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INCREASING RETURNS TO SCALE AND THE LONG RUN EFFECTS OF A TARIFF REFORM

by

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ABSTRACT

In this paper, modified versions of the ORANI model of the Australian economy are used to simulate the longrun effects of tariff reductions. Results based on conventional assumptions of constant returns to scale in production are compared with those generated under various specifications of increasing returns to scale. The aim is to identify the influence of each specification on simulation results, and so to highlight the most important modelling decisions. We find that the simulated benefits of a move to freer trade tend to be increased, when increasing returns to scale and imperfect competition are modelled.

1 INTRODUCTION

Most large general equilibrium models make use of the assumptions that each industry or sector distinguished by the model operates under constant returns to scale technology, and that product markets are perfectly competitive. Such models are relatively simple to construct and solve[1]; their formal properties have been heavily analysed, and their mechanisms are well understood.

Although convenient, these assumptions may be unrealistic. In particular, increasing returns to scale is thought to be an important feature of some industries. Also, the assumption of perfect competition is harder to justify where there are such increasing returns.

It is thought, too, that relaxing the two assumptions may have a strong influence on model simulation results. For example, while most studies using perfect-competition constant-returns (hereafter PCCR) models find that a tariff reduction will generate a small welfare gain[2], Dixon (1978) and Harris (1984) found the simulated gain was greatly increased when imperfect competition and increasing returns were incorporated into their models. Others, such as Graham (1923) and Snape (1977), found that when the PCCR assumptions were relaxed the lowering of the tariff could reduce, rather than increase, national welfare. The divergence between these results stems from the fact that there is a variety of alternatives to the traditional PCCR assumptions.

The purpose of this paper is to investigate how alternative methods of modelling imperfect competition and economies of scale affect the simulated longrun results of a tariff reform. Variants of the Australian ORANI model (see DPSV, 1982) are used; in its standard form this model is based on PCCR assumptions. In previous papers (Cory and Horridge, 1985, and Horridge, 1987) we have shown how the standard ORANI model might be adapted to alter these assumptions.

To anticipate the conclusions, the relaxation of PCCR assumptions forces the modeller to choose from a range of alternative assumptions, and also necessitates the gathering of considerable extra data. Currently, the question of which are the best alternative assumptions is not settled, and the extra data has not been gathered. This means that the revised version of ORANI that we employ here has a hybrid status: those parts of ORANI which we have not altered rest on the empirical basis described in DPSV; the new equations that we have added are parameterized using only hypothetical data. Our results, then, are speculative, but they advance the useful project of understanding how various alternatives to the PCCR assumptions affect model results, and how sensitive these results are to the new data. Such an understanding is a vital preliminary to a more empirically based study.

The remainder of this paper is structured as follows. In Section 2 we compare results from three simulations of a 25 per cent reduction in the ad valorem rates of <u>all</u> tariffs. In the first simulation we assume that PCCR obtains in all industries; in the second and third simulations we show the effects of two alternatives to the PCCR assumptions. In Section 3 we concentrate upon the effect of reducing a single tariff -- that on imported Motor Vehicles and Parts. Again using results based on PCCR as a standard of comparison, we investigate the results of a wider range of alternative assumptions than were canvassed in Section 2. Finally, in Section 4, we draw on the material in Sections 2 and 3 to highlight some of the key problems facing the modeller who wishes to depart from traditional PCCR assumptions.

2 THREE LONGRUN SIMULATIONS OF A 25 PER CENT ACROSS-THE-BOARD TARIFF CUT

In this section we examine the longrun effects of a 25 per cent across-the-board (ATB) cut in the tariff, within three different environments. The first, in Subsection 2.1, exhibits constant returns to scale (CRTS) for all industries. We include the CRTS results as a benchmark, with which to compare results from the next two environments -- which assume increasing returns to scale. In Subsection 2.2 we assume that scale economies are external to the firm, yet internal to the industry. Finally, Subsection 2.3 shows the effect of assuming that scale economies are internal to the firm.

2.1 A Tariff Reform with Constant Returns To Scale

The first column of Table 1 shows the effects of the 25 per cent across-the-board (ATB) tariff cut, under standard CRTS assumptions. The results shown represent the percentage deviations from the values these variables would have assumed in the absence of the tariff shock. They are computed using the recommended longrun closure of the version of ORANI described by Horridge (1985). The macro features of this environment, which are common to all of the simulations reported in this paper, include the following assumptions:

* Capital is in elastic supply to each industry at fixed real rates of return.

* The aggregate labour supply, measured in efficiency or wage units, is fixed, although labour is mobile between industries. The average wage is endogenous, but relativities are fixed.

* The third primary factor, land, is used only by certain agricultural industries. The amount used by each such industry is fixed.

TABLE 1 Effects of a 25 per cent Across-the-Board Tariff Cut in Three Different Environments[1]

Variable[2]	Environment[3] (1) CRTS	(2) EXTERN	(3) HARRIS
Consumer Price Index	-0.737	-0.648	-1.002
Investment Price Index	-0.975	-0.890	-1.361
Government Spending Price Index	-0.136	-0.351	0.267
Duty-paid Imports Price Index	-3.154	-3.154	-3.154
Exports Price Index	-0.278	-0.343	-0.237
GDP Price Index	-0.730	-0.704	-0.902
GNP Price Index	-0.668	-0.641	-0.833
Real Household Consumption	0.143	-0.133	0.852
Real Investment	1.561	1.036	3.104
Real Government Spending	0.143	-0.133	0.852
Aggregate Imports (foreign currency)	2.519	3.127	2.017
Aggregate Exports (foreign currency)	2.703	3.245	2.516
Change in Balance of Trade ($000m.)	0.025	0.015	0.071
Real GDP	0.530	0.197	1.468
Real GNP	0.182	-0.087	0.909
Real Wage	0.908	0.476	1.894
Aggregate Capital Stock	1.628	1.175	3.089
Australian-Owned Capital Stock	0.151	0.046	0.505
Output: Import-Competing Industries	-1.571	-3.058	0.912
Output: Other Industries	0.675	0.449	1.465
Output: All Industries	0.424	0.057	1.403
Tech. Change: Import-Competing Industries	0.000	-0.647	1.556
Motor Vehicles - Domestic Basic Price	-1.952	1.812	-6.040
- Imported Basic Price	-8.199	-8.199	-8.199
- Price Index for Variable Costs	-2.463	-1.333	-3.880
- Price Index for Fixed Costs	0.093	-0.231	0.747
- Total Input Price Index	-1.952	-1.113	-2.955
- Industry Capital Stock	-6.070	-1.075	-9.402
- Industry Employment	-8.037	-2.581	-13.079
- Industry Output	-7.938	-14.625	-0.111
- Industry Wide Technical Change	0.000	-2.925	3.085
- Number of Firms	-7.938	-11.700	-15.535
- Volume of Imports	15.102	22.169	8.025

[1] All results are long run percentage deviations from the value which the variable would have taken in the absence of the tariff shock, except that the 'Balance of Trade' is given in ordinary change form (measured in 1978-9 $A.'000m.).

[2] Appendix 2 contains more information about the variables listed here.

[3] In column 1, labelled 'CRTS', it is assumed that all industries are CRTS.
In column 2, labelled 'EXTERN', it is assumed that the import-competing industries enjoy external economies of scale.
In column 3, labelled 'HARRIS', it is assumed that the import-competing industries exhibit economies of scale at the firm level.

* The nominal values of national saving and household consumption move in proportion to each other.

* Government demands move in line with real household consumption.

* In each industry, investment grows at the same rate as the capital stock.

* Saving and aggregate investment are not necessarily equal, implying that foreign funds may be required to fund part of investment. We recognize this by specifying that only part of the national capital stock belongs to Australians. Australian equity is determined by the level of national saving, and only revenue from Australian-owned capital accrues to Australians. Hence we distinguish between income accruing to Australians (GNP) and income generated in Australia (GDP).

* National income (GNP) is divided between household consumption, government demands, and national saving.

* The nominal exchange rate is the numeraire. The real exchange rate, however, is endogenous.

To ease comparison between the various experiments reported below, the same format has been adopted for all of the experimental results. The first rows of the tables show values for selected macro price indices. Their real counterparts follow. Next, aggregate output (a weighted sum of industry value added) is allocated between a set of 'import-competing' industries -- described in subsection 2.2 -- and the remaining industries. In some of the experiments we will be assuming that the 'import-competitors' enjoy economies of scale; the row marked 'Technical Change: Import-Competing Industries' shows the average productivity gain attained by this group. A zero value is shown in column 1, since we have assumed here that all industries display CRTS. Finally, we report more detailed results for one industry -- Motor Vehicles and Parts (MVP). In our first group of experiments, which report the effect of an ATB tariff cut, the MVP results serve only to illustrate the micro mechanisms underlying the economy-wide results. We have selected the MVP industry as our example because Section 3 examines the effect of a reduction in the tariff on imported MVP alone. Appendix 2 provides a technical description of all the variables shown in Table 1 and the subsequent, similar, tables of results.

Since production technology is CRTS, and since, with the exception of agricultural land, primary factors are available to each industry in perfectly elastic supply, the cost of production for each non-agricultural industry is independent of that industry's output. In other words, most individual industry supply curves are flat, although they may move up or down as input prices change. Where import competition is strong, demand curves are also flattish, since even a small increase in the price of a domestic product (relative to its imported equivalent) can induce substitution towards imports. The effect of each tariff cut is to reduce the (duty-paid) price of competing imported goods, shifting the demand curve for the domestic product downwards. Unless the supply curve happens to be translated downwards by as great an amount, domestic production contracts sharply.

The bottom part of the first column of Table 1 illustrates this process for one heavily-protected industry -- Motor Vehicles and Parts (MVP). The cut in the tariff on imported MVP causes the imported price to fall by over 8 per cent. Since both the nominal exchange rate and the foreign currency prices of imports are fixed, the cuts in <u>other</u> tariffs have no effect on the price of imported MVP. The effect of the ATB tariff cut is to reduce costs economy-wide, so that the supply curve shifts downwards about 2 per cent (assuming flat supply, this is given by the reduction in the domestic price). Hence the domestic price rises by 6 per cent relative to the imported.

Market share is lost to imports, and output contracts by nearly 8 per cent. Labour is released to the rest of the economy, which also benefits from the reduced price of imported cars. The chief gainers are the exporting industries which face elastic demand and so translate reduced input costs into greater output. At the same time, the reduction in input costs partially offsets the loss of tariff protection for the import-competing industries. In aggregate, output expands by 0.42 per cent. Since the aggregate labour supply is fixed, this output expansion is possible only because of an increase in the aggregate capital stock of 1.63 per cent. This increase underlies three processes which partially counteract the initial cost-reducing effect of the tariff reform. First, an increase in capital-labour ratios implies a higher marginal product of labour and an economy-wide increase in real wages of 0.91 per cent. Second, our modelling of investment implies that the increase in capital stocks brings about an increase in investment demands. This makes fresh calls on resources, especially labour, acting to increase the overall price level. Third, the rise in wages contributes to an increase of 0.18 per cent in real GNP -- the income accruing to Australian residents. This increase in income causes an increase in household and government consumption. Like the increase in investment demand, this tends to raise the overall cost level.

Our assumptions imply that the increase in saving by Australians is roughly proportional to GNP. Hence, although saving increases, it does not increase sufficiently to purchase all of the newly-employed capital. Australian-owned capital stock only increases by 0.15 per cent, while real unit payments to capital remain constant, by assumption. Hence most of the welfare gain, shown by the increase in real GNP, accrues through the rise in real wages.

The upper part of Table 2 shows 'Winners and Losers' from the ATB tariff cut under CRTS assumptions. These are the industries for which output increased or decreased the most. The greatest winner -- Oil, Gas and Brown Coal - faces very elastic demand due to strong import competition and a high degree of substitutability between imported and domestic products. It benefits greatly from the overall reduction in costs brought about by the tariff reform. Most of the remaining winners face elastic export demand. Mining and manufacturing industries dominate this group since their supply curves are flat. The agricultural industries - which use the industry-specific fixed factor, land - have sloping supply curves, and so their output expands less. Only one agricultural industry, Northern Beef, appears in the list[3]. Finally, export-related industries such as Services To Mining, Construction Equipment, and Locomotives and Rolling Stock benefit from the expansion of the exporting industries, which require more inputs to production, transport to ports, and investment in both these activities.

The corresponding 'Losers' list shows mainly those industries enjoying the highest level of protection. Since the reduction in the tariff is proportional to the initial tariff level, these industries face the sharpest increase in import competition, and so contract the most.

TABLE 2 'Winners and Losers' from the ATB Tariff Cut[1]

CRTS Environment:

WINNERS		LOSERS	
OIL GAS AND BROWN COAL	11.76	*MAN MADE FIBRES	-14.80
SERVICES TO MINING	8.12	*FOOTWEAR	-10.52
COAL	7.71	*COTTON SILK FLAX YARNS	-8.58
IRON	6.94	*MOTOR VEHICLES, PARTS	-7.94
OTHER METALLIC MINERALS	3.93	*LEATHER PRODUCTS	-4.62
OTHER BASIC METAL PRODUCTS	3.69	*WOOL, WORSTED YARNS ETC	-2.80
*CONSTRUCTION EQUIPMENT	2.68	*CLOTHING	-2.59
FOOD PRODUCTS n.e.c.	1.97	*KNITTING MILLS	-2.43
LOCOMOTIVES,ROLLING STOCK	1.83	TEXTILE FINISHING	-1.96
NORTHERN BEEF	1.61	*OTHER BASIC CHEMICALS	-1.83

External Economies of Scale Environment:

WINNERS		LOSERS	
OIL GAS AND BROWN COAL	12.82	*MAN MADE FIBRES	-29.55
COAL	9.07	*COTTON SILK FLAX YARNS	-16.12
SERVICES TO MINING	8.86	*FOOTWEAR	-15.35
IRON	7.91	*MOTOR VEHICLES, PARTS	-14.62
OTHER METALLIC MINERALS	4.32	*LEATHER PRODUCTS	-7.14
OTHER BASIC METAL PRODUCTS	3.85	*WOOL, WORSTED YARNS ETC	-3.74
*CONSTRUCTION EQUIPMENT	2.74	TEXTILE FINISHING	-3.47
FOOD PRODUCTS n.e.c.	2.49	*RUBBER PRODUCTS	-3.22
NORTHERN BEEF	2.09	*OTHER BASIC CHEMICALS	-3.20
LOCOMOTIVES,ROLLING STOCK	1.72	*CLOTHING	-3.11

Environment with Economies of Scale Internal to Firms:

WINNERS		LOSERS	
OIL GAS AND BROWN COAL	14.34	*MAN MADE FIBRES	-5.19
SERVICES TO MINING	9.85	*FOOTWEAR	-4.03
IRON	8.10	*COTTON SILK FLAX YARNS	-2.54
COAL	7.73	*LEATHER PRODUCTS	-1.48
OTHER BASIC METAL PRODUCTS	4.71	*CLOTHING	-0.38
OTHER METALLIC MINERALS	4.56	*KNITTING MILLS	-0.35
*CONSTRUCTION EQUIPMENT	4.51	*WOOL, WORSTED YARNS ETC	-0.26
OTHER CONSTRUCTION	3.16	TEXTILE FINISHING	-0.16
LOCOMOTIVES,ROLLING STOCK	2.80	HIGH RAINFALL ZONE	-0.12
FORESTRY, LOGGING	2.70	*MOTOR VEHICLES, PARTS	-0.11

* member of set of import-competing industries

[1] Corresponding to the results reported in columns 1, 2 and 3 of Table 1, this table lists, for each environment, the 10 industries for which the percentage gain in output was largest, and the 10 for which the percentage decrease was largest. For each industry listed, the percentage change in output is also shown.

2.2 A Tariff Reform with External Economies of Scale

One appealing feature of the CRTS assumption is that it is compatible with the hypothesis of perfect competition. If each firm within an industry is a price-taker, output price will be set at the marginal cost of production -- equal, under CRTS, to the average cost of production. Hence the revenue accruing to each firm will just cover its production costs. Second, the CRTS assumption allows us to choose the industry level as our unit of analysis. Industry output and pricing are independent of the division of production between firms.

The assumptions of perfect competition and CRTS industry technology may also be consistent with plant (or firm) technology which displays 'U-shaped' average cost curves. Assume that an industry is made up of a number of identical firms, and that, at given input prices, each firm's unit production costs reach a minimum at some output level which is small compared to the size of total industry output. If the products of all firms are perfect substitutes, competition will drive their market price down to this minimum cost of production. Either below or above the efficient output level, the average cost of production will exceed the market price, so that it will be unprofitable to produce. Hence we can expect each firm (plant) to operate at the bottom of the U-shaped cost curve, where production <u>locally</u> displays CRTS. At an industry level, the CRTS assumption will once again be appropriate. Output per firm will be constant, so that any change in industry output will be matched by a equiproportional change in the number of firms. Thus, in Column 1 of Table 1, we have shown that both the output of the MVP industry, and the number of participating firms each declined by 7.94 per cent.

The alternative to the CRTS assumption is to assume that, within any industry, the unit cost of production is a function not only of input prices, but also of how industry output is divided between firms, of how firm production is divided among plants, and of how plant output is divided among different product lines or versions of the same 'good'. In other words, under CRTS the industry-wide unit cost of production for some particular industry can be written as a function of input prices alone:

$$U = U(W,P), \tag{2.2.1}$$

where U is the unit cost of production, and W and P are vectors of prices of primary factors and material inputs. By contrast, with increasing returns to scale (IRTS) at the firm (or plant) level, industry-wide unit cost depends on at least one of N, the number of firms in the industry, M, the number of plants in the industry, or V, the total number of product lines produced:

$$U = U(W,P,\frac{Z_t}{N},\frac{Z_t}{M},\frac{Z_t}{V}), \tag{2.2.2}$$

where Z_t is the volume of industry output. To write the industry unit cost function in this way, we make two important assumptions. First, the function U displays homogeneity of degree zero in quantity. Thus, the industry is duplicatable -- if M, N, V and Z_t were all doubled, unit costs would be unaffected. Second, at given levels of Z_t/N, Z_t/M and Z_t/V, costs are unaffected either by the relative sizes of the different firms, or by some firms operating more plants than others, or by the relative sizes of plants, or by some plants producing more product lines than others. Only the total number of firms, plants or lines (per unit of industry output) matters. This assumption is made purely to ease the task of analysis and data-gathering. It is implied by the usual 'symmetry' assumption -- all firms and plants are of equal size, each firm operates an equal number of plants, each plant produces the same number of lines, and equal volumes of each line are sold.

Increasing returns to scale are built in via assumed properties of the unit cost function U. These properties are that, with industry output and input prices fixed, unit production costs are positively related to some or all of M, N, and V. Alternatively, with M, N, and V fixed, unit costs decline with industry output, Z_t. The rationale for these assumptions could be either that the total costs of administering a firm do not increase in proportion to the output of the firm, or that the total costs of operating a plant do not increase in proportion to the output of the plant, or that the unit cost of some particular product line falls as output of that line increases.

For our purposes, the precise source of these scale economies is not important. We shall assume that each firm in a sector operates one plant, which in turn produces only one product line. At the industry level, our unit cost function then simplifies to:

$$U = U(W,P,\frac{Z_t}{N}) \tag{2.2.3}$$

so that output per firm is the sole determinant of an industry's efficiency. We will use the terms 'plant' and 'product line' virtually interchangeably with the term 'firm', as all three are in one-to-one correspondence. However, in interpreting our results, it should be stressed that we remain agnostic as to the source of scale economies. Thus, productivity gains which stem -- according to our manner of speaking -- from increases in output per firm could equally well be interpreted as arising from increased output per plant, or from increased production runs of a particular line.

By our symmetry assumption, $Z_t = N.Z_f$. Hence (2.2.3) may be rewritten to show the firm's unit cost function:

$$U = U(\mathbf{W},\mathbf{P},Z_f) \tag{2.2.4}$$

where again U declines as Z_f increases.

Where firm technology is characterised by cost functions such as (2.2.4), returns to scale (IRTS), marginal cost must be less than the average unit cost of production, so that perfectly-competitive marginal-cost pricing would imply operation at a loss. Therefore, some other pricing rule must be hypothesized. At the same time, industry efficiency is a decreasing function of the number of firms, so that we need to specify some mechanism which determines how many firms engage in production. The characteristics of the industry -- as it affects the rest of the economy -- are determined jointly by the firm-level technology, the firm pricing rule, and the nature of the entry/exit decision.

The last two factors are overlooked by one popular argument in favour of protection. According to this view, Australian manufacturers are disadvantaged by the small size of the domestic market -- which prevents potential economies of scale from being realized. In turn, high unit costs cause market share to be lost to imports. An increased tariff, it is argued, allows the output of the import-competitors to expand, with accompanying efficiency gains. This argument, which appears in various forms, may be criticised on several grounds. Here we point out that it is incomplete. Even where production at the firm level displays IRTS, an expansion of production by the increasing returns sector need not imply a sectoral efficiency gain. If the number of firms increases in line with aggregate production, output per firm is not increased, so that individual firms are unable to reap economies of scale. Second, even if firm output levels increase, reducing average unit costs, output prices may remain steady, or even -- as import competition is restrained -- rise. Thus efficiency gains in the protected sector need not be transmitted to the rest of the economy.

The popular argument rests on two questionable assumptions: (a), regardless of any changes in the number of participating firms in a protected industry, unit costs of production decline as industry output increases; and (b), the industry passes on these cost reductions in full *via* lowered output prices. In the remainder of this section we consider one special case which does satisfy these conditions. It combines increasing returns to scale at the industry level with perfect competition between firms. We suppose that economies of scale in the protected sector are external to the firm, but internal to the industry. Under this assumption, the average unit cost for each *firm* is (locally) unaffected by its own output level. However, an expansion in *industry* output is accompanied by a decrease in average costs for all firms within the industry. The unit cost function for a representative firm is given by:

$$U = U(\mathbf{W},\mathbf{P},Z_t), \qquad (2.2.5)$$

where it is understood that there are sufficiently many firms that no one firm can materially influence total *industry* output, Z_t. As Z_t increases, unit cost U declines. This gain in technical efficiency arises from some symbiotic relationship between the competing firms. Perhaps each firm adds to a common stock of skill and experience which is available to all other firms. Again, a larger sectoral output may allow greater specialization amongst suppliers of services to the sector, augmenting the quality of these inputs to sectoral production. Finally, a larger sector may be able to make more efficient use of infrastructural facilities, such as roads, railways and utilities, the cost of which does not increase in direct proportion to their use.

We assume, for the moment, that the products of any one firm in a particular industry are perfect substitutes for the products of any other. Hence each firm is a price-taker, so that marginal revenue is equal to price. No firm supposes that changes in its own output will materially change industry output, so that each firm is operating, at least locally, under CRTS, so that average cost is equal to marginal cost. The profit-maximising condition, that marginal revenue equals marginal cost, then implies that each firm is pricing at average cost. Under our symmetry assumption that all firms comprising an industry are identical, it will be true too that, for the industry as a whole, price equals the average unit cost given by (2.2.5). <u>Industry</u> average cost will be a declining function of <u>industry</u> output. Hence, just as under conventional PCCR assumptions we may conceive an entire industry as a single producer, operating under CRTS and pricing at average cost, so, according to the external economies of scale hypothesis, may we represent an industry as a single producer, enjoying IRTS yet still pricing at average cost. Industry output is given by the intersection of the market demand curve with the industry average cost (i.e. supply) curve.

By assuming external economies of scale, we can test Graham's (1923) hypothesis that, where a protected sector displays IRTS and the remainder of the economy displays CRTS, the tariff could move resources from the CRTS sectors to IRTS sectors, allowing the IRTS sectors to reap an efficiency gain, without affecting the efficiency of the CRTS sectors. The IRTS sectoral efficiency gain could, Graham thought, outweigh the economy-wide efficiency loss which results from the tariff-induced distortion of the price system. Helpman and Krugman (1985) have constructed an example of this type, showing that a country whose comparative advantage lies in the CRTS sector may lose from trade.

The second column of Table 1 shows results from an ORANI simulation where external economies of scale are assumed for certain industries. The macro environment for this simulation is the same as that described above, used to generate results for the CRTS environment in column 1. The only difference between the two columns is that in the second column we have assumed that a subset of the industries display external economies of scale. The members of this set, which are listed in Table 3, are those 40 non-exporting manufacturing industries for which the imported share of the domestic market is greater than 8.2 per cent. They account for 11.5 per cent of national value-added, and the corresponding imported commodities account for 72 per cent of all imports (duty paid). They include most of the protected industries and account for 97 per cent of all tariff revenue.[4]

In this simulation we assume that each of these 'import-competing' industries is composed of a number of firms operating at (locally) CRTS, and pricing competitively at average cost. As each industry expands by, say, 1 per cent the amount of inputs required for production expands by only 0.8 per cent[5]. That is, each import-competing industry displays external economies of scale with a scale elasticity of 1.25 (= 1/0.8).

The results in column 2 show that there is at least some truth in the Graham hypothesis -- if protected industries enjoy external economies of scale the tariff cut results in a small decline in real GNP, our welfare indicator[6]. As in the CRTS case, the lowering of the tariff results in a fall in the output of the import-competing industries. The fall in output results in a loss of technical

TABLE 3 Members of the 'Import-Competing' Set of Industries[1]

No.	ORANI Industry Name	Share of Imports in Market
21	MARGARINE,OILS, FATS	.216
24	CONFECTIONERY PRODUCTS	.136
28	ALCOHOLIC BEVERAGES n.e.c.	.213
30	PREPARED FIBRES	.239
31	MAN MADE FIBRES	.542
32	COTTON SILK FLAX YARNS	.506
33	WOOL, WORSTED YARNS ETC	.186
35	TEXTILE FLOOR COVERING	.275
36	TEXTILE PRODUCTS n.e.c.	.235
37	KNITTING MILLS	.205
38	CLOTHING	.190
39	FOOTWEAR	.301
40	SAWMILL PRODUCTS	.198
41	PLYWOOD VENEERS	.160
44	PULP,PAPER, ETC	.082
46	PAPER PRODUCTS, n.e.c.	.155
47	PUBLISHING, PRINTING	.196
50	OTHER BASIC CHEMICALS	.391
52	PHARMACEUTICALS,ETC	.161
55	OTHER CHEMICAL PRODUCTS	.276
56	PETROLEUM,COAL PRODUCTS	.182
57	GLASS, GLASS PRODUCTS	.259
58	CLAY PRODUCTS, ETC	.261
63	BASIC IRON, STEEL	.105
67	METAL PRODUCTS n.e.c.	.191
68	MOTOR VEHICLES, PARTS	.307
69	SHIP, BOAT BUILDING	.332
71	AIRCRAFT BUILDING	.549
72	SCIENTIFIC EQUIP n.e.c.	.643
73	ELECTRONIC EQUIPMENT	.537
74	HOUSEHOLD APPLIANCES n.e.c.	.289
75	ELECTRICAL MACHINERY n.e.c.	.274
76	AGRICULTURAL MACHINERY	.374
77	CONSTRUCTION,ETC EQUIP	.534
78	OTHER MACHINERY, EQUIP	.417
79	LEATHER PRODUCTS	.310
80	RUBBER PRODUCTS	.303
81	PLASTIC, RELATED PROD	.226
82	SIGNS,WRITING EQUIP ETC	.220
83	OTHER MANUFACTURING	.432

[1] The table lists the 40 ORANI industries for which the imported share of the domestic market (imports + non-exported domestic production) is less than 0.082 -- except for one industry (no. 25, FOOD PRODUCTS n.e.c.) which, although its import share was 0.115, was excluded because of its export orientation.

efficiency in these industries, forcing them to raise their prices. This price rise leads to greater import penetration and exacerbates the output decline. However, although the import-competing sector shrinks by more than in the CRTS case, the other industries expand by less. Under IRTS, the import-competitors become less productive as they shrink. Thus, a given decline in their output releases less labour to the rest of the economy than would be released if they shrank by the same amount under CRTS conditions.

The results for the Motor Vehicles and Parts (MVP) industry, in the bottom part of column 2 of Table 1, illustrate the micro foundation of these results. As under CRTS, the impact effect of the tariff cut, through the fall in the price of imported MVP, is to move the demand curve for domestic MVP 8.2 per cent downwards at each output level. However, instead of being flat, the domestic supply curve now has a downward slope of about 0.2, since, for each 1 per cent output expansion, there is only a 0.8 per cent expansion in input requirements. Because of this downward slope, industry output falls by 14.6 per cent -- almost twice as much as in the CRTS case. The output contraction leads to a loss of scale economies, so that industry productivity falls by 2.9 (= 0.2 x 14.6) per cent[7]. Since average cost pricing is assumed, this efficiency loss means that the domestic price must rise, even though, as in the CRTS case, the price of inputs fell. However, although output falls by more than under CRTS, employment in MVP falls by less, so that less labour is released to the rest of the economy.

As under CRTS, we have assumed that each firm in the MVP industry is operating at the lowest point of a U-shaped average cost curve. Under CRTS we may say that this lowest point corresponds either to a fixed level of output, or to a fixed quantum of inputs:

the distinction is irrelevant. Under external economies the correspondence between input level and output level is broken. Here we have assumed that the bottom of the U is fixed in terms of inputs. The total output achievable by any firm at this least-average-cost input level, however, is an increasing function of the output of the industry as a whole. As industry output contracts, input levels per firm are held constant, so that each firm continues to operate at minimum cost. Hence the number of firms falls by less than industry output -- the difference is due to the industry-wide fall in productivity.

The middle part of Table 2 shows the principal 'Winners and Losers' in the external economies of scale environment. The members of each list and their ordering are similar to those in the CRTS environment. Again, the losers are import-competing industries with high initial rates of protection. However, under external economies the contractions in output are about twice as much as under CRTS, reflecting the fact that all the losers are members of the non-CRTS import-competing set (marked by an asterisk). The winners, on the other hand, tend to gain slightly more than under CRTS. The reason is that, under our macro assumptions, the balance of trade is unlikely to change much[8]. Hence the greater inflow of imports, implied jointly by the tariff cut and the increased prices charged by contracting import-competing industries, is balanced by a greater increase in export volumes. The export gains are possible because private and government consumption contract markedly.

The results of column 2 show that where there are external economies of scale, it is possible for a country to lose from a lowering of protection. Two features of our environment particularly contributed to this result. The first was the close correspondence between the industries exhibiting external economies and those protected industries which were most directly harmed by a cut in tariffs. The coincidence of these two categories is artificial - it was enforced only in order to allow the model to demonstrate key mechanisms. If external economies of scale exist in the import-competing sector, it seems likely that they are present too in other sectors -- although perhaps in a lesser degree. In other, unreported, experiments we have found that if even one or two export-oriented industries are included amongst those displaying external economies, results may be dramatically altered[9]. The tariff reduction then enables these industries to greatly expand their exports. The small GNP loss in column 2 becomes a gain. Second, our assumed value of 1.25 for scale elasticities within the import-competing sector is a hypothetical figure, chosen to represent the likely potential scale economies available at the <u>firm</u> level in manufacturing industry. To aid comparability between experiments, we have used this value wherever non-CRTS behaviour is assumed. It is, moreover, an exceedingly generous estimate of the plausible extent of scale economies. To justify it, we would have to assume that the sources of the external gain -- the industry's common stock of knowhow, specialized services and infrastructural facilities -- accounted for 20 per cent of its costs, even assuming that an expansion by the industry would require no expansion of this resource base. A scale elasticity nearer to unity would cause experimental results to resemble those of Column 1[10]. Hence our demonstration of the possibility of a welfare loss through trade expansion actually casts doubt on its likelihood.

On a theoretical level, two criticisms may be levelled at the external economies hypothesis. The first is that it serves as a proxy method to allow for effects that could be modelled more directly. For example, if the scale economies reaped by some growing industry are traced to the benefits of a larger, more specialised group of maintenance or service firms, supplying the industry in question, then the scale economies are really internal to the supplying sector; the question of how they might best be analysed is open. Second, we may ask whether national output in some industry is the appropriate measure of how far that industry can realise external economies. If these derive from more efficient use of infrastructural facilities, such as roads or ports, it may be that the region, rather than the nation, is the proper unit of analysis. Alternatively, if shared technology underlies the external benefit, world output, rather than national output, may be the more important determinant of efficiency in the local industry.

2.3 A Tariff Reform with Firm-Specific Economies of Scale

We now examine the effect of the 25 per cent ATB tariff cut, assuming that some industries exhibit economies of scale which are internal to the firms comprising those industries. Our treatment follows Cory and Horridge (1985), which in turn is based on Harris (1984). Once again we assume that these IRTS industries are the import-competitors listed in Table 2. Each is composed of a number of identical firms, with the production technology of each firm in industry j given by:

$$Z_f^j = \text{Min} \quad \left[H^{0j}(\mathbf{X}), G\{H^{1j}(\mathbf{V})\} \right] \qquad (2.3.1)$$

where $\mathbf{X}$ is the vector of material inputs to production, and $\mathbf{V}$ is the vector of factor inputs. H^{0j} and H^{1j} are linearly homogenous functions, that is, for any λ, $H^{0j}(\lambda\mathbf{X}) = \lambda H^{0j}(\mathbf{X})$, while increasing returns to scale is provided by the function G such that, for $\lambda > 1$, $G\{\lambda H^{1j}(\mathbf{V})\} \geq \lambda . G\{H^{1j}(\mathbf{V})\}$. Functions H^{0j} and H^{1j} are specified and parameterized just as in the standard CRTS version of ORANI; (2.3.1) reduces to the standard ORANI production function if G is the identity function. Suppose $C^f(Z_f^j, \mathbf{P}, \mathbf{W})$ to be the minimum total cost of producing Z_f^j using the technology given by (2.3.1), where $\mathbf{P}$ and $\mathbf{W}$ are price vectors corresponding to $\mathbf{X}$ and $\mathbf{V}$. Then, for firms in each of the IRTS import-competing industries, we assume that the elasticity of scale, defined (where industry subscripts have been dropped) by:

$$\frac{C^f(Z_f, \mathbf{P}, \mathbf{W})/Z_f}{C^f_{Z_f}(Z_f, \mathbf{P}, \mathbf{W})} = \frac{\text{average cost}}{\text{marginal cost}} = \text{elasticity of scale,} \qquad (2.3.2)$$

is equal to 1.25 -- the figure assumed in the previous subsection. In fact, in our analysis above of external economies, we also assumed the production technology given by (2.3.1), except that there (2.3.1) was applied at the industry level, rather than at the firm level.

We adopt a special case of (2.3.1): we assume that while average cost declines with firm output, marginal cost is a function of **P** and **W** alone. This technological assumption may be supported by a metaphor: we may imagine that, once production is started, each firm transforms materials and factors into output in standard CRTS fashion. However, before production can take place in any period, each firm must expend a fixed additional amount of factor inputs. At given factor prices, these will correspond to a periodic fixed cost of production, representing, perhaps, the considerable cost of maintaining and operating a plant even when the output level is tiny. Alternatively, the fixed cost could represent that part of the expenses of administration and marketing which is independent of output level. The total cost function of such a firm might be written:

$$C^f(Z_f,\mathbf{P},\mathbf{W}) = A.F^1(\mathbf{W}) + Z_f\{F^0(\mathbf{P}) + F^1(\mathbf{W})\} \qquad (2.3.3)$$

total cost = fixed cost + output.(marginal cost)

where F^0 and F^1 respectively, are the indices of material and factor prices which, in the standard CRTS version of ORANI, are dual to H^0 and H^1 as given in (2.3.1). Average cost will then decline as output increases, eventually approximating marginal cost. Our assumed scale elasticity of 1.25, corresponds, within this framework, to the assumption that fixed costs account for 20 per cent of total costs at the <u>initial</u> equilibrium level of output (the scale elasticity is the reciprocal of the share of variable costs in total costs).

Since all firms are assumed to be the same we can add up the individual firms' cost functions given by (2.3.3) to obtain the total cost function for the whole industry:

$$C^t(Z_t,\mathbf{P},\mathbf{W}) = N.A.F^1(\mathbf{W}) + Z_t\{F^0(\mathbf{P}) + F^1(\mathbf{W})\} \qquad (2.3.4)$$

where Z_t is <u>industry</u> output and N is the number of firms in the industry, so that $Z_t = N.Z_f$. (2.3.4) forms the basis for the Zero Pure

Profits equation:

$$Z_t.P_Z = N.A.F^1(W) + Z_t(F^0(P) + F^1(W)) \qquad (2.3.5)$$

where P_Z is the price of the industry's output. (2.3.5) merely states that the value of sales by industry j is equal to its costs.

In contrast to the environments where we specified CRTS or external economies of scale, production technology at the industry level is affected in this environment by the number of firms. At a given level of industry output, the more firms there are, the less efficient will production be. Hence the need to specify some mechanism to determine the number of firms. Here we assume that, in the long run, each of the identical firms is earning 'normal' profits from the capital it employs. The rate of return is exogenously fixed, as in the preceding simulations. We reason that if the profit rate exceeded this norm, more firms would be attracted into the industry, lowering output-per-firm, efficiency and hence profitability for the incumbent firms, until profits were reduced to the normal level. Conversely, firm exit can neutralize a tendency for the industry to earn profits below the normal rate. Hence, the assumption of zero pure profits is sufficient to determine the number of firms in the long run.

For any firm, the average cost of production will exceed the marginal cost. Hence, perfectly-competitive marginal-cost pricing cannot be assumed as it was in the preceding two simulations. We restrict competitive behaviour by assuming that each firm differentiates its own product from those of other firms, so that each firm is, in effect, a monopolist. Following Harris (1984), we propose that each firm sets a markup over marginal cost, which is influenced by the price of competing imported goods. More precisely,

$$P_Z = B.\{F^0(P) + F^1(W)\}^{(1-\alpha)} P^{\alpha}_{imp} \qquad (2.3.6)$$

where P_Z is the price of the domestic product, $\{F^0(P) + F^1(W)\}$ is again marginal cost, P_{imp} is the (duty-paid) price of the competing imported product, and B is a constant term. In percentage change form, we get:

$$\%\Delta \text{ domestic price} = \alpha(\%\Delta \text{ imported price}) + (1-\alpha)(\%\Delta \text{ marginal cost}) \qquad (2.3.7)$$

It would be natural to assume that the value of α lay between 0 and 1. Like Harris (ibid.) we have set $\alpha = 0.5$ for all of the industries in the import-competing set.

The pricing rule (2.3.7) is ad hoc; economic theory predicts that each firm will set a markup over marginal cost which is related to the perceived elasticity of demand for its product. For the moment we assume that there is a mechanism which allows a change in the import price to influence this perceived demand elasticity. We discuss plausible values for α in the conclusion.

The results of the ATB tariff cut, under the above assumptions, are shown in column 3 of Table 1. We first analyse the results for the MVP industry, which received two external impulses. The first, as in all the simulations, was the 8.2 per cent drop in the price of imported cars. The second was the 3 per cent fall in the price of inputs, made up of a 0.75 per cent rise in the cost of 'fixed' inputs[11], and a 3.9 per cent fall in variable or marginal costs. Only the latter enters into the pricing rule (2.3.7), so that the domestic price falls by the average of the imported price and marginal costs -- 6 per cent (= (8.2+3.9)/2). Because the imported price has not fallen by much more than the domestic price and because the lower price of each type of car stimulates demand for cars in general -- as does the general expansion of the economy -- output of domestic cars falls by only 0.1 per cent.

Since the domestic industry lowered prices by 6 per cent, while cost per unit input fell by only 3 per cent, zero-pure-profits implies that industry productivity has increased by the difference, 3 per cent. This efficiency gain must come about through an increase in output per firm. Our assumption that 20 per cent of costs are 'fixed' (i.e., do not increase with output) means that a 10 per cent increase in output per firm would, cet. par., result only in an 8 per cent increase in total costs per firm -- a 2 per cent productivity gain at both firm and industry levels. Conversely, the simulated 3 per cent productivity gain requires a 15 per cent increase in output per firm. Since industry output has hardly changed, this requires that about 15 per cent of firms exit the industry. Note that, had we assumed that fixed costs accounted for only 10 per cent of total costs, 30 per cent of firms would have left. However, the industry productivity gain and the amount of resources released to the economy through the saving of 'fixed' inputs would have been the same. Hence, our technology assumptions have only a limited influence on our simulation results. The reason is that, for each industry, the degree of returns to scale affects only one equation -- the Zero Pure Profits equation (2.3.5). This is also the only equation in which the number of firms in each industry appears.

A similar story could be told for the other import-competing industries. Table 3, showing the 'Winners and Losers', lists the same group of highly protected import-competitors amongst the losers as in the previous two simulations. Here, however, their output decreases by considerably less than before. Less sales are lost to imports than in the CRTS or external economies environments, because domestic prices fall by more than previously. The pricing rule (2.3.7) shows the two reasons for this larger fall in domestic prices. First, the domestic price now falls as a direct response to the reduced duty-paid price of imports. This means both that the most-highly protected industries reduce their prices the most -- tending to preserve their market share -- and that the initial deflationary impact of the tariff cut is larger than previously. Thus, input prices economy-wide --indicated by changes in the GDP price index in Table 1 -- fall by 0.9 per cent (column 3), while the falls in column 1 and 2 are only about 0.7 per cent. Because of the second term in (2.3.7), this fall in input prices causes the less protected import-competitors to reduce their prices -- perhaps by more than the fall in the duty-paid price of the imported equivalent. Together with the general expansion of the economy, such falls in domestic price can lead to expansion by some of this less-protected group. Indeed, the aggregate output of the import-competing sector (Table 1) actually increases, in this environment. The total output gain is made possible by a process of rationalization amongst the most protected import-competitors, leading to a 1.6 per cent increase in sectoral productivity. This efficiency increase is transmitted throughout the economy <u>via</u> cheaper import-competing goods. Were quantities of both aggregate labour and capital fixed, the real rewards to each would increase. With the real return to capital fixed, capital is attracted into the country until rising real wages restore pre-existing rates of return. The increase in capital employed allows for a large increase in GDP, although most of the new capital is foreign-owned. The increase in wages allows an increase in GNP, which although smaller than the GDP rise is still far larger than in either of the two preceding simulations. Finally the GNP rise leads to an increase in household and government consumption, while the rise in capital usage implies a roughly proportional increase in investment. This rise in absorption allows GDP to increase without greatly affecting the balance of trade.

3 THREE LONGRUN SIMULATIONS OF A 25 PER CENT CUT IN THE TARIFF ON IMPORTED MOTOR VEHICLES AND PARTS

3.1 Effects under Constant Returns To Scale

The first column of Table 4 shows the effects, under CRTS assumptions, of a 25 per cent cut in the tariff on imported MVP alone. The importance of this industry in tariff reform is seen from the fact that, when the tariff on MVP alone is reduced the overall duty-paid price of imports drops by 0.83 per cent -- a quarter of the drop achieved when all tariffs are reduced by the same amount (see Table 1, column 1). This reflects the high tariff rate on MVP and the large volume of imports. Moreover, the tariff on MVP has a particularly bad effect on the economy, even after adjusting for the high initial rate and the import volume. The reduction in the MVP tariff leads to increases in GDP and GNP of about one third those achieved by the ATB tariff cut under CRTS assumptions. The greater damage per unit change in the cost of the original import volume reflects certain characteristics of the MVP industry. Imports account for less than half of the domestic market, and we have assumed a relatively large elasticity of substitution between domestic and imported versions of MVP.[12]

Most features of these results are similar to those of the results from the 25 per cent ATB tariff cut under CRTS, described earlier. Of particular interest here is the fall in the price of inputs to the MVP industry. Although economy-wide prices indices, such as the CPI or the GDP price index, fall by only a third of a per cent, the prices of inputs to MVP fall by two per cent. The reason is that the ORANI commodity MVP (Motor Vehicles and Parts) includes not only finished cars, but also many inputs to car production. This

TABLE 4 Effects of a 25 per cent Cut in the Tariff on Imported Motor Vehicles and Parts under Three Different Assumptions[1]

Variable[2]	Environment[3] (1) CRTS	(2) HARRIS	(3) HARRIS#
Consumer Price Index	-0.332	-0.376	-0.381
Investment Price Index	-0.428	-0.539	-0.548
Government Spending Price Index	-0.189	-0.063	-0.055
Duty-paid Imports Price Index	-0.831	-0.831	-0.831
Exports Price Index	-0.133	-0.099	-0.100
GDP Price Index	-0.350	-0.374	-0.378
GNP Price Index	-0.316	-0.336	-0.339
Real Household Consumption	0.056	0.196	0.214
Real Investment	0.480	0.847	0.883
Real Government Spending	0.056	0.196	0.214
Aggregate Imports (foreign currency)	1.152	0.763	0.763
Aggregate Exports (foreign currency)	1.238	0.914	0.921
Change in Balance of Trade ($000m.)	0.012	0.021	0.022
Real GDP	0.184	0.380	0.403
Real GNP	0.066	0.211	0.230
Real Wage	0.181	0.415	0.438
Aggregate Capital Stock	0.476	0.795	0.827
Australian-Owned Capital Stock	0.048	0.121	0.131
Output: Import-Competing Industries	-0.904	0.080	0.119
Output: Other Industries	0.253	0.377	0.398
Output: All Industries	0.124	0.344	0.367
Tech. Change:Import-Competing Industries	0.000	0.356	0.394
Motor Vehicles - Domestic Basic Price	-1.697	-5.703	-5.708
- Imported Basic Price	-8.199	-8.199	-8.199
- Price Index for Variable Costs	-2.082	-3.207	-3.217
- Price Index for Fixed Costs	-0.160	0.016	0.032
- Total Input Price Index	-1.697	-2.563	-2.567
- Industry Capital Stock	-8.488	-14.242	-14.175
- Industry Employment	-8.741	-14.830	-14.804
- Industry Output	-8.728	-1.788	-1.757
- Industry Wide Technical Change	0.000	3.140	3.141
- Number of Firms	-8.728	-17.490	-17.461
- Volume of Imports	15.207	7.503	7.518

[1] All results are long run percentage deviations from the value which the variable would have taken in the absence of the tariff shock, except that the 'Balance of Trade' is given in ordinary change form (measured in 1978-9 $A.'000m.).

[2] Appendix 2 contains more information about the variables listed here.

[3] In column 1, labelled 'CRTS', it is assumed that all industries are CRTS.
In column 2, labelled 'HARRIS', it is assumed that the import-competing industries exhibit economies of scale at the firm level.
In column 3, labelled 'HARRIS#', it is assumed that only the MVP industry exhibits economies of scale at the firm level.

reflects the fact that our input-output tables are compiled on an establishment (rather than an enterprise) basis, that subcontracting is common within the MVP industry, and that some 'production' of motor vehicles makes heavy use of imported components. Indeed, domestically-produced MVP accounted for 23 per cent of all input costs to the MVP industry, while imported MVP accounted for 14 per cent. Hence, the fall in the price of imported MVP has a strong direct effect on the costs of the domestic industry. The direct effect is multiplied by 1.3 (= 1/(1-.23)) through the effect on the costs of the MVP industry of the fall in the price of its own product.

3.2 Effects under Firm-Specific Economies of Scale

The second column of Table 4 shows the effects of the single 25 per cent cut in the MVP tariff, within the Harris-style environment used in subsection 2.3.

As in the CRTS simulation described in the previous subsection, the fall in the MVP tariff causes the overall duty-paid price of imports to fall by 8.3 per cent - about 1/4 of the effect of the ATB tariff cut when computed under the same assumptions (Column 3, Table 1). Within the Harris environment, the principal macro effects of a tariff cut follow from this fall in the price of imports which leads, *via* the pricing rule, to a fall in domestic prices. The domestic price fall in turn requires an increase in industry productivity, in order to maintain normal profits. Thus, the increases in real GDP and GNP induced by the single tariff cut are also about 1/4 of those caused by the ATB tariff cut.

Although only one tariff is reduced, all 40 industries of the import-competing set are governed by the production technology and pricing rule described in subsection 2.3. This means that some of the productivity gains achieved by the MVP industry are counteracted by productivity losses by other import-competing industries. The MVP industry achieves an increase in productivity of 3.1 per cent. Since this industry accounts for 12.2 per cent of all production by the import-competing set of industries, the MVP productivity gain would translate into a 3.8 per cent gain for the group as a whole. In fact, the whole group gained only 3.6 per cent. The 39 members apart from MVP suffered a productivity loss of 0.03 per cent. For these industries, the price of competing imports did not change. Hence, by (2.3.7), for each 1 per cent fall in the price of their inputs, their output price was only reduced by 1/2 per cent, so that the full benefit of cheaper cars was not passed on to the rest of the economy[13]. To preserve normal profits, the numbers of firms increased -- leading to a productivity decrease. If all industries apart from MVP had been modelled as CRTS, the gains from the MVP tariff cut would have been greater. Results calculated on this basis are shown in column 3 of Table 4. The gain in GNP, for example, is marginally greater.

3.3 Effects of a Taste for Variety

Although, in the simulations reported above, we have deviated from the standard version of ORANI in our specification of industry technology and pricing, we have made no change to ORANI's specification of final demand. In particular, for each commodity the imported share of each market is a function only of the relative price of imported and domestic versions. For example, in all of our simulations, the difference between the percentage change in the output of the domestic MVP industry and the percentage change in the volume of MVP imports is about 3.7 times the difference in percentage changes between the imported and domestic prices.[14]

The implication of this treatment is that the consumer derives no benefit from the enrichment of product variety made possible by the fact that there is a number of local (and foreign) producers. As long as the relative price of imported and domestic cars remains unchanged, an unchanged budget share will be allotted to each type, whether the number of local models is doubled, or reduced to only one model.

In particular, the reduction -- in our previous simulation -- of 17.5 per cent in the number of local MVP firms did not, in itself, influence any consumer to switch to imported cars. We assumed that, as the number of local firms declined, the market shares of departing firms were completely transferred to the survivors.

How realistic is this assumption ? A stylised picture of the Australian motor industry (as it may have existed some years ago) can serve to illustrate the main points at issue. Imagine that the local industry comprises five firms, each producing a number of models. Two of the firms specialize in large cars peculiarly adapted to Australian needs. The other three firms produce small cars which closely resemble imported models[15]. Following the tariff cut, and assuming as we did that domestic manufacturers lower their prices to maintain market share, the domestic market can only support 4 manufacturers. Which manufacturer will cease production ? If one of the two large car manufactures were to close, it would seem likely that most of its sales would be transferred to the other, since no imported substitute is available. This would accord with the assumptions underlying column 2 of Table 4. On the other hand, if one of the small car manufacturers were to close, it seems likely that its customers would be diverted, not only to the two remaining small car manufacturers, but also to imports. That is, the withdrawal of this one firm would of itself alter the ratio of domestic to imported cars in consumption, in addition to any changes induced by relative price effects.

To investigate the effect of such a leakage of demand from domestic to imported cars, we introduce a summary measure, β, defined as the percentage of demand for domestically produced cars which (in the absence of relative price changes) would be diverted to imported cars, if the number of domestic varieties (or firms) were to be reduced by one per cent. Column 1 of Table 5 is consistent with a zero value for β. Column 2 allows us to calculate how our simulation results would be affected by the choice of alternative values for β. It shows the effects of a taste change, such that overall, one per cent of non-export demand for domestically-produced MVP is diverted towards imports[16]. Results consistent with other β values may be computed by adding multiples of column 2 to the basic results contained in column 1:

$$\text{revised results} = \text{column 1 results} \qquad (3.3.1)$$
$$+ (\text{column 2 results}).\beta.(\text{simulated reduction in the number of firms})$$

To apply this formula, we need to take account, not only of any change in the number of firms induced by the tariff shock, but also of any change induced by the switch towards imports. Let r^1 be some result from column 1 (say the real gnp result) and r^2 be the corresponding result in column 2. Let n^1 and n^2 be the percentage changes in the number of firms shown in these two columns. Then, a new column 3 (containing results r^3 and n^3) can be constructed showing the effect of the tariff shock assuming some non-zero value of α, by solving:

TABLE 5 Effects of a 25 per cent Cut in the Tariff on Imported Motor Vehicles, Incorporating a Taste for Variety[1]

Variable[2]	Environment[3] (1) HARRIS	(2) SWITCH	(3) COMBINED
Consumer Price Index	-0.376	-0.023	-0.758
Investment Price Index	-0.539	-0.021	-0.881
Government Spending Price Index	-0.063	-0.033	-0.613
Duty-paid Imports Price Index	-0.831	0.000	-0.831
Exports Price Index	-0.099	-0.015	-0.350
GDP Price Index	-0.374	-0.027	-0.815
GNP Price Index	-0.336	-0.025	-0.741
Real Household Consumption	0.196	0.001	0.204
Real Investment	0.847	0.002	0.875
Real Government Spending	0.196	0.001	0.204
Aggregate Imports (foreign currency)	0.763	0.129	2.881
Aggregate Exports (foreign currency)	0.914	0.141	3.231
Change in Balance of Trade ($000m.)	0.021	0.002	0.049
Real GDP	0.380	0.005	0.460
Real GNP	0.211	+0.000	0.213
Real Wage	0.415	-0.017	0.135
Aggregate Capital Stock	0.795	0.011	0.980
Australian-Owned Capital Stock	0.121	-0.001	0.109
Output: Import-Competing Industries	0.080	-0.157	-2.493
Output: Other Industries	0.377	0.018	0.668
Output: All Industries	0.344	-0.002	0.315
Tech. Change:Import-Competing Industries	0.356	-0.012	0.157
Motor Vehicles - Domestic Basic Price	-5.703	-0.006	-5.804
- Imported Basic Price	-8.199	0.000	-8.199
- Price Index for Variable Costs	-3.207	-0.012	-3.410
- Price Index for Fixed Costs	0.016	-0.039	-0.626
- Total Input Price Index	-2.563	-0.018	-2.853
- Industry Capital Stock	-14.242	-1.248	-34.767
- Industry Employment	-14.830	-1.217	-34.834
- Industry Output	-1.788	-1.266	-22.601
- Industry Wide Technical Change	3.140	-0.012	2.951
- Number of Firms	-17.490	-1.209	-37.358
- Volume of Imports	7.503	1.817	37.381

[1] All results are long run percentage deviations from the value which the variable would have taken in the absence of the tariff shock, except that the 'Balance of Trade' is given in ordinary change form (measured in 1978-9 $A.'000m.).

[2] Appendix 2 contains more information about the variables listed here.

[3] Column 1, labelled 'HARRIS', repeats column 2 of Table 4.
Column 2, labelled 'SWITCH', shows the effect, within the same environment as column 1, of a diversion of 1 per cent of demand for domestic MVP to imported MVP.
Column 3, labelled 'COMBINED', shows a linear combination of columns 1 and 2, consistent with a value for the parameter α of 0.44.

$$r^3 = r^1 - r^2.\beta.n^3 \tag{3.3.2}$$

$$n^3 = n^1 - n^2.\beta.n^3 \tag{3.3.3}$$

giving:

$$r^3 = r^1 - r^2.\beta.n^1/(1 + n^2.\beta). \tag{3.3.4}$$

Column 3 of Table 5 shows results calculated using $\beta = 0.44$. This figure was derived on the assumption that the customers of the departing firms were allocated between imported and remaining domestic suppliers in the same proportion as imports bear to sales of domestically-produced MVP in our base equilibrium. The imported volume is 44 per cent of domestic output (excluding that exported). Drawing values for n^1 and n^2 from Table 5, we get

$$r^3 = r^1 + 16.44(r^2) \tag{3.3.5}$$

A comparison of columns 1 and 3 shows that setting β to 0.44, instead of to zero, dramatically worsens our simulated results for the MVP industry. Output now falls by 23 per cent (previously 1.8 per cent), employment by 35 per cent (previously 15 per cent), while the number of firms falls by 37 per cent (previously 17 per cent). On the other hand, macro results -- such as that for real GNP -- are slightly improved. Figure 1 graphs percentage change results in these 4 variables against values of β between 0 and 1. It shows that the effect of assuming an even larger value for β is more dramatic still. As β approaches 0.83, the magnitudes of all the results become unbounded.

To explain these results, we return to the figures in column 2 of Table 5, showing the effects of a diversion of 1 per cent of demand for domestic cars to imported cars. Industry output declines by 1.22 per cent, instead of by 1 per cent -- as we might have expected. The reason is that about 1/4 of all MVP production is recycled as input to

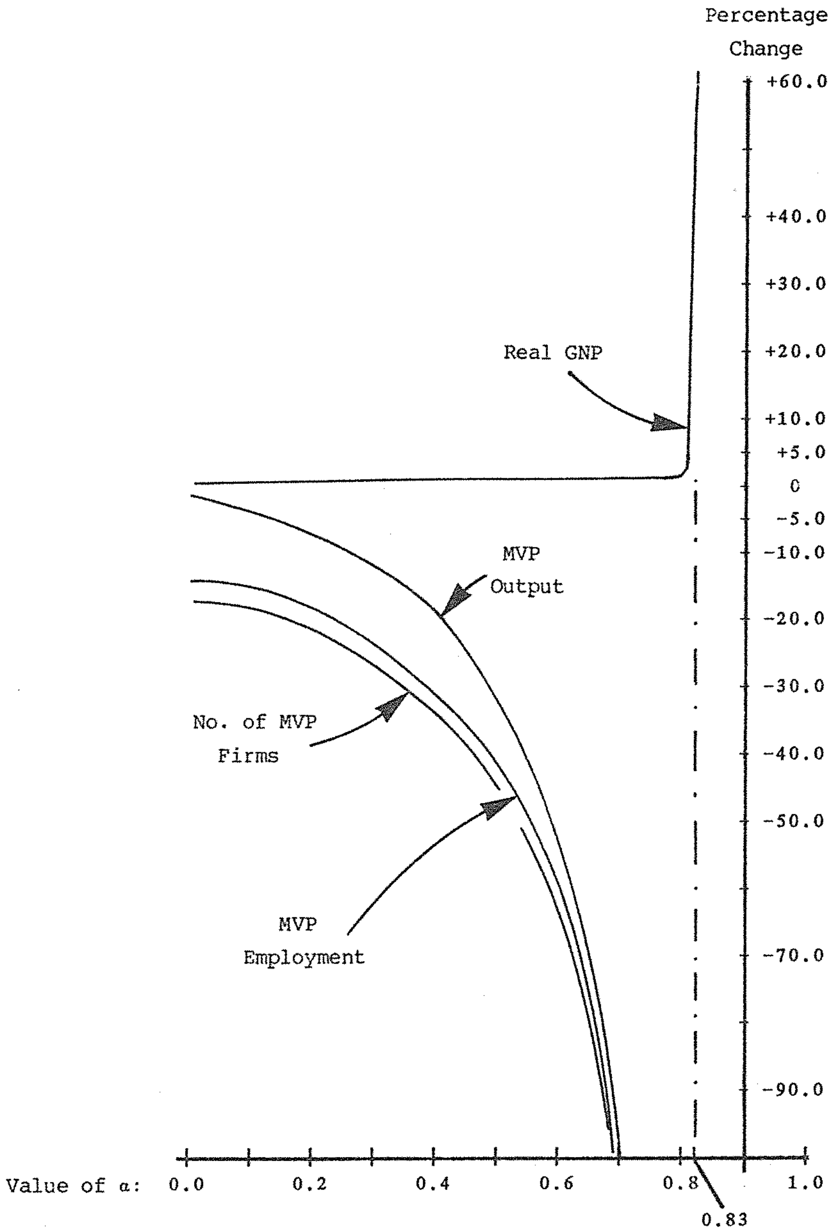

FIGURE 1

Effects, on Selected Variables, of a 25 per cent Cut in the Tariff on Imported Motor Vehicles and Parts, Plotted Against Values of the Parameter β the MVP industry, as explained in subsection 3.1. Hence, to consume 3 extra cars, it is necessary to produce about 4 extra cars. Conversely, to consume 1 car less, we need produce 1.21 cars less. Next, the demand switch has very little effect on input prices, and no effect on the price of imported MVP, so that the output price of MVP hardly changes either. This implies that industry productivity must be maintained near its original level, in turn implying that output per firm must be nearly constant. Hence, the number of firms declines by 1.21 per cent - virtually equal to the fall in industry output.

As β approaches 0.83 (= 1/1.21), each 1 per cent drop in the number of firms directly induced by the tariff shock (column 1 results) causes 0.83 per cent of domestic demand to be diverted to imports. The diversion itself induces another one per cent drop in the number of firms, leading to another diversion of 0.83 per cent of domestic demand to imports, and so on <u>ad infinitum</u>. The industry experiences a catastrophic decline. For smaller values of β the chain of effects peters out, merely exaggerating the decline in industry output shown in column 1.

The 1 per cent demand switch has a positive, but comparatively small effect on real GNP, although it too becomes enormously magnified as β approaches 0.83. The positive GNP effect is the result of two opposing tendencies. First, if the tariff on imported MVP were the only distortion in the economy, the substitution of one dollar's worth of imported MVP (measured at final purchasers', duty-paid prices) for one dollar's worth of domestic MVP increases tariff revenue (and hence GNP) by T cents, where T is the ad valorem tariff rate in per cent[17]. However, other distortions in the economy reduce this gain. The chief such distortion in this case is the uncompetitive behaviour of firms in the import-competing sector. As less domestic MVP is required, labour is released to other industries, so that wages fall. The import-competing sector does not pass on the full benefit of this wage reduction to its customers. By the pricing rule (2.3.7), for each 1 per cent fall in the price of inputs, the output prices of import-competitors are only reduced by 1/2 per cent. Correspondingly, the import-competing sector suffers a productivity loss of 0.012 per cent. This has a negative impact on GNP.

In summary, if we assume that a decline in the number of domestic firms reduces the available variety of domestic products, and that the reduction in variety inclines some consumers to turn towards imports, our predictions of the effect of a tariff cut on the motor industry become markedly more gloomy. The predicted benefits to national welfare, by contrast, are slightly increased.

In Section 2.3 we noted that, in the imperfectly competitive environment simulated there, our assumptions about the extent of potential scale economies had little influence on simulation results. Under the pricing rule (2.3.7), productivity changes in each imperfectly competitive industry were determined purely by the changes in the prices of inputs and of competing imports. Scale elasticities -- which correspond to the share of fixed in total industry costs -- affected only the change in the number of firms which was necessary to achieve the given productivity change. This was because, for each industry, the fixed costs share affected only the Zero Pure Profits equation (2.3.5) -- the sole equation in which the number of firms in that industry appeared.

After our introduction of a taste for variety by consumers, changes in the number of firms also affect all other variables. If the number of varieties of MVP produced locally is proportional to the number of local firms, an induced reduction in the number of firms will cause substitution from local MVP towards imported, with economy-wide effects. Hence, the importance of the assumed initial level of scale economies is greatly increased, since this determines what change in firm numbers will be required to achieve a given change in industry productivity. The effect (on the results of a given experiment) of, say, halving the initial share of fixed costs could also be produced by doubling the parameter β. In each case all variables, apart from the change in the number of firms, would have the same value. Alternatively, a simultaneous doubling of both β and the fixed costs share would have no effect on simulation results except that the simulated percentage change in the number of firms would be halved.

4 SUMMARY AND CONCLUSION

In this paper we have used a longrun version of the ORANI model to simulate the effects of tariff reductions, under various assumptions about industry technology and pricing behaviour. In Section 2 we examined the effects of a 25 per cent ATB tariff cut. The first simulation, which assumed CRTS, served as a reference point. There, the tariff cut caused a substantial movement of resources from the protected import-competing sector towards the export-oriented industries. Real GDP rose by half a per cent. Most of this increase in output arose from capital inflows which were financed by foreigners. Accordingly, most of the rentals from the newly arrived capital accrued to foreigners. Thus, real GNP -- the income accruing to Australians -- rose by only a fifth of a per cent.

Our second simulation of the 25 per cent ATB tariff cut assumed that the import-competing industries exhibited external economies of scale. Because the scale economies were external to firms we were able to retain the assumption of marginal-cost pricing. As under CRTS, the tariff cut caused exporting industries to expand at the expense of the import-competing sector. Here, however the contraction of the import-competing sector caused it to suffer a loss of efficiency. Hence GDP rose by less than under CRTS and GNP decreased slightly. The implication was that the tariff might be welfare-increasing. We pointed out, however, that this result reflected certain special features of our hypothetical data base. A more realistic data base would probably yield simulation results closer to those from the CRTS environment.

Thirdly, we examined the effect of the ATB tariff cut under assumptions borrowed from Harris' (1984) model of the Canadian economy. Each firm within the import-competing sector was now assumed to operate under internal economies of scale, implying some form of imperfect competition. According to our specification, when firms set their output prices they were influenced both by their own marginal cost of production and by the price of competing imports.

Under the Harris-style assumptions, the tariff cut led to marked increases in both GDP and GNP, by comparison with the CRTS results. As before, lowered costs enabled an expansion of exports, yet here, by contrast, the import-competing sector expanded its production. Because they lowered their own prices in response to the fall in the duty-paid price of competing imports, firms within the import-competing industries were compelled to become more efficient. This entailed that output per firm increase -- which was achieved by a reduction in the number of firms. The efficiency gain brought about by this process of industry rationalization allowed both capital and labour used in the import-competing sector to become more productive. Real GDP increased by nearly three times as much as under CRTS assumptions. Because the output gain resulted from the more efficient use of existing resources -- rather than from an increase in the use of (foreign-owned) capital, as under CRTS -- real GNP rose by even more, increasing by five times as much as under CRTS.

The Harris-style environment was investigated further in a series of simulations of the effect of a 25 per cent cut in only the tariff on imported Motor Vehicles and Parts (MVP). Again, the gains in both GDP and GNP were greater than under CRTS. However, these Harris-style assumptions did not relate consumer demand behaviour to the simulated rationalisation of the domestic MVP industry. We suggested that, as the number of domestic firms declined, so too might fewer varieties of locally-produced car be available to the domestic consumer. Even in the absence of relative price changes, the reduced variety of local goods might induce substitution towards imported MVP. We elaborated our model to allow for this effect, and found that the effects of the tariff cut on the MVP industry were dramatically worsened. Because demand leaked away to imports as the number of local firms was reduced, industry rationalization no longer had the effect of raising output per firm. Hence, it became very difficult for the MVP industry to meet the challenge of cheaper imports. However, the benefits of the tariff cut to the economy as a whole were not reduced by the introduction of a taste by consumers for variety.

Two important assumptions underly our simulations of tariff reform under imperfectly competitive conditions. The first is that import-competing firms reduce their prices in response to the fall in the duty-paid price of imports. Such a fall in domestic prices would occur under CRTS conditions with industry-specific fixed factors, so that domestic supply curves sloped upward. Then, downwardly translated demand curves would trace out a movement down the supply curves. Here, by contrast, the price reduction comes about through a downward translation of flattish local industry supply curves. According to neoclassical economic theory, each profit-maximizing firm sets its price equal to its marginal cost of production, multiplied by a markup which is inversely related to the elasticity of demand which it faces.

Cory and Horridge (1985) argue that a fall in import prices can appreciably influence this markup only if local firms perceive imports, rather than domestic competition, to be the chief threat to their market. This requires that substitution between the product of each firm and the closest imported equivalent is easier than substitution between the products of domestic firms. Alternatively, even if domestic products are good substitutes for one another, collusion between domestic firms could allow imported prices to exert a strong influence on domestic prices.

The second important assumption is that firms may freely enter or leave the domestic market, subject to the requirement that each firm earns a given rate of return on its capital. This assumption allowed the import-competing industries to achieve efficiency gains through industry rationalization. It imposes a fairly long timescale for the interpretation of our results, since we assume that the import-competing sector has regained the same level of profitability after the tariff reductions as it enjoyed under the initial level of protection. Further, to the extent that collusion between domestic firms justifies our link between domestic and import prices, the assumption of free entry is strained.

The longrun framework also poses difficulties for the task of gathering data to replace our hypothetical estimates of scale elasticities and elasticities of domestic prices with respect to imported prices. Even where data is available, it may reflect the fact that, in the short run, industry capital stocks are fixed. Hence, as import prices and input costs vary, local firms will move up and down upwardly-sloping supply curves. The resulting changes in the outputs and prices of domestic goods will only be indirectly related to the longrun parameters we are seeking.

Our simulations suggested that the longrun gains from tariff reform were substantially higher under the assumption of imperfect competition than under CRTS assumptions. Extrapolating from our 25 per cent tariff cut results, we might estimate that a complete removal of tariffs, under CRTS assumptions, would increase real GDP by about 2 per cent. Real GNP would rise by 0.7 per cent. Where scale economies at the firm level imply imperfect competition we would find the GDP gain to be about 6 per cent and the GNP gain to be about 3.6 per cent. The introduction of a 'taste for variety' by local consumers, while it strongly influences the pattern of industry results, would probably not alter these macro results significantly.

More realistic parameter values would reduce these projected gains from freer trade. Our assumption that domestic producers would reduce their prices by one half the reduction in imported prices (at constant input prices) may fairly represent the reaction of a local monopolist who faces only competition from imports. Where domestic competition exists, the elasticity of domestic price with respect to the imported price -- our parameter α -- might reasonably be expected to be less than 0.5. Our estimates of potential scale economies were also fairly high, implying that a given increase in industry efficiency could be achieved by a relatively small increase in output per firm. This meant that the reductions in the number of firms which were necessary to defend the domestic market share against increased import competition were lower than they would be if scale elasticities were closer to unity. If -- as seems likely -- industry rationalization were more painful than we supposed, it would be difficult to defend the empirical relevance of values of α as high as 0.5.

To a first approximation, the difference between GDP and GNP results under CRTS, and the corresponding results under our imperfectly competitive assumptions is linear in α. Hence if α were set at 0.2 instead of at 0.5 (as it was in the reported simulations) we might expect the gains from tariff reform to be only 3.6 per cent of GDP and 2 per cent of GNP. These more conservative estimates still effectively double the gains which were simulated under CRTS assumptions.

In our discussion of external economies of scale, we noted that the gains from tariff reform tend to be greater if some of the exporting industries exhibit scale economies. The observation can be generalized to the imperfectly competitive environment. To take maximum advantage of scale economies it is necessary to produce for the world, rather than for the domestic market. According to the ORANI database, the Australian manufacturing sector exports very little. Indeed, manufacturing exports were held constant in our simulations, as we considered that existing manufactured exports were unrepresentative of the output of the producing industries. Hence, one of the principal sources of gains from trade (where scale economies exist) was effectively excluded from our estimates. To improve our modelling of manufacturing exports is one of the most urgent tasks on the agenda for ORANI development.

Finally, we imagined that the extent of potential economies and the response of domestic prices to cheaper imports were the same across the whole import-competing sector. Plainly, industry technologies and market structures differ markedly within that category. We have suggested that to construct a complete vector of parameters on an industry basis is dauntingly difficult. A more promising approach may be to focus on a single industry. Simplifying assumptions, e.g., that all firms are of equal size, or that all firms react identically to reduced import prices, might be abandoned in favour of a more realistic representation of industry conditions.

NOTES

1. The solution procedure is simplified by the property of these models, that the price of each domestically-produced commodity can be expressed as an index of the prices of inputs to production, and is not affected by any quantity variable. Thus, the dimensionality of the price system can be reduced to the number of factor prices added to the number of import prices. Especially where factors are mobile between sectors, the length of the price vector may be greatly reduced. Commonly, the solution algorithm consists of a search of this reduced form price space (or price simplex) for a price vector which will allow quantity markets to clear. Any reduction in the number of dimensions of the price space shortens this search considerably. Appendix B of Dervis, De Melo and Robinson (1982) reviews this type of solution algorithm.

2. The gain resulting from a reduction in the tariff-induced deadweight loss tends to be small, and may even be outweighed by negative terms-of-trade effects, or by the exacerbation of other, pre-existing distortions within the economy. See Dixon (1978).

3. ORANI's specification of multiproduction within agriculture lies behind the good performance of the Northern Beef industry. First, reduced costs and elastic export demand allow a large expansion in the output of the Meat Products industry, which makes intensive use of Meat Cattle. Meat Cattle is the sole product of the Northern Beef industry, and also forms part of the output of several other agricultural industries. It is easier for the Northern Beef industry, which specializes in Meat Cattle, to supply the increased demand, than it is for the other producers to skew their output mix towards Meat Cattle. Thus Northern Beef increases its share of the Meat Cattle market -- so that its output increases by more than either the total production of Meat Cattle or the output of the Meat Products industry.

4. The tariff revenue mentioned here is computed by multiplying the database tariff rates by import volumes. These rates include the effect not only of direct tariffs but also of quota restrictions.

5. That is, a 1 per cent increase in inputs leads to a 1 per cent increase in output. Our modelling here of scale economies at the industry level is closely analogous to our modelling, in the next subsection, of scale economies at the firm level. There, in equations (2.3.1) and (2.3.2), we set out a fuller and more formal description of the associated production and cost functions.

6. Thus the tariff increases welfare. Presumably, a subsidy to the IRTS industries would achieve similar results more effectively.

7. The same relationship holds for the import-competitors as a whole, if the aggregate output is computed using total cost weights, rather than the primary-factor-cost-weighted aggregate shown in Table 1. Using total cost weights, 'Output: Import-Competing Industries' comes to -3.235 (instead of -3.058). Accordingly, 'Tech. Change:Import-Competing Industries' is -0.647 (= 0.2 x -3.235).

8. To appreciate why the balance of trade changes little, consider the following simplified model:

$$GDP = C + I + BT = R.K + W.L$$

$$GNP = C + S = Q.R.K + W.L$$

where GDP = total factor income generated in Australia
GNP = total factor income accruing to Australians
C = nominal consumption
I = nominal investment
BT = balance of trade surplus (A$)
R = wage to capital
W = wage to labour
K = national capital stock
L = national labour endowment
S = nominal national saving
Q = proportion of capital belonging to Australians

We may express the balance of trade as:

$$BT = R.K - I - Q.R.K + S$$

In absolute change form:

$$\Delta BT = \Delta(R.K) - \Delta I - \Delta(Q.R.K) + \Delta S$$

Letting lower case letters denote proportional changes:

$$\Delta BT = R.K(r+k) - Ii - Q.R.K(q+r+k) + Ss$$

According to our longrun assumptions, the real quantities of investment and capital stock change equiproportionately in each industry. Also the wage to capital in each industry is tied to the price of a unit of investment in that industry. Overlooking any discrepancy between the distribution of capital usage and the distribution of investment between industries, the percentage change in the nominal value of aggregate capital rentals will then equal the percentage change in aggregate nominal investment. It happens that in our database, the original values of these two aggregates are fairly close. Therefore the absolute changes in each are also nearly equal. Adopting this approximation, we get:

$$\Delta BT = - Q.R.K(q+r+k) + Ss$$

Now let u = the percentage change in the real value of saving, and recall that r = the percentage change in the investment price index. We get:

$$\Delta BT = - Q.R.K(q+r+k) + S(u + r)$$

Once again, it happens that our database values of Q.R.K and S are fairly close. Hence we may approximate again:

$$\Delta BT = - Q.R.K(q+k) + S(u)$$

Our model specifies a link between real saving (a flow) and the capital stock owned by Australians (QK). In percentage change form, it is:

$$q+k = \lambda.u$$

where λ is a parameter. Using this relation, and assuming that Q.R.K=S:

$$\Delta BT = S.(1-\lambda).u$$

Our macro environment requires real consumption, real saving, and real GNP to move in approximate proportion. Thus:

$$\Delta BT = S.(1-\lambda).gnpr$$

where gnpr is the percentage change in real GNP. In the experiments reported here, real GNP does not change by enough to allow much change in BT.

9. In preliminary experiments we included the industry 'FOOD PRODUCTS N.E.C.' in the 'import-competing' set of industries which enjoyed IRTS, on the basis that 11.5 per cent of domestic usage of 'FOOD PRODUCTS N.E.C.' is imported. Since it is not a highly protected industry, and since 28 per cent of its output is exported, and since the export demand elasticity is fairly high (-20.0), this industry expanded greatly as a consequence of the tariff reduction. The efficiency gains accruing via the expansion of 'FOOD PRODUCTS N.E.C.' outweighed the efficiency losses incurred via the contraction of the remaining IRTS industries, so that the tariff cut increased real GNP. Subsequently, we removed 'FOOD PRODUCTS N.E.C.' from the list of IRTS industries, because of its export orientation.

10. Meikle and Norman (1985) used a version of ORANI which incorporated external economies of scale to assess the effects of increased immigration. Their estimates of scale elasticities lay between 1.0 and 1.05 -- reflecting smaller potential scale economies than we have assumed here.

11. The 'fixed' inputs rose in price because they are composed only, by assumption, of capital and labour. Whilst the rate of return to capital has been held fixed, the real wage to labour has endogenously risen in response to increased capital/labour ratios economy-wide.

12. Assuming that the domestic supply curve is flat, in a simple partial equilibrium model of the welfare gain from a tariff cut we find the gain (in consumer surplus less tariff revenue) to be proportional to $S(1-S)\sigma T$, where S is the share of imports in the domestic market, σ is the elasticity of substitution between imports and the domestic product and T is the existing ad valorem tariff rate.

13. This illustrates the point made by Corden (1974, p.227) that, while a tariff reduction may have a 'cold shower' effect in forcing the (previously) most protected industries to rationalise, the

consequent lessening of costs in the rest of the economy may allow other imperfectly commpetive sectors to reduce their efficiency or 'relax in the warm sun'.

14. The factor 3.7 is the apparent elasticity of substitution between imported and domestic MVP, where the changing prices are measured exclusive of indirect taxes or of distribution costs. Purchaser's prices of MVP include these specific costs, and so are 20 per cent higher. Hence, a given percentage rise in the manufacturer's price of MVP causes a smaller percentage rise in the purchaser's price. Thus, our value of 3.7 is lower than the 'Armington' elasticity found in the ORANI parameter files -- 5.2. The latter is expressed with respect to purchaser's prices.

15. Some modellers imagine the various types of product or varieties to be equally spaced around a 'circle of taste'. The varieties are arranged on the circle so that each is a closer substitute to its two neighbours than it is to other varieties. It is customary to allow for two distinct arrangements. In the 'split' case it is assumed that imported varieties are closer substitutes for each other than they are for any domestic varieties, i.e. that the imports have an entire segment of the circle to themselves. Alternatively it may be assumed that the closest two substitutes for any domestic varieties are imported, and vice versa, leading to the 'interleaved' arrangement whereby domestic and imported varieties occupy alternate positions on the circle. Simulated results are often strongly influenced by the choice of arrangement. Our stylised picture of the MVP industry bears most resemblance to the 'split' case.

16. The effects of the taste change were computed by shocking the ORANI shift variables f15 and f25, which govern the quantities of 'other' (autonomous) demands in the ORANI model. The shocks corresponded to a reduction in demand for local MVP, and an offsetting increase in demand for imported MVP, each equal in magnitude to one percent of non-export demand for locally-produced MVP. Thus, the share of the consumer's budget devoted to cars-in-general (whether domestic or imported) was not directly affected by the taste change. The last feature is consistent with reactive behaviour by foreign firms, so that when the number of domestic models declines, the number

of imported models increases to fill gaps left in the market. If this increases the utility derived from each imported car by enough to offset the diminished utility derived from the less heterogeneous domestic cars, consumer utility derived from cars-in-general is unchanged.

17. Although our longrun environment incorporates a number of distortions -- e.g. the tariffs on other imported goods -- this estimate of the GNP gain from substitution towards imports is still fairly accurate, as long as CRTS is assumed. Within ORANI's neoclassical framework, users of MVP are assumed to choose an optimal mix of imported and domestic MVP. Hence, at the margin, they are indifferent between spending a dollar on imported MVP and spending a dollar on domestic MVP. The substitution of one bundle of goods for the other does not affect their utility. However, each of the two bundles have differing national opportunity costs. The bundle of domestic MVP costs the nation about a dollar, since, by ceasing to produce it, a dollar's worth of primary factors and materials can be released for some other purpose. The national opportunity cost of the bundle of imported MVP is given by the amount paid to foreigners for these imports. Since the one dollar that this bundle cost the final purchaser includes tariff duty, the cost to the nation is less than a dollar. The difference is the GNP gain. However, as we point out in the text, the introduction of imperfect competition is a sufficiently severe distortion to nearly outweigh this gain.

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Relevant GEMPACK Documents

GED-5, Two Standard Implementations, within GEMPACK 1, of Short-run ORANI with 1977/8 data, First edition, April 1986, pp.6+18.

GED-19, The Horridge Extension to ORANI, forthcoming (temporary version available).

APPENDIX 1: DETAILS OF THE SIMULATIONS

This appendix provides further details of the simulations reported in results Tables 1, 4 and 5. All of the simulations were carried out using the version of ORANI described by Horridge (1987), which was specially developed to investigate scale economies. This version is capable of reproducing -- as special cases of a larger range of possibilities -- results either from the standard version of ORANI described by DPSV, or from the longrun version of ORANI described by Horridge (1985). The database used was the 1977-78 ORANI database, tabulated by Blampied (1985).

The equations of the model were implemented and solved using the GEMPACK general purpose software system for CGE models (Pearson, 1986). The process of solving the linear equations used the Harwell sparse matrix code (Duff,1977).

For all the simulations reported here, the set of exogenous variables includes the exogenous set recommended for the Horridge (1985) longrun version of ORANI. Features of this longrun closure are summarised in subsection 2.1.

In order to model various types of CRTS and IRTS behaviour in each sector, the Horridge (1987) scale-economies version of ORANI adds, in essence, two equations and three variables (for each industry) to the conventional longrun ORANI model. The new vector equations are:

(1) The pricing rule, which relates domestic prices to input prices, to the prices of competing imports, and to an autonomous 'shift' variable. This is similar to our equation (2.3.7).

(2) An equation which relates industry technical change (or deviation from CRTS) to changes in output per firm. This enables us to implement (2.2.3)

The three new vectors of variables show, for each industry:

(i) The number of firms, which appeared only in equation (2).

(ii) The degree of technical change (or deviation from CRTS). This variable appears in the ORANI factor demand and zero pure profit equations.

(iii) The autonomous 'shift' variable, which appears only in the pricing rule (1).

Thus, for each industry, one extra variable had to be included in the exogenous list. Alternative modellings of CRTS and IRTS behaviour in each industry were achieved by different choices of this exogenous variable. To model a particular industry as CRTS, we held the technical change variable (ii) for that industry constant at zero. Variables (i) and (iii) were endogenous, so that equations (1) and (2) influenced only these variables. To mimic 'external economies' for a particular industry, we held the number of firms (variable (i)) for that industry constant at zero. Then, equation (2) enforced a positive correlation between industry output and industry efficiency, via the endogenous variable (ii). Since the price shift variable (iii) was endogenous, equation (1) had no effect. The reported value for variable (i) was later recalculated by hand, as explained in the text. Finally, for the imperfectly competitive Harris-style environments, we held the price shift variable (iii) constant. Then, the pricing equation (1) determined output price, which in turn determined both industry output, through the model's demand equations, and the degree of technical change, through the zero pure profit conditions. Equation (2) then determined the number of firms.

Other details of the computing are given in Horridge (1987), which describes some very similar experiments.

APPENDIX 2: DESCRIPTION OF VARIABLES REPORTED IN TABLES 1, 4 AND 5

In this appendix we relate the variables reported in the results Tables 1, 4 and 5 to standard ORANI variables, and to variables forming part either of the longrun version of ORANI described by Horridge (1985), or of the version of ORANI described by Horridge (1987), which was specially developed to investigate scale economies.

The following variables come from the standard version of ORANI described by DPSV and implemented under GEMPACK as described in GED-5:

Description in Tables 1, 4 and 5	GEMPACK Symbol
Consumer Price Index	xi3
Real Household Consumption	cR
Aggregate Imports (foreign currency)	m
Aggregate Exports (foreign currency)	e
Change in Balance of Trade ($000m.)	delB
Real Wage	f1
Motor Vehicles - Domestic Basic Price	p1
- Imported Basic Price	p2
- Industry Capital Stock	kappa0
- Industry Employment	x(g+1,1)
- Industry Output	z
- Volume of Imports	x2

The following variables come from the longrun version of ORANI described by Horridge (1985):

Description in Tables 1, 4 and 5	GEMPACK Symbol
Investment Price Index	PI.INV
Government Spending Price Index	PI.GOV
Exports Price Index	PI.EXP
GDP Price Index	PI.GDPE
Real Investment	INVREAL
Aggregate Capital Stock	K.EFFCT

The following, derivative, variables have been calculated from ORANI solutions as follows:

Duty-paid Imports Price Index: This is an aggregate of the basic prices of imports (foreign price + duty), weighted by import volumes at basic prices.

GNP Price Index: The longrun version of ORANI described by Horridge (1985) computes price indices for the three components of GNP -- household consumption, government consumption and saving. Here we weight these according to the initial shares in GNP.

Real Government Spending: The longrun version of ORANI described by Horridge (1985) computes the nominal value of government consumption and a corresponding price index. We show the difference between the two.

Real GDP: The longrun version of ORANI described by Horridge (1985) computes the nominal value of GDP and a corresponding price index. We show the difference between the two.

Real GNP: The longrun version of ORANI described by Horridge (1985) computes the nominal value of GNP. A corresponding price index is described above. We show the difference between the two.

Australian-Owned Capital Stock: The longrun version of ORANI described by Horridge (1985) computes both an aggregate capital stock -- whether the capital belongs to foreigners or to Australians -- and an aggregate share showing the overall proportion of all capital stock belonging to Australians. We show the sum of the two.

Output: Import-Competing Industries
Output: Other Industries
Output: All Industries
These quantity indexes are computed by weighting up output by industry -- the ORANI vector **z** -- by the initial levels of value added in each industry.

Total Input Price Index
Price Index for Fixed Costs
Price Index for Variable Costs

These three indices of input cost for the MVP industry are all calculated by the special version of ORANI described by Horridge (1987). The first is an index of the prices of all inputs to the MVP industry weighted by the initial expenditure levels on each. To calculate the second, we make use of the assumption that the fixed input for each industry is formed by combining only capital and labour in the same proportions as they are used in the total production process. Thus the Fixed Cost Price Index is merely an index of primary factor prices, weighted by the original expenditure on each factor, whether used for variable or fixed purposes. Finally, the Price Index for Variable Costs is calculated as a residual from the preceding two indices, by making use of the assumed share of fixed in total industry costs.

Industry Wide Technical Change: This variable shows the productivity gain in the MVP industry. It is the percentage decrease in the cost of a unit of output, assuming inputs are priced at their initial level. For example, a value of 5 per cent means that 5 per cent less inputs are required to make the original output. At the industry level, the gain comes about through a reduction in the required amount of capital and labour per unit of output. We show the negative of the percentage change in this ratio, multiplied by the initial share of factor costs in total input costs.

Tech.Change, Import-Competing Industries: This variable is formed by weighting up the productivity gain in each import-competing industry according to the value of industry output. The individual industry elements are computed in just the same way as that for the MVP industry, described immediately above.

Number of Firms: For most of the simulations, this variable is calculated as shown in Horridge (1987), which describes a special version of ORANI developed to investigate scale economies. However, in column 2 of Table 1 -- which shows the results of a simulation assuming external economies of scale -- we have computed the number of firms in a slightly different way, which is explained in the accompanying text.