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ECONOMIES OF SCALE AND IMPERFECT COMPETITION IN AN APPLIED GENERAL EQUILIBRIUM MODEL OF THE AUSTRALIAN ECONOMY

by

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ABSTRACT

Recently some researchers have suggested that economies of scale and imperfect competition play a major role in determining the effects of exogenous policy shocks. Thus they have emphasised the need to incorporate industrial organisation features into computable general equilibrium (CGE) models. However, our knowledge of this new paradigm is still in its infancy—it is not yet clear how models of this type should be specified and to what extent their predictions are sensitive to the choice of specification. This paper describes a 23-sector CGE model of the Australian economy, based on ORANI and on Horridge (1987a and 1987b), which incorporates economies of scale and imperfect competition. The model is used to investigate whether adding these new features affects simulation results. We present results for three different types of non-competitive regime and compare these with results generated by a traditional (constant returns and perfect competition) version of the same model.

Key words: Economies of scale, imperfect competition, applied general equilibrium models.
JEL Classification Nos: C68, L11, L13.

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1. Introduction

In a pioneering paper, Harris (1984) emphasised the importance of imperfect competition and economies of scale in understanding the effects of trade liberalisation on the Canadian economy within an applied general equilibrium framework. He argued that a general equilibrium analysis which incorporates scale economies and imperfect competition yields significantly different results from one that does not. Thus, his estimated static long-run gains to Canada of trade liberalisation were in the range of 8-12 percent of GNP: considerably larger than those suggested by conventional estimates which assume perfect competition; these are often between 0.5 to 2 percent of GNP.

Harris's dramatic results have stimulated similar studies for several other countries—with mixed results. While applications such as Cory and Horridge (1985), Horridge (1987a and 1987b), Wigle (1988), Norman (1990), Nguyen and Wigle (1992) and Harrison, Rutherford and Tarr (1995) do not find substantial difference between perfect and imperfect competition in applied general equilibrium modelling, some applications such as Devarajan and Rodrik (1989 and 1991) seem to confirm the findings of Harris (though see Hertel *et al.*, 1991). An interesting feature of the work of Cory and Horridge (1985), Horridge (1987a) and Nguyen and Wigle (1992) is that they found Harris's results are not due to an inherent feature of imperfect competition and economies of scale in his general equilibrium modelling but are due to his ad hoc pricing rule: a mixture of Lerner markup pricing with import parity pricing. At present general equilibrium modellers share no consensus as to how models of this type should be specified and to what extent their predictions are sensitive to particular specifications.

This paper reports new estimates of short-run and long-run effects of unilateral trade liberalisation on the Australian economy using an applied general equilibrium model incorporating scale economies and imperfect competition. The present model draws on the Cory/Horridge work mentioned above, which mimicked the Harris approach. However, a number of advances have been made. While the Cory/Horridge model covered 8 sectors, the present model has 23. The behavioural specification is also more complex. The Cory/Horridge model was a long-run equilibrium model with free entry which ensured each industry operated with zero pure profits. The new model covers short-run as well as long-run profit-maximising firm behaviour. In the short run there is a fixed number of firms and each firm may earn non-zero pure profits. In the long run, the number of firms varies, as entry and exit are free. Each firm earns zero pure profits. In the model economies of scale are introduced either at the industry level or at the firm level. Similarly, pricing behaviour may be modelled as perfectly competitive, monopolistically competitive or in other *ad hoc* ways. The different assumptions about technology, pricing and firm entry are combined in various ways to produce a variety of scenarios.

In the next section of the paper we describe the basic neo-classical core of the model. Section 3 describes our additions to this core, incorporating new specifications of pricing and technology. The model simulation procedure is explained in Section 4. Section 5 explains the major results of the paper. Concluding remarks are presented in Section 6.

2. The Standard Neo-Classical Core Model

Our analysis builds on ORANI, an applied general equilibrium (AGE) model of the Australian economy (Dixon, Parmenter, Sutton and Vincent (DPSV), 1982). It has been widely used in Australia as a tool for practical policy analysis by academics, and by other private and public sector economists (Powell and Lawson, 1989).

The standard version of ORANI has over 100 sectors and is rather cumbersome for experimental work. Our starting point has been Horridge, Parmenter and Pearson's (1993) aggregated version of ORANI covering 23 sectors. We refer to this as HPP.

Figure 1 is a schematic representation of the model's input-output database (which derives from the 1986-87 Australian Input-Output Tables). It reveals the basic structure of the model. The columns identify the following agents:

(1) domestic producers divided into I industries;

(2) investors divided into I industries;

(3) a single representative household;

(4) an aggregate foreign purchaser of exports;

(5) an 'other' demand category, broadly corresponding to government; and

(6) changes in inventories of domestically produced goods.

The rows show the structure of the purchases made by each of the agents identified in the columns. Each of the C commodity types identified in the model can be obtained locally or imported from overseas. The source-specific commodities are used by industries as inputs to current production and capital formation, are consumed by households and governments, are exported, or are added to or subtracted from inventories. Only domestically produced goods appear in the export and inventory columns. M of the domestically produced goods are used as margins services (wholesale and retail trade, and transport) which are required to transfer commodities from their sources to their users. Commodity taxes are payable on purchases.

		Absorption Matrix					
		1	2	3	4	5	6
		Producers	Investors	Household	Export	Other	Change in Inventories
	Size	← I →	← I →	← 1 →	← 1 →	← 1 →	← 1 →
Basic Flows	↑ C×S ↓						
Margins	↑ C×S×M ↓						
Taxes	↑ C×S ↓						
Labour	↑ O ↓						
Capital	↑ 1 ↓						
Land	↑ 1 ↓						
Other Costs	↑ 1 ↓						

C = 23 = No. of Commodities
I = 22 = No. of Industries

S = 2: Domestic, Imported,
O = 2 = No. of Occupation Types

M = 2 = No. of Commodities used as Margins

Figure 1. The HPP Flows Database

Table 1: Commodity and Industry Classification

	Commodities		Industries
1	Cereals		
2	Broadacre rural	1	Broadacre rural
3	Intensive rural	2	Intensive rural
4	Mining, export	3	Mining, export
5	Mining, other	4	Mining, other
6	Food & fibre, export	5	Food & fibre, export
7	Food, other	6	Food, other
8	Textiles, clothing & footwear	7	Textiles, clothing & footwear
9	Wood related products	8	Wood related products
10	Chemicals & oil products	9	Chemicals & oil products
11	Non-metallic mineral products	10	Non-metallic mineral products
12	Metal products	11	Metal products
13	Transport equipment	12	Transport equipment
14	Other machinery	13	Other machinery
15	Other manufacturing	14	Other manufacturing
16	Utilities	15	Utilities
17	Construction	16	Construction
18	Retail & wholesale trade	17	Retail & wholesale trade
19	Transport	18	Transport
20	Banking & finance	19	Banking & finance
21	Ownership of dwellings	20	Ownership of dwellings
22	Public services	21	Public services
23	Private services	22	Private services

Current production requires intermediate inputs and three categories of primary factors: labour (divided into O occupations), fixed capital, and agricultural land. The 'other costs' category covers various miscellaneous industry expenses.

The industry and commodity classifications are different. Both are listed in Table 1. Multiproduction is confined to the first two industries, which produce the first three, agricultural, commodities. Each of the remaining industries produces a single commodity. Three categories of primary factors (labour, capital and land) are distinguished, with the last used only in the first two industries. Labour is split into 2 occupational categories, skilled and unskilled.

Commodities 18 and 19 are margins commodities, i.e., they are required to facilitate the flows of other commodities from producers (or importers) to users. The costs of margins services, together with indirect taxes, account for differences between *basic* prices (received by producers or importers) and *purchasers'* prices (paid by users).

Although there are fewer sectors, the theoretical specification of HPP is almost identical to that of ORANI[1]. It has a theoretical structure which is typical of an AGE model. It consists of equations describing, for some time period:

- producers' demands for produced inputs and primary factors;
- producers' supplies of commodities;
- demands for inputs to capital formation;
- household demands;
- export demands;
- government demands;
- the relationship of basic values to production costs and to purchasers' prices;
- market-clearing conditions for commodities and primary factors; and
- numerous macroeconomic variables and price indices.

Demand and supply equations for private-sector agents are derived from the solutions to the optimisation problems (cost minimisation, utility maximisation, etc.) which are assumed to underlie the behaviour of the agents in conventional neoclassical microeconomics. Like ORANI, the model is specified as a system of linear equations relating percentage changes of the variables.

In HPP, production functions display constant returns to scale. Also, agents are assumed to be price takers, with producers operating in competitive markets which prevent the earning of pure profits. Our modifications, described below, alter these two aspects of the HPP model.

[1]The original version of HPP contained additional stock-flow relationships, not present in ORANI, and omitted from the present model.

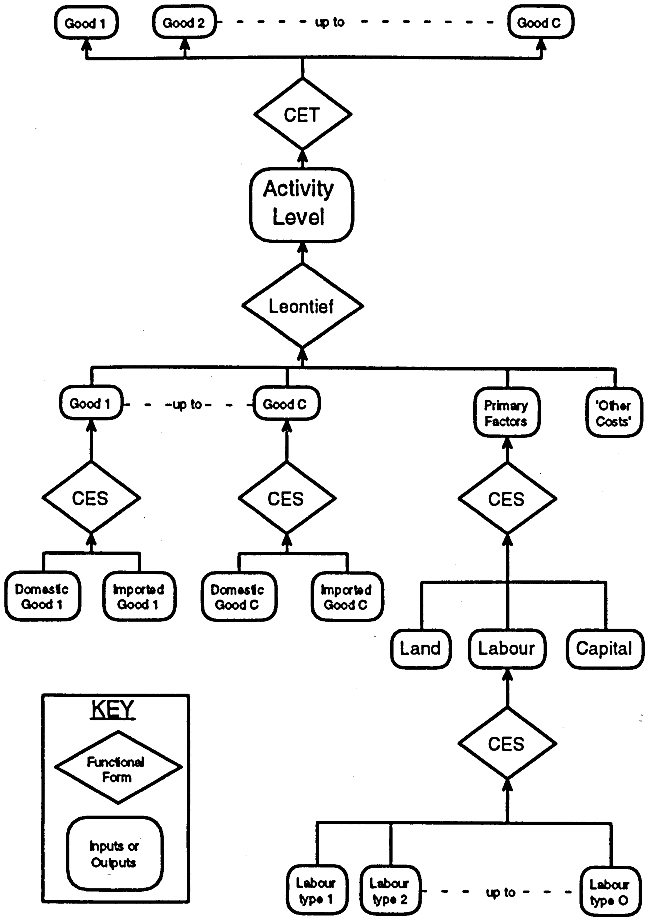

Figure 2: Structure of Production

2.1. Structure of Production

HPP allows each industry to produce several commodities, using as inputs domestic and imported commodities, labour of several types, land, capital and 'other costs'. The multi-input, multi-output production specification is kept manageable by a series of separability assumptions, illustrated by the nesting shown in Figure 2. For example, the assumption of *input-output separability* implies that the generalised production function for some industry:

$$F(\text{inputs, outputs}) = 0 \tag{1}$$

may be written as:

$$H(\text{inputs}) = Z = G(\text{outputs}) \tag{2}$$

where Z is an index of industry activity. Assumptions of this type reduce the number of estimated parameters required by the model. Figure 2 shows that the G function is derived from a constant elasticity of transformation (CET) aggregation function, while the H function is broken into a sequence of nests. At the top level, commodity composites, a primary-factor composite and 'other costs' are combined using a Leontief production function. Consequently, they are all demanded in direct proportion to Z. We adopt the Armington (1969, 1970) assumption that imports are imperfect substitutes for domestic supplies: each commodity composite is a constant elasticity of substitution (CES) function of a domestic good and the imported equivalent. As an example, cost minimising yields the following percentage forms of the intermediate input demand equations:

$$x^d = z - \sigma S^m(p^d - p^m) \qquad (3)$$

$$x^m = z + \sigma S^d(p^d - p^m) \qquad (4)$$

where x^d and x^m are the percentage changes in demands by some industry (with output z) for domestic and imported variants of some commodity. S^d and S^m are the value shares in demand of domestic and imported goods, and σ is the elasticity of substitution between domestic and imported variants. These equations are repeated for every commodity and industry, although we suppress the corresponding superscripts here and in subsequent equations.

The primary-factor composite is a CES aggregation of land, capital and composite labour. Composite labour is a CES aggregation of occupational labour types. Although all industries share this common production structure, input proportions and behavioural parameters may vary between industries.

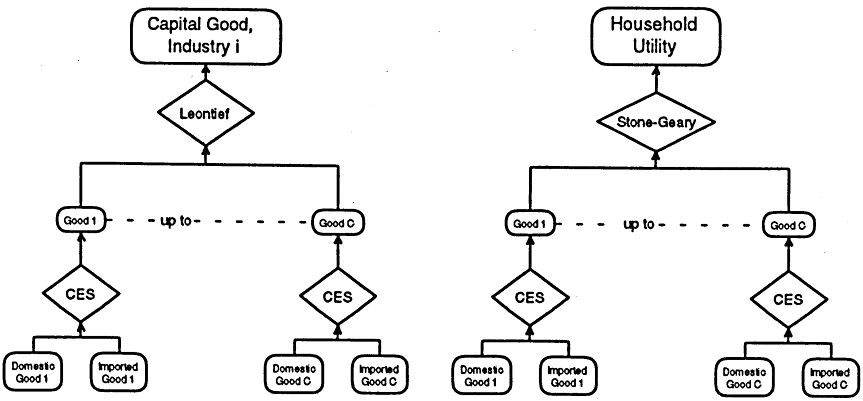

Figure 3: Structure of Investment and Consumer Demand

2.2. Final Demands

The left hand side of Figure 3 shows the nesting structure for the production of new units of fixed capital. Capital is assumed to be produced with inputs of domestically produced and imported commodities. The production function has the same nested structure as that which governs intermediate inputs to current production. No primary factors are used directly as inputs to capital formation. The right hand side of Figure 3 shows the nesting structure for household consumption. The only difference is the Stone-Geary utility function used to aggregate commodity composites. This gives rise to the Linear Expenditure System.

The remaining categories of final demand are treated as follows. Government ('Other') demands and stocks display no substitution behaviour. Demand for exports of each commodity is assumed to be sensitive to price, using a constant-elasticity demand curve.

3. Modifications to the HPP Model

Our additions to the core model consist of two parts: new technology and new pricing behaviour. With respect to technology, we model economies of scale either at the firm level or at the industry level. For pricing, the new equations are specified at the firm, rather than the industry, level. Our vehicle for modelling firm behaviour is the idea of the 'representative firm'. We assume that each industry consists of N identical firms; the value of N differing between industries. In the short run the number of firms is assumed to be fixed. In the long run the number of firms becomes an endogenous variable which is determined by the entry and exit of firms in response to pure profits and losses experienced by the industry.

Each firm produces a single commodity output which is a close but imperfect substitute for the products of its domestic and foreign competitors[2]. The firm is presumed to be a price taker with respect to inputs and a price maker with respect to sales. Domestically produced goods are used in both final demand (as consumption goods, capital goods, and export goods) and in demand for intermediate inputs. The firm faces a downward sloping demand curve for its products in each of these markets.

3.1. Increasing Returns to Scale Technology at the Firm Level

We have restricted increasing returns to scale technology (IRTS) to the single product industries. This allows us to adopt a simpler form for industry production functions:

$$Z = H(\text{inputs}) \tag{5}$$

where Z is domestic output. The H functions used in HPP are homogeneous degree 1, meaning that both unit production costs and input proportions are dependent on input prices but are invariant to output level.

We reformulate the production function at the firm level as follows:

$$Z^f = L(\text{inputs}) = H^f(\text{inputs}) - F \tag{6}$$

[2]Our modifications apply only to those industries which produce a single commodity. We continue to treat the agricultural sectors as CRTS and perfectly competitive.

where Z^f is firm output. F is a fixed (real) cost of production which is invariant to output levels, and is incurred annually by each firm. The fixed cost is treated as a recurrent cost rather than as a 'sunk' cost. The H^f function is a scalar multiple of the original CRTS production function H:

$$H^f(\text{inputs}) = \alpha.H(\text{inputs}) \tag{7}$$

This gives rise to a total cost function:

$$C = (F + Z^f).M(\text{input prices}) \tag{8}$$

where M is the dual function of H^f and shows the marginal cost of producing a unit of output at given input prices. Firm unit costs are given by:

$$U = C/Z^f = \frac{F + Z^f}{Z^f} M \tag{9}$$

implying that unit costs decline with output, as shown in Figure 4.

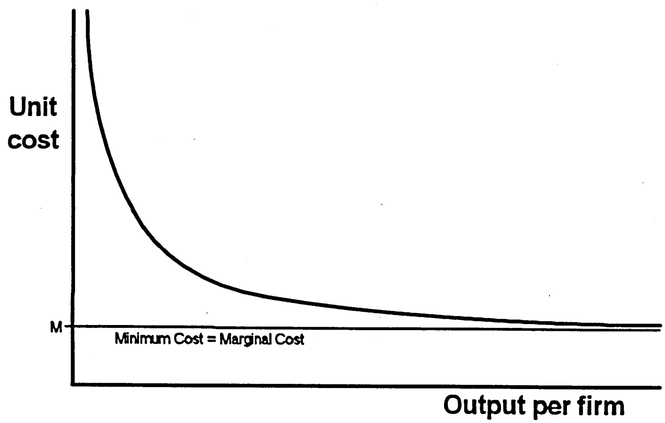

Figure 4: Unit Costs Decreasing with Output

The symmetry of our representative firm assumption allows us to write total industry output, Z^t as $N.Z^f$. Thus our unit cost function may be written in terms of industry output as:

$$U = \frac{N.F + Z^t}{Z^t} M \tag{10}$$

Total industry fixed costs are thus directly related to the number of firms in the industry. On the other hand, total industry variable costs are proportional to output. Hence, the total industry unit cost, which includes both fixed and variable components, is a decreasing function of output, and an increasing function of the number of firms.

The assumption of hyperbolic unit cost curves is established practice in AGE implementations of IRTS. It implies that marginal cost is independent of output, although average cost falls. In empirical work, potential scale economies are often measured by *cost disadvantage ratios* (CDRs). This is the fraction by which unit costs exceed minimum costs. Industries with high CDRs lie on the leftward, steeper part of the hyperbola and have strongly increasing returns to scale. Industries which approach CRTS have low CDRs and lie on the flatter, rightward part of the curve.

A special feature of our implementation is that total input proportions are functions of relative prices only and do not vary with output. This follows from our assumption that at given prices, both the fixed and the variable parts of total input require the same proportions of commodities and primary factors. Some authors have assumed that the input proportions vary between the fixed and variable components. For example, Harris assumed that commodities (intermediate inputs) fed only into variable production, whilst capital and labour were used for both components. Moreover, the capital/labour ratio (K/L) for the fixed component was twice that for the variable component. The Cory/Horridge model followed the same procedure. Horridge (1987b) also excluded commodities from the fixed part of production, although he assumed that the K/L ratio was the same for both fixed and variable parts.

Our current view is that the linking of input proportions to output per firm is a complicating assumption, unsupported by data or indeed by economic priors. The idea that fixed costs are capital intensive perhaps arises from a mechanical metaphor: the same machine will produce double the output if we feed in double the materials. But we can think of equally compelling examples in which the fixed costs are overwhelmingly labour costs. Microsoft's Win95, for example, exhibits tremendous economies of scale—yet the fixed cost which Microsoft must recoup is largely composed of salaries. Systematic estimates of scale elasticities (or CDRs) are scarce; data relating input proportions to output per firm are virtually non-existent. Lacking the latter, most researchers have imposed ad hoc assumptions. Assumptions such as Harris's have the effect of adding factor demand shifts to the efficiency changes and pricing changes which already distinguish the IRTS model from its CRTS counterpart. This makes results even harder to explain.

Under internal scale economies, average cost exceeds marginal cost, so that perfectly-competitive, marginal-cost pricing would result in losses. Hence we must combine the hypothesis of internal scale economies with the hypothesis that firms enjoy some market power, enabling them to price above marginal cost. Our treatment of firm pricing is explained in Sections 3.4 and 3.5.

3.2. External Economies of Scale

Since economies of scale at the industry level are external to the firm, they are labelled 'external' economies of scale. Under this scenario, individual firms have a standard CRTS production function. However, as industry output expands, each firm's unit cost curve falls. Thus, as an industry becomes bigger it becomes more efficient. This might happen because of some symbiosis effect. To implement this idea, we specify an industry-level unit cost function:

$$U = \frac{Q + Z^t}{Z^t} M, \tag{11}$$

where Q is some positive constant. Figure 4 can again be used to illustrate this cost curve, as long as we re-label the horizontal axis 'Industry Output'. However, from each firm's point of view, marginal and average costs of production are equal.

3.3. User's Love of Variety

Underlying our model of monopolistic competition, described below, is the idea that users differentiate between the products of different firms. This gives firms a degree of market power. We assume that, in purchasing, say, domestically produced shoes, the user regards the products of the various local firms to be imperfect substitutes. We effect this *via* the addition of another layer of CES nests to the bottom of Figures 2 and 3. This is illustrated in Figure 5. In the original HPP model each user (intermediate, investment, or consumer) treated 'shoes' as a CES composite of domestic and imported shoes. Now we add the idea that domestic shoes are in turn a CES composite of the product of N local shoe producers. For completeness, we have shown a similar nest for the N* varieties of foreign shoes.

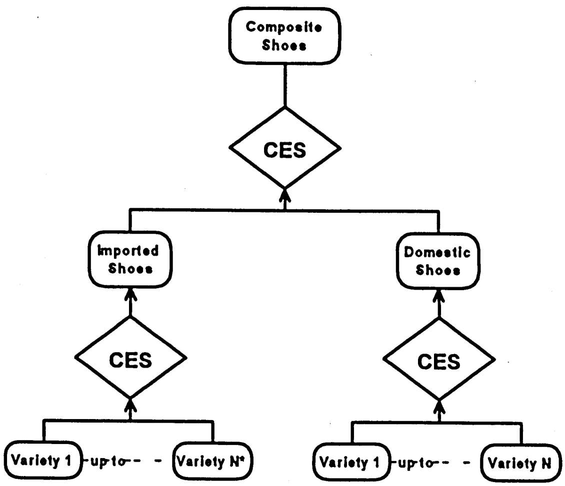

Figure 5: User's Love of Variety

The percentage change in demand for the output of firm j is given by:

$$x_j = x^d - \gamma(p_j - p^d) \tag{12}$$

where x^d is the total demand for the domestic product, γ is the elasticity of substitution between varieties and p^d is the average price charged by domestic firms, given by:

$$p^d = \frac{1}{N}\Sigma p_k, \qquad k = 1..N \tag{13}$$

The symmetry of our representative firm assumption ensures that, *ex ante*, all firms producing a given commodity charge the same price. Hence, equations such as (12) need not actually appear in the model. Nevertheless, this specification, which has been adopted by most AGE modellers of imperfect competition, has two effects:

(1) it allows us to calculate the elasticity of demand facing an individual firm, and so to implement a model of optimal pricing (this is described below); and

(2) it implies that the ratio of imported to domestic shoes, demanded by some user, is a function not only of relative prices but also of the relative numbers of domestic and foreign varieties.

The second effect has been ignored, probably by Harris and certainly by many of those following in his wake such as Cory and Horridge. Yet it is an important part of the theoretical tradition following Spence (1976) and Dixit and Stiglitz (1977). The CES function implies that the subutility obtained from domestic shoes is positively related to the number of domestic varieties:

$$U(x^d) = (\Sigma x_k{}^{\beta})^{1/\beta}, \qquad k = 1..N$$

but $x_k = x^d/N$

so $$U(x^d) = (N(x^d/N)^{\beta})^{1/\beta} = x^d N^{(1-\beta)/\beta} = x^d N^{1/(\gamma-1)}, \quad \text{where } \beta = (\gamma-1)/\gamma \qquad (14)$$

where N is the number of domestic varieties, and γ is the elasticity of substitution between varieties.

To accommodate the relation between subutility and N, we modify the intermediate demand equations (3) and (4) by replacing each occurrence of x^d with x^d+n/(γ-1). Similarly, we replace each occurrence of p^d with p^d-n/(γ-1), to get:[3]

$$x^d = z - n/(\gamma-1) - \sigma S^m(\{p^d - n/(\gamma-1)\} - p^m) \qquad (15)$$

$$x^m = z + \sigma S^d(\{p^d - n/(\gamma-1)\} - p^m) \qquad (16)$$

The number of foreign varieties has been presumed constant in these equations. We have also assumed that γ is constant: a more plausible assumption might be that it declined with N.

[3]Note: Our transformation of these demand equations follows Helpman and Krugman (1985, p.181). To see why it is appropriate, note that the optimization problem underlying the original equations (3) and (4) is: choose X^d,X^m to minimize $P^dX^d + P^mX^m$ such that CES(X^d,X^m)=constant. With love of variety, the constraint becomes CES(X^dQ,X^m)=constant, where $Q = N^{1/(\gamma-1)}$. Rewriting the minimand as $(P^d/Q)(X^dQ) + P^mX^m$, we find that our problem has resumed its original form, except that X^d has been replaced by X^dQ and P^d by P^d/Q.

3.4. Monopolistic Pricing Rule

We have specified two alternative pricing rules for the imperfectly competitive firm. The first is the optimal markup rule or Lerner Pricing Rule (LPR). The size of the markup is inversely related to the elasticity of demand that each firm in the industry perceives for its product:

$$P^l = \frac{E^t}{E^t - 1} M. \tag{17}$$

Here P^l is the Lerner price, M is marginal cost and E^t is the absolute value of the perceived elasticity of total demand for a firm. In percentage change form:

$$p^l = m + \varepsilon^t/(1 - E^t) \tag{18}$$

where p^l, m and ε_t are the percentage changes in P^l, M and E^t respectively.

Although each firm has several markets with different demand elasticities, we have excluded the possibility of discriminatory pricing. Instead, each firm faces a total demand curve. The total perceived elasticity of demand is then merely the average of the perceived elasticities in the various markets for that commodity:

$$E^t = \Sigma B_k E_k \tag{19}$$

where the B_k is the share of market k in total sales. The first values of k represent the 22 industries; the next the 22 capital creators, and the rest other final users.

To find the perceived elasticity of intermediate demand facing firm j in its sales to some industry, we assume that the firm conducts the following Bertrand-Nash experiment. It considers the effect of changing the price charged to each industry, assuming that the number of firms remains fixed, that rival firms will keep their prices constant[4], and that there is no negative (downstream) impact of the change in the price of its product on the output level of the customer industry. Accordingly, the firm takes into account only the effects of substitution between its variant and those of other firms, and between domestic and imported equivalents. Substituting together equations (3), (12) and (13) derived above:

$$x^d = z - \sigma S^m(p^d - p^m)$$

$$x_j = x^d - \gamma(p_j - p^d)$$

$$p^d = \frac{1}{N}\Sigma p_k$$

and including the assumptions mentioned, we get:

$$x_j = -[\sigma S^m(1/N) + \gamma(1-1/N)]p_j \tag{20}$$

---

[4]The alternative, Cournot, assumption would be that rivals kept their output constant. This would imply some adjustment of prices by the rivals.

so that the perceived elasticity of demand for one customer industry is $[\sigma S^m(1/N) + \gamma(1-1/N)]$. We can derive its percentage change as (see Cory and Horridge, 1985, p.17):

$$\varepsilon NE = S^m S^d \sigma(\sigma - 1)(p^d - p^m) + (\gamma - S^m \sigma)n \tag{21}$$

Assuming that $\sigma > 1$, we see that if the domestic price rises relative to imports, the domestic market share (and each firm's share of this) falls and so the elasticity increases. The elasticity is also positively related to the number of firms. Following the pattern set for intermediate demand elasticities, we can derive the percentage changes in elasticities of final demand, yielding similar expressions.

3.5. Harris Pricing Rule

For an alternative pricing rule we follow Harris's (1984) mixed pricing rule—a mixture of the Lerner markup pricing rule and Eastman-Stykolt's (1966) import-parity pricing rule. Here we assume that the firm sets its price to a geometric mean of the price of the imported substitute, P^m and the price suggested by the markup pricing rule, P^l. In percentage change form we have:

$$p^d = \alpha p^m + (1 - \alpha)p^l \tag{22}$$

where α is a parameter, with value between zero and unity (0.5 in our simulations). p^m and p^l are respectively the percentage changes in the import price and in the Lerner price.

The Harris or mixed pricing rule is not derived from a single consistent model of optimising behaviour; its specification is obviously *ad hoc*. Nevertheless, it is widely used in econometric studies such as Bloch (1992 and 1994) as a flexible device to model pricing behaviour of manufacturing industries in an open economy such as Australia, which may lie between the bounds of import parity and Lerner markup pricing.

3.6. Market Equilibrium

With free entry or exit of firms from the industry, long-run equilibrium is ensured by the zero pure profit (ZPP) condition of the model. Thus, output per firm changes until each firm's recurrent fixed cost is just balanced by the excess of sales revenue over variable costs.

An important feature of our model is that ZPP is enforced through entry or exit of firms. In the standard version of ORANI, output price is determined by the ZPP condition together with CRTS production technology. That is, if each firm within an industry is a price taker, output price would be set at the marginal cost of production which is equal, under CRTS, to the average cost of production. Hence, the revenue accruing to each firm would just cover its production costs. In the present model since each firm is setting its output price, the adjustment in the number of firms is necessary to eliminate pure profits. That implies a shift in the industry-wide production technology, as the amount of fixed cost per unit of output

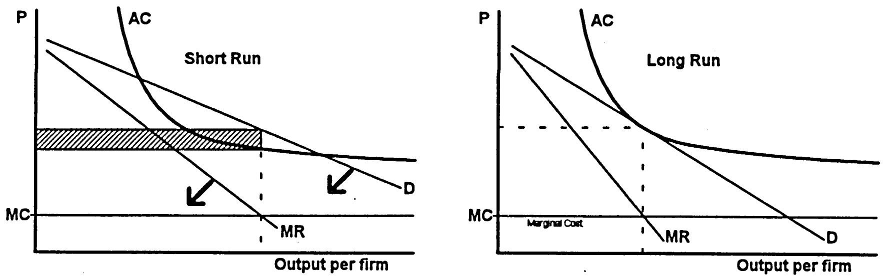

Figure 6: Short-Run and Long-Run Lerner Pricing Equilibria

responds. Thus, in long-run equilibrium, price setting determines industry production technology.

The mechanism of Lerner markup pricing is illustrated in the two panels of Figure 6. Each panel shows the firm demand curve D, the marginal revenue curve MR, the average cost curve AC and the marginal cost curve MC. In each case, the profit-maximising output is that where the MR and MC curves intersect. In the left hand panel, this output allows a price higher than average costs to be charged, giving rise to pure profits (the shaded area). The profits induce the entry of more firms into the market, so reducing the market share of the typical firm. This causes both demand and marginal revenue curves to swivel clockwise, as indicated by the arrows. Eventually, the long-run equilibrium depicted at the right will be reached. There, the average cost curve is tangent to the demand curve, and pure profits have been eliminated.

A significant feature of the diagram is that the optimal Lerner markup over marginal cost is nearly the same in both panels. Indeed, had the demand curve been of the constant elasticity type, the profit-maximizing price and markup would have been identical in the two panels.

3.7. Database and Calibration

Our modifications to the HPP model entail extensions to its database. This must now contain data describing for each non-agricultural industry:

A The number of rival firms, N. It is a mistake to equate this with the number of establishments in an industry. More correctly, it is the average number of competitors faced by producers within a sector. For example, within the chemical industry producers of shampoo do not compete with producers of sheep-dip. We set N at 10 for all sectors.

B The share of fixed in total costs. We set this at 10% for all sectors, implying that if output rose by 1%, unit costs would fall by 0.1%. Many would consider this figure to be on the high side.

C The elasticity of substitution between the products of rival firms, γ. This was set to around 12 for most sectors—see below.

D The level of pure profits as a share of value of output. This was set initially at zero, so that the same database could be used for both short- and long-run simulations.

Under the Lerner pricing hypothesis, any 3 of the above facts can be combined with the standard HPP database to imply the 4th, remaining, data item. For example, C and A could be used to deduce the perceived demand elasticity, and hence the markup over marginal costs. With B, the markup could be used to find D. We chose to deduce C from A, B and D. The resulting values varied somewhat between sectors, because of different sales shares and degrees of import competition.

All of the data that we added was purely hypothetical. We found no Australian data which could substitute for our own inventive powers. One reason is that none of the quantities A-D are directly observable. They must be measured indirectly, using supplementary hypotheses. For example, we hoped that Bloch (1992) might provide some data. Unfortunately, his regressions seemed to identify the whole of each industry's gross operating surplus with pure profits. Such an assumption seemed inconsistent with our model.

4. Results of Simulations

To investigate the effects of adding imperfect competition and increasing returns to scale to the neoclassical HPP model, we simulated the effect of a tariff reduction. The magnitudes of the tariff cuts are reflected in the following changes in duty-paid import prices:

Table 2: Effect of Tariff Changes on Import Prices

	Commodity	% Change
4	Mining, export	-1.17
6	Food & fibre, export	-0.77
7	Food, other	-2.64
8	Textiles, clothing & footwear	-12.81
9	Wood related products	-5.56
10	Chemicals & oil products	-2.91
11	Non-metallic mineral products	-4.17
12	Metal products	-8.80
13	Transport equipment	-9.12
14	Other machinery	-5.32
15	Other manufacturing	-9.63

A variety of simulations were performed using different assumptions about production technology, pricing behaviour and market structure. Each simulation enforced one assumption from each of the following 3 groups:

Table 3: Differences Between Simulations

Technology	C	Constant returns to scale
	I	Increasing returns to scale—internal to the firm
	E	Increasing returns to scale—external to the firm
Pricing Rule	M	Marginal cost pricing rule
	O	Optimal markup (Lerner) pricing rule
	H	Harris (mix) pricing rule
Entry/Exit	S	Short Run: Fixed number of firms
	L	Long Run: Free entry to ensure zero pure profits

The letters C, I, E, M, etc., are used to build concise names for each simulation. Thus simulation CMS denotes constant returns to scale, marginal cost pricing, and fixed number of firms. Only some of the 18 possible combinations are simulated here; they are listed in Tables 4 and 5. Some combinations make little sense. Marginal cost pricing with firm-level scale economies implies losses—this combination has been marked 'n.a.' in both short- and long-run tables. In the short run, firms may exercise market power even without firm-level scale economies; we simulate this for the Harris case under CRTS but do not report analogous simulations under external economies of scale.

Table 4: Short-Run Simulations

	Pricing Rule		
Technology ⇓	Marginal-Cost Pricing	Lerner Pricing	Harris Pricing
CRTS	CMS	not reported	CHS
IRTS (internal)	n.a.	IOS	IHS
IRTS (external)	EMS	not reported	not reported

In the long run, neither the CRTS nor the external economies case provide a mechanism whereby variations in numbers of firms can restore ZPP to an imperfectly competitive industry. Thus, Lerner and Harris pricing are allowed only with firm-level scale economies. In the other long-run scenarios we have assumed that firm numbers follow industry output: this would be consistent with U-shaped firm unit cost curves.

Table 5: Long-Run Simulations

Technology ⇓	Pricing Rule		
	Marginal-Cost Pricing	Lerner Pricing	Harris Pricing
CRTS	CML	n.a.	n.a.
IRTS (internal)	n.a.	IOL	IHL
IRTS (external)	EML	n.a.	n.a.

The simulations named CMS and CML generate the standard HPP results based on CRTS and perfect competition[5]. They serve as bench-marks, with which to compare the results from the alternative assumptions about technology and pricing.

Our simulations are designed to elucidate the effects that the various pricing and technology assumptions have on our numerical results. So, for example, we have assumed that *all* sectors use Lerner pricing, or that *none* do. This simplifies interpretation. More realistic simulations might, for example, specify Lerner pricing for one sector, and Harris pricing for another. Again, it is unlikely that the same degree of scale economies applies to all industries.

4.1. Factor Markets and Macro Environment

Apart from the firm entry/exit assumptions the short- and long-run simulations differ in their treatment of factor markets. In the short run, capital stocks in each industry are fixed, and capital rentals move freely. Real wages are held fixed, and labour is assumed to be in elastic supply. In the long-run simulations, opposite assumptions apply: industry capital stocks adjust to maintain fixed real rates of return, and wages for the different industries and skill groups all move as one to maintain an exogenous economy-wide employment target.

For both sets of simulations, real household, government and inventory demands are held fixed, as are investment/capital ratios in each industry. The numeraire is the exchange rate.

4.2. Short-Run Results

The results of our short-run simulations are seen in Table 6. The first 12 rows of the table show macro results, the next 23 commodity outputs, and the final 10 rows show some results for the Textiles, Clothing and Footwear (TCF) sector.

The columns correspond to the various short-run simulations. In all columns the tariff cut causes the average price of imports to fall by 5.5%. The first column of results (CMS) corresponds to a conventional short-run simulation which assumes

[5]Except that in the long run, changes in the numbers of firms influence utility and demands slightly, via the love-of-variety effect.

constant returns to scale and average cost pricing. The chief losers are the import-competing sectors such as TCF, Transport Equipment, and Other Manufacturing; these are also the 3 sectors which suffered the greatest tariff reductions. The winners are the exporting industries which face elastic overseas demand and enjoy reduced input costs: the agricultural and mining sectors. The margins industry Transport follows in their wake. The other industries enjoy smaller gains, benefiting both from the reduction in costs (which enables them to capture market share from imports), and from the increase in intermediate demand from the most successful industries. Employment and GDP rise by 0.85% and 0.65% respectively.

Turning to the TCF details at the bottom of the table we see that TCF imports rose by 8.9%, while local output fell by 5.4%. While import prices fell by 12.8% (see Table 2), local prices fell by 4.9%. This price response arises from the upwardly-sloping short-run supply curve of the industry.

The second column of results includes the effects of partial import-parity pricing. Sectors facing increased import competition reduce prices more than compared with previous cases. This reduces import penetration so that total imports rise by only 2.6%, less than in the preceding column. The converse effect is that sectors only pass on one half of the decrease in input costs caused by the lower import prices. Hence, compared to the CMS case import-competing output contracts less, while the other sectors reap less benefit. We enforced the Harris pricing rule irrespective of import share, so that where tariffs are reduced sharply but at the same time a sector faces little or no import competition, domestic prices fall and output increases, relative to CMS. An example is Commodity 12, Metal products.

Table 6: Results of Short-Run Simulations of a Tariff Cut

Simulation:	CMS	CHS	IOS	IHS	EMS
Returns:	Constant	Constant	Internal	Internal	External
Pricing:	Marginal	Harris	Lerner	Harris	Marginal
Macro Variables:					
1 Employment	0.8586	1.2832	0.8188	1.1647	1.0081
2 Duty-paid Import P.I.	-5.4789	-5.4789	-5.4789	-5.4789	-5.4789
3 GDP P.I.	-2.6721	-2.1285	-2.7257	-2.1602	-2.8726
4 Investment P.I.	-3.1510	-2.7842	-3.1829	-2.8008	-3.2716
5 Consumer P.I.	-2.3366	-1.9579	-2.3866	-1.9883	-2.5256
6 Export P.I.	-0.7800	-0.8579	-0.8226	-0.8981	-0.9235
7 Real GDP	0.6519	0.9321	0.7163	1.0105	0.8761
8 Import Volumes	3.5396	2.6132	3.5498	2.5243	3.7654
9 Capital Stock	0.0000	0.0000	0.0000	0.0000	0.0000
10 Real Investment	0.0000	0.0000	0.0000	0.0000	0.0000
11 Real Consumption	0.0000	0.0000	0.0000	0.0000	0.0000
12 Export Volumes	8.2428	9.0519	8.6783	9.4685	9.9707
Commodity Outputs:					
1 Cereals	1.4601	1.1581	1.4863	1.1709	1.6519
2 Broadacre rural	1.5459	1.2528	1.5447	1.2387	1.8446
3 Intensive rural	2.3259	2.3784	2.2893	2.3154	2.8211
4 Mining, export	2.2335	2.9121	2.5043	3.1869	3.1026
5 Mining, other	0.9315	1.2015	1.0617	1.3158	1.1707
6 Food & fibre, export	3.5267	2.9687	3.7229	3.0790	5.2934
7 Food, other	1.3689	1.7989	1.4015	1.8169	1.6245
8 TCF	-5.4828	-1.8610	-5.3585	-1.8218	-5.7640
9 Wood products	0.4196	1.0470	0.4152	0.9905	0.5829
10 Chem/oil products	1.3178	2.0457	1.3271	1.9875	1.6372
11 Mineral products	0.1670	0.4948	0.1731	0.4678	0.2478
12 Metal products	0.0300	1.4853	0.0932	1.4378	0.2935
13 Transport equipment	-5.0463	-0.7022	-4.9797	-0.6865	-5.5837
14 Other machinery	0.7101	1.6425	0.7539	1.6636	1.0254
15 Other manufacturing	-1.9112	0.5005	-1.8406	0.4697	-1.6787
16 Utilities	0.3558	0.5489	0.3417	0.4859	0.4453
17 Construction	0.0456	0.0525	0.0438	0.0495	0.0503
18 Trade	0.7242	1.0439	0.7397	1.0271	0.8727
19 Transport	2.6477	3.0941	2.7296	3.1349	3.1353
20 Banking & finance	0.6996	0.9605	0.6852	0.8941	0.8160
21 Dwellings	0.0000	0.0000	0.0000	0.0000	0.0000
22 Public services	0.1356	0.0474	0.1357	0.0413	0.1550
23 Private services	0.0412	-0.2525	0.0341	-0.2778	0.0517
TCF Details:					
1 Unit Cost	-4.8981	-5.2016	-4.3246	-5.0195	-4.3024
2 Elasticity	0.0085	-0.0338	0.0072	-0.0354	0.0060
3 Lerner Markup	-0.0009	0.0038	-0.0008	0.0039	-0.0007
4 Marginal Cost	-4.8981	-5.2016	-4.8604	-5.2017	-4.8788
5 No. of firms	0.0000	0.0000	0.0000	0.0000	0.0000
6 Output	-5.4828	-1.8610	-5.3585	-1.8218	-5.7640
7 Imports	8.9298	4.9529	9.1929	5.0039	9.8204
8 Love of variety	0.0000	0.0000	0.0000	0.0000	0.0000
9 Price	-4.8981	-9.0039	-4.8612	-9.0039	-4.3024
10 Employment	-6.3673	-2.1612	-5.6007	-1.9041	-6.0245

Table 7: Results of Long-Run Simulations of a Tariff Cut

Long-Run Simulation:	CML	IOL	IHL	EML
Returns:	Constant	Internal	Internal	External
Pricing:	Marginal	Lerner	Harris	Marginal
Macro Variables:				
1 Employment	0.0000	0.0000	0.0000	0.0000
2 Duty-paid Import P.I.	-5.4789	-5.4789	-5.4789	-5.4789
3 GDP P.I.	-0.7834	-0.7407	-0.9131	0.4139
4 Investment P.I.	-1.4630	-1.4290	-1.1961	-0.4546
5 Consumer P.I.	-0.7217	-0.6780	-0.9888	0.4858
6 Export P.I.	-0.4837	-0.4897	-0.7627	-0.7272
7 Real GDP	0.6526	0.6687	1.0516	1.1981
8 Import Volumes	3.8691	3.9558	4.2088	6.5378
9 Capital Stock	1.5751	1.6037	1.4033	2.4892
10 Real Investment	1.8818	1.9179	1.8978	2.9890
11 Real Consumption	0.0000	0.0000	0.0000	0.0000
12 Export Volumes	5.7617	5.9097	8.7423	10.6527
Commodity Outputs:				
1 Cereals	-0.1497	-0.2147	-0.4444	-2.2441
2 Broadacre rural	-0.1223	-0.1887	-0.3194	-2.3713
3 Intensive rural	0.3340	0.2518	0.6964	-2.3067
4 Mining, export	7.4016	8.2126	7.8581	30.4348
5 Mining, other	10.1543	9.7827	11.2379	4.0552
6 Food & fibre, export	-0.0956	-0.2381	0.5644	-6.0316
7 Food, other	0.2076	0.1549	1.4931	-1.0993
8 TCF	-8.0800	-8.1576	-5.7778	-10.2383
9 Wood products	-0.3045	-0.3357	1.7524	-0.9871
10 Chem/oil products	0.4837	0.4654	1.5432	0.1384
11 Mineral products	0.4858	0.4882	1.9496	0.4254
12 Metal products	-0.7390	-0.7777	2.6797	-1.3247
13 Transport equipment	-9.0844	-9.2582	-6.0746	-14.3245
14 Other machinery	0.3966	0.3799	2.4332	0.3078
15 Other manufacturing	-3.6574	-3.7445	-0.3011	-5.2245
16 Utilities	0.5129	0.5597	0.1037	1.6985
17 Construction	1.1403	1.1730	0.9542	1.8014
18 Trade	0.6137	0.6053	1.6696	0.5726
19 Transport	1.4653	1.4601	2.4219	1.4211
20 Banking & finance	0.3873	0.3838	0.5869	0.2844
21 Dwellings	-0.2000	-0.1942	-1.3343	-0.1347
22 Public services	-0.1096	-0.1122	-0.1802	-0.2252
23 Private services	-0.1738	-0.1719	-0.7651	-0.2708
TCF Details:				
1 Unit Cost	-2.1502	-2.0405	-6.9152	0.3892
2 Elasticity	-0.7347	-0.6660	-5.8017	-0.8826
3 Lerner Markup	0.0816	0.0740	0.6446	0.0981
4 Marginal Cost	-2.1502	-2.1145	-1.6650	-0.6346
5 No. of firms	-8.0800	-7.4177	-58.2796	-10.2383
6 Output	-8.0800	-8.1576	-5.7778	-10.2383
7 Imports	13.1493	13.1607	15.7793	16.4681
8 Love of variety	-0.8084	-0.7421	-5.8306	-1.0243
9 Price	-2.1502	-2.0405	-6.9152	0.3892
10 Employment	-8.3193	-8.3253	-11.2829	-9.5232

The next two columns (IOS and IHS) are simulated using internal economies of scale: unit costs fall as output rises. However, because marginal (rather than average) costs enter into our pricing rules, the results are very similar to those derived under CRTS assumptions. The small differences result from the fact that contracting sectors release less resources and expanding sectors absorb more, than under CRTS.

The final column (EMS) assumes external economies of scale and average cost pricing. The increasing returns to scale imparts a clockwise twist to the upwardly-sloping short-run supply curves of the CRTS environment. This leads to a general flattening of supply curves, and so, in general, to more polarized sectoral results than under CRTS. As in the previous two columns, sectoral efficiency changes, proportional to output, are taking place; unlike the previous two columns the efficiency changes are passed on to customers. Thus, the exporting sectors fare better in this scenario than in all the preceding columns.

4.3. Long-Run Results

Table 7 shows results from our long-run simulations. The main difference from the short-run simulations is that we assume that aggregate employment is fixed (although mobile between industries) and that capital is available in elastic supply, but must earn fixed real rates of return. The changed factor market assumptions mean that individual industry supply curves are very much flatter than in the short run.

In the first, CML, column (with CRTS) we see that the industries which contracted in the short run contract more in the long run. Amongst the gainers, mining has displaced agriculture, due to the elastic demand assumed for mineral exports. Real GDP rises 0.65%, as in the short run. In the long run, however, the increased output comes from increased employment of capital, rather than labour. Because we assumed that investment/capital ratios were fixed, absorption has risen—it was fixed in the short run. The increased absorption diverts resources from the traded sector, so that exports have risen less than in the short-run simulations.

In the TCF sector we see that the output and thus the number of firms fell by 8% in the CML column. TCF row 8 (Love of variety) indicates that the 8% reduction in the number of local varieties means that 0.8% more locally produced TCF is needed to give the user the same satisfaction as he or she previously obtained from TCF.

The second column of results (IOL) assumes internal economies of scale with Lerner pricing. It closely resembles column 1, even though results for the TCF sector suggest that changes in numbers of firms have caused perceived demand elasticities to change more than in the short run. Two facts lie behind the similarity. First, as the TCF figures show, although the import-domestic ratio has increased by about 21%, there has been a 0.7% *decrease* in the overall perceived elasticity of demand facing individual firms. That is, the increase in foreign competition has been outweighed by the reduction in domestic competition due to firm exit. In turn, the change in the optimal or Lerner markup is only 0.07%. The arithmetic behind these tiny changes may be deduced from equations (18) to (21) and is dissected at length in Cory and Horridge (1985). Second, the entry and exit of firms to restore zero pure profits means, with near-constant markups over marginal costs, that each industry is acting as though it faced CRTS technology.

The third column of results (IHL) assumes internal economies of scale with Harris pricing. Like the original Harris simulations, it exhibits the strong industry rationalization effects which are needed to prevent losses when an import-parity pricing rule is followed. In TCF, for example, the number of firms (and thus industry expenditure on fixed costs) is halved, in order to fight off import penetration. These efficiency savings are responsible for the greater GDP gains than are seen in the first two columns. Interestingly, the increase in GDP is not as dramatic as Harris's own simulations might lead us to expect. One reason is that reductions in firms numbers increase industry efficiency but, through the love-of-variety effect, reduce consumption efficiency (so to speak). For TCF, the 58% reduction in the number of firms (and local varieties) has rendered local output 5.8% less attractive than it was before. Offsetting this is the increase in output and variety for the expanding sectors. However, much of their output goes to foreigners. We have assumed that increased local variety benefits only local users, but does not, of itself, make exports more attractive. Second, we did not link the number of foreign varieties to the volume of imports. Both assumptions can increase the gains from multi-lateral trade liberalization in multi-country models (Helpman and Krugman, 1985).

Another point to note is that the rationalisation of the TCF industry in this scenario helps to preserve local production of TCF at the expense of TCF employment.

The final column of results (EML) contains fairly dramatic shifts in sectoral outputs. In this simulation industry supply curves are genuinely downward sloping, as factor scarcities apply only at the economy-wide level. The losers (TCF, Transport Equipment, Other Manufacturing) slide back *up* their supply curves and so fare worse than in any other scenario. Results are dominated by the dramatic expansion of the Mining, Export sector, which faces the most elastic overseas demand. Probably, the assumption of increasing returns is unrealistic for this sector.

5. Concluding Remarks

We have simulated the short-run and long-run effects of unilateral trade liberalisation on the Australian economy using an applied general equilibrium model which incorporates scale economies, love of variety, and imperfect competition. The present model builds on the work of Cory and Horridge (1985) and Horridge (1987a and 1987b) who in turn followed Harris (1984).

The main results of our benchmark simulations, using CRTS and marginal/average cost pricing, were fairly familiar. Tariff reforms caused import-competing industries such as TCF, Transport Equipment and Other Manufacturing to shrink. On the other hand, exporting industries such as agriculture and mining expanded. The resource shifts between sectors were greater in the long run than in the short.

Quite different results were obtained by using some of the alternative assumptions about pricing and technology. The Harris pricing rule, of which one component is import-parity pricing, had the effect of partially shielding the import-competing sectors from the lower import prices. In the long-run simulation, the assumption of external economies of scale dramatically altered simulation results. Unfortunately, neither the Harris pricing nor the external economies of scale are supported by a sound theoretical underpinning.

On the other hand, simulations using Lerner pricing and internal economies of scale yielded results which were very similar to those obtained under CRTS. Certainly the differences were far less than those which would result from differences in assumptions about export demand elasticities or factor substitution elasticities or about macro closure. One lesson is that AGE models which assume CRTS and perfect competition also treat some types of IRTS and imperfect competition quite accurately.

Love-of-variety effects were present only in the long-run simulations and were not large. They dampened the effect of Harris-type assumptions, where efficiency gains came from reductions in firm numbers. By contrast, the effects of external economies were exaggerated, under our assumption that the number of varieties increased with output.

These results reinforce the last decade's experience of incorporating IRTS and imperfect competition into AGE models. GE modellers are obliged to posit behaviour for every sector in the economy, but typically lack the sectoral time-series data which are needed. This lack is usually made up for by bland assumptions supported by strong economic priors: the simple neo-classical assumptions. A high level of sectoral disaggregation is the GE modellers' most potent method of increasing the realism of simulations. For example, work in progress by Dixon and Menon (1995) suggests that much of the increase in intra-industry trade that Australia has experienced in the last decade can be explained by MONASH (the successor to ORANI) using only the traditional neo-classical assumptions. Contrary to the opinion of many economists, IRTS and imperfect competition are not needed to explain the increase.

Furthermore, it is difficult to choose between the many possible ways of modelling IRTS and imperfect competition. The approaches that seem theoretically attractive—such as Lerner pricing and internal scale economies—seem often to have little effect on results. So far no approach has emerged which both affects model results and commands a consensus amongst modellers.

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