbourne, 265-86.

—— (1985), 'The Sensitivity of ORANI Projections of the Short-Run Effects of Increases in Protection to Variations in the Values Adopted for Export Demand Elasticities', in K. Jungenfelt and D.C. Hague (eds), *Structural Adjustment in Developed Open Economies*, Macmillan, London.

Dixon, P.B., Powell, A.A. and Parmenter, B.R. (1982), 'Farm Incomes and the Real Exchange Rate: ORANI Simulations with a Back-of-the-Envelope Explanation', IMPACT Project General Paper No. G-38.

—— (1979), *Structural Adaption in an Ailing Macroeconomy*, Melbourne University Press.

Dixon, P.B., Parmenter, B.R., Sutton, J. and Vincent, D.P. (1982), *ORANI: A Multisectoral Model of the Australian Economy*, North-Holland, Amsterdam.

Freebairn, J.W. (1978), 'Projections of Australia's World Trade Opportunities: Mid and Late Nineteen Eighties', IMPACT Working Paper No. I-07.

Harrison, G.W. and Kimbell, L.J. (1983), 'How Robust is Numerical General Equilibrium Analysis', Working Paper 8325C, University of Western Ontario.

Higgs, P.J., Parmenter B.R. and Powell, Alan A. (1984), 'The Scope for Tariff Reform Created by a Resources Boom: Simulations with the ORANI Model', *Australian Economic Papers*, **23**, 1-26.

Horridge, M. and Powell, A.A. (1984), 'Long-Run Closure of ORANI: A Proposal', IMPACT Preliminary Working Paper OP-46.

Industries Assistance Commission (1983a), *Certain Iron and Steel Products and Certain Alloy Steel Products*, AGPS, Canberra.

—— (1983b), 'A Reply to the Bureau of Industry Economics' Comments on the Commission's Short Term Effect of Restricting Steel Imports', mimeo.

Lloyd, A.G. (1983), 'The Elasticity of Aggregate Agricultural Supply', in R. Dixon (ed.), *The Agricultural Sector and Economy-Wide Modelling*, Institute of Applied Economic and Social Research, University of Melbourne, 259-64.

Ng, O.H. (1983), The Elasticity of Substitution Between Imported and Domestically Produced Commodities: An Evaluation, unpublished Honours Thesis, Australian National University.

Pagan, A.R. and Shannon, J.H. (1985a), 'Sensitivity Analysis for Linearised Computable General Equilibrium Models', in J. Piggott and J. Whalley (eds), *New Developments in Applied General Equilibrium Analysis*, Cambridge University Press.

Pagan, A.R. and Shannon, J.H. (1985b), 'How Reliable are ORANI Conclusions', Centre for Economic Policy Research Discussion Paper No. 130, Australian National University.

Parmenter, B.R. and Meagher, G.A. (1985), 'Policy Analysis Using a Computable General Equilibrium Model: A Review of Experience at the Impact Project', *Australian Economic Review*, 1.

Pearson, K.R. (1986), 'Automating the Computation of Solutions of Large Economic Models', IMPACT Project Preliminary Working Paper No. IP-27.

Walker, A.E.G. (1981), 'Estimates of the Elasticity of Substitution Between Imported and Domestically Produced Goods for Three 4-Digit ASIC Industries', Industries Assistance Commission, mimeo.