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Introducing Imperfect Competition into the SALTER Model

Report to the Industry Commission

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Introduction and Motivation

The purpose of this document is to outline an approach to incorporating imperfect competition and increasing returns to scale into the SALTER model of global trade. The motivation for this effort derives from the increasing body of evidence which indicates that many industries set price above marginal cost (eg., Hall). Furthermore, recent analyses of trade liberalization suggest that the presence of imperfect competition can alter the likely outcomes in important ways (Helpman and Krugman; Brown and Stern). In light of this evidence, the Industry Commission has supported a project to implement a prototype model of global trade in the presence of imperfect competition, based on an aggregated version of the SALTER data base. (See Appendix A.) Calibration and simulation of this model is intended to shed light on the potential costs and benefits of extending this approach to the full SALTER model.

Adjustments to the Data Base

Before discussing the behavioral modifications to the SALTER model, it is important to have a clear picture of the data base upon which this report is built. While it is based entirely upon the SALTER-II data base, there are several modifications required by this project.[1]

Intraregional Trade

First of all, the SALTER-II data base contains intra-regional trade flows for those regions which represent aggregations of countries (e.g., ASEAN). This is an attractive feature of the data base, particularly when postulated reforms are likely to alter *intra*-regional barriers. However, this distinction is only possible when imports and domestic production are treated *asymmetrically* as in the case in the Armington formulation employed in SALTER. In the model developed below, products are differentiated by firm, rather than by region. Apart from price differences, there is no fundamental distinction made between

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[1] These modifications are thoroughly documented in an electronic appendix, which provides the TABLO file, nicknamed "BALDAT.TAB,", used to perform the associated operations.

consumers' attitudes towards foreign and domestic goods. Thus there is no convenient vehicle for distinguishing intraregional sales from domestic sales. Consequently the two are merged. Import duties on intraregional trade are blended in with domestic commodity taxes, as are export taxes. International transportation services associated with these sales are retained in the data base, but the associated *margin* is diluted by the fact that these services are now applied to the sum of intraregional trade and domestic sales.

International Transport Services

The next adjustment to the SALTER-II data base involves generating services exports to cover the level international transport activity observed in the benchmark equilibrium. These exports are drawn from the services sector in each region, in proportion to their initial level of services activity.

Zero Profits

In order to be assured that Walras' Law will be satisfied in the final model, the initial data base must be precisely balanced. At this stage a zero profits adjustment is made. First, excess profits are computed for each sector in each region. Since the initial data base was already "balanced" this figure is generally quite small. Next, sales to all regions are proportionately reduced to eliminate these excess profits. This adjustment is forced through the system, while preserving the *rates* of *ad valorem* taxation present in the initial data base. The discrepancy is ultimately absorbed in final demand, as a reduction in purchases from the relevant sector/region.

Global Savings = Investment

The final adjustment required of the SALTER-II data base involves equating global savings and investment. This is accomplished indirectly, by calculating the level of excess income in each region, once purchases of all consumables have been accounted for. This excess income is denoted "savings". If all flows have been properly accounted for, this sum of savings over all regions must equal the sum of capital goods production for investment, i.e., global savings equals investment.

Derivation of Behavioral Equations for the Imperfectly Competitive Sectors

Pricing Decisions

Representative firms in each region are assumed to maximize profits, taking into account the effect which their own action--and the anticipated reactions of competitors--will have on market prices. This gives rise to the standard first order condition whereby price is set above marginal cost, with the ratio equaling the optimal markup ratio for product i sold by a firm located in region r:

(1L) $$MKUP(i,r) = PS(i,r)/MC(i,r),$$

This equation presumes that the same price is charged for sales to all markets, subject to adjustments for differential export and import taxes and transportation margins (i.e., the integrated markets assumption).

This optimal markup is based on the perceived price elasticity of demand facing a representative producer of commodity *i* in region *r*. Under the integrated markets hypothesis, this perceived demand elasticity (*ET*) is a quantity-weighted average of the perceived demand elasticities, *E(i,r,s)*, in each of the individual market destinations:

(2L) $$ET(i,r) = \sum_{s \in DEST} SSHR(i,r,s)\, E(i,r,s) \quad ,$$

where: $SSHR(i,r,s) = VSA(i,r,s) / VOA(i,r)$, and $VOA(i,r) = \sum_{s \in DEST} VSA(i,r,s)$.

Here *VSA(i,r,s)* = the value of sales from i in r to s, at *agent's prices*, and *VOA(i,r)* denotes the value of output at agent's prices. [Note that while *SSHR(i,r,s)* is computed as a ratio of two value flows, cancellation of the common price implicit in the numerator and denominator reveals this to be a quantity share.]

The manner in which individual perceived demand elasticities are formed depends upon the structure of consumer preferences and upon the nature of the static, non-cooperative game which firms are assumed to be playing (i.e., Bertrand or Cournot). This will be dealt with momentarily. But first, consider the expression for the optimal markup as a function of the perceived demand elasticity:

$$MKUP(i,r) = ET(i,r) / [ET(i,r) - 1] \qquad \text{(3L)}$$

Together, (1L) - (3L) determine the partial equilibrium pricing structure of a representative domestic firm. Changes in market conditions (i.e., relative prices, firm numbers, and market shares) motivate changes in perceived demand elasticities. When combined with changes in the pattern of a firm's sales across regions, we obtain changes in the total perceived elasticity, and hence in the optimal markup. If it falls, then the policy shock in question may be said to have "procompetitive" effects.

Comparative static analysis of (1L) - (3L) requires these equations to be converted into percentage (or proportional) changes, denoted here by lower case variables. Consider first equation (1P). Total differentiation simply yields the result that any proportionate change in supply price is the sum of two parts: the proportionate change in marginal cost and the proportionate change in the markup. I follow standard practice in this literature whereby total costs are made up of a fixed, R & D/marketing component, and a constant variable component (e.g. Dixit and Stiglitz).[2] Therefore, marginal costs are invariant to scale, and marginal cost equals average variable cost, so that:

$$ps(i,r) = avc(i,r) + mkup(i,r) \qquad \text{(1P)}$$

In a similar fashion, we have:

$$mkup(i,r) = [1 - MKUP1(i,r)]\ et(i,r) \qquad \text{(3P)}$$

Since $MKUP\ (i,r) \geq 1$, this gives negative relationship $et(i,r)$ and $mkup(i,r)$. That is, an increase in the perceived demand elasticity will give rise to a "procompetitive" effect.

Proportionate differentiation of the total demand elasticity expression, (3L), gives the following:

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[2]The R&D component is assumed to be produced from primary factors in the same proportions as total value-added. Furthermore, capital and labor substitute for one another to the same degree in both the fixed and variable components of value-added.

$$et(i,r) = \sum_{s\epsilon DEST} ELSHR(i,r,s)\,\{[qs(i,r,s) - qo(i,r)] + e(i,r,s)\}$$

Here, $ESLHR(i,r,s) = SSHR(i,r,s)\ E(i,r,s)/ET(i,r)$, represents the contribution of the *sth* market to the *(i,r)* firm's total perceived demand elasticity. Also, $dSSHR(i,r,s)/SSHR(i,r,s)] = qs(i,r,s)$, which is the difference between the proportional change in sales to the *sth* market and total sales. Recognizing that $\sum_{s\epsilon DEST} ELSHR(i,r,s) = 1$, we can remove $qo(i,r)$ from the summation to obtain:

(2P) $$et(i,r) = -qo(i,r) + \sum_{s\epsilon DEST} ELSHR(i,r,s)\,[qs(i,r,s) + e(i,r,s)]\ .$$

Thus, even if $e(i,r,s) = 0\ \ \forall\ s$, $ET(i,r)$ may change if the policy shock causes sales to be shifted between markets with differing perceived demand elasticities.

As noted above, the specific manner in which individual perceived demand elasticities in each of the markets change depends on the structure of demand and conjectures about rival's behavior. I now turn to these issues.

Demand Structure

The SALTER trade data base, upon which this work builds, identifies bilateral trade flows among individual regions. In order to preserve these distinct trade flows in an empirical model, it is necessary to introduce some sort of product differentiation. The most direct approach to this problem involves the "Armington" assumption, whereby products are differentiated by origin, but are otherwise homogeneous. This is generally accompanied by an assumption of separability in consumption or production, such that products from different origins are first combined to form a composite importable good which substitutes (less well) for the domestic good. This is the approach adopted in the SALTER model.

An alternative view of product differentiation is provided by the industrial organization literature (Spence; Dixit and Stiglitz). Here, *individual firms* incur fixed R & D/marketing costs in order to differentiate their product, thereby establishing a market niche which permits them to markup their price above the marginal cost of production. This explanation is more appealing for purposes of a study seeking to incorporate imperfect competition.

The first implication of this industrial organization approach is that an individual firm's perceived demand elasticity will depend on the number of firms active in a given market. As the number of firms drops, the perceived demand elasticity also falls and optimal markups rise. A second implication of the firm-level product differentiation approach is that the *origin* of a given product assumes a secondary role, with particular product characteristics and brand name now in the forefront. Thus, it no longer makes sense to treat foreign and domestic products in a fundamentally different way. Indeed, consumers often do not know precisely where a given product was made, but they usually do know the brand name. This calls for a demand structure where products are *symmetrically* differentiated.

An appropriate functional form for demand in symmetrically differentiated market is the CES. The associated unit expenditure function, or composite price index, is given by:

$$PD = [\sum_{v \in VARIETIES} PDS(v)^{(1-\sigma)}]^{\frac{1}{(1-\sigma)}}$$

Unit expenditure, *PD*, is increasing in any individual price, *PDS*, but decreasing in the total number of varieties available. That is, at constant prices and expenditure, the consumer is able to attain a higher level of utility if more varieties are available.

In order to relate the unit expenditure function above to data on bilateral trade among *regions*, we make the assumption that all firms in any given region, r, charge the same price, and furthermore, that firms are active in any region s, where sales from r appear. Thus, we obtain a revised version of (4L) in which prices are indexed over regions, and each price is weighted by the number of firms operating in each region. This yields:

$$PD(i,s) = [\sum_{rREG} N(i,r)\, PDS(i,r,s)^{(1-\sigma)}]^{\left(\frac{1}{1-\sigma}\right)} \quad \text{(4L)}$$

It is useful to proportionately differentiate (4L) with respect to prices and the number of firms. This gives the following:

$$pd(i,s) = \left[\frac{1}{1-\sigma}\right] \sum_{r\epsilon REG} \Theta(i,r,s)[n(i,r) + (1-\sigma)pds(i,r,s))], \quad \text{or}$$

(4P)
$$pd(i,s) = \sum_{r\epsilon REG} \Theta(i,r,s)pds(i,r,s) - \left[\frac{1}{\sigma-1}\right]\left[\sum_{r\epsilon REG} \Theta(i,r,s)n(i,r)\right]$$

where $\Theta(i,r,s) = N(i,r)\,[PDS(i,r,s)/PD(i,s)]^{(1-\sigma)}$ is the share of total sales in region s, provided by firms from region r. Equation (4P) shows how the price index is *decreasing* in the number of varieties (provided $\sigma > 1$).

Partial differentiation of (4L) respect to the price of a particular variety, *PDS(i,r,s)*, gives the following market share equation:

(5L)
$$[QDS(i,r,s)/QD(i,s)] = N(i,r)[PDS(i,r,s)/PD(i,r)]^{-\sigma}$$

where *QD(i,s)* is total demand for commodity i in region s. Note that increasing the number of firms in regions other than r reduces *PD(i,s)*, thereby diluting *[QDS(i,r,s)/QD(i,s)]*.

Proportionate differentiation of (5L) gives the following expression:

(5P)
$$[qds(i,r,s) - qd(i,s)] = n(i,r) + \sigma[pd(i,s) - pds(i,r,s)]$$

This may be rewritten in a variety of ways to facilitate alternative insights. For example, substitution of (4P) into (5P) and rearranging gives:

(5P[1])
$$[qds(i,r,s) - n(i,r)] = qd(i,s) + \sigma\{[\Theta(i,r,s) - 1]pds(i,r,s) + \sum_{k\epsilon REG} [1 - \delta(k,r)]\Theta(i,k,s)pds(i,k,s)\} - \left[\frac{\sigma}{\sigma-1}\right]\sum_{k\epsilon REG} \Theta(i,k,s)n(i,k)).$$

The left hand side of this expression is the proportionate change in market s demand for a representative producer of i in r, as the difference between the proportionate changes in market s demand for *all* producers of i in r, *qds(i,r,s)*, and the number of firms actively producing i in r, *n(i,r)*.

The first term on the right hand side of (5P[1]) captures changes in the overall size of the market in s for product *i*. The second term captures the substitution effect--that is changes in the representative firm's market share as a consequence of relative price changes. It consists of two pieces. The first is the own-price effect due to changes in *pds(i,r,s)*. The second is the cross-price effect. The Kronecker delta $[\delta(k,r) = 0 \ \forall \ k \neq r$ and $\delta(r,r) = 1]$ simply drops the own-price changes from this term. Finally, we have the effect of changes in firm numbers. As more firms enter the market--regardless of their location--existing firms lose market share (at unchanged relative prices and constant market size).

Perceived Demand Elasticities

Having detailed the structure of demand for the differentiated products, it remains to discuss the manner in which firms form their perceived demand elasticities. Two standard avenues are open to us in the context of static, noncooperative behavior. In the first, firms conduct their thought experiment about changes in *QDS* in response to a perturbation in *PDS* based on the (Bertrand) assumption that rival firms will leave their price unaltered. This results in the following perceived demand elasticity (for detailed derivations, see Hertel, 1992):

(6L-Bertrand) $$E(i,r,s) = \sigma - [\sigma - 1][\Theta(i,r,s)/N(i,r)] \ .$$

The alternative approach is to assume that firms take their rivals' quantities as given, assuming instead that rivals will adjust their prices to clear the markets for differentiated products. This (Cournot) conjecture results in a smaller perceived demand elasticity, the formula for which follows:

(6L-Cournot) $$E(i,r,s) = \sigma/\{1 + (\sigma - 1)[\Theta(i,r,s)/N(i,r)]\} \ .$$

In order to understand how $E(i,r,s)$ changes as a function of changes in market shares and numbers of firms, we totally differentiate (6L) to obtain the following expression:

$$e(i,r,s) = \{[1-\sigma]\Theta(i,r,s)/D(i,r,s)\}shr(i,r,s)$$

where the form of D (•) depends on the nature of individual firm conjectures and $shr(i,r,s)$ is the proportionate change in a representative firm's (value-based) market share: $\Theta(i,r,s)/N(i,r)$. Since $\Theta(i,r,s) = N(i,r)[PDS(i,r,s)/PD(i,s)]^{(1-\sigma)}$ we have:

$$shr(i,r,s) = [1-\sigma][pds(i,r,s) - pd(i,s)] \ .$$

The two alternative forms of D(•) are given by:

$$D_B(i,r,s) = N(i,r)\,E(i,r,s) \quad \text{and}$$

$$D_C(i,r,s) = N(i,r) + \Theta(i,r,s)[\sigma(i) - 1] \ .$$

In summary, the general form of the individual firm's perceived demand elasticity in the *sth* market is:

(6P) $$e(i,r,s) = -(1-\sigma)^2\,[\Theta(i,r,s)/D(i,r,s)]\,[pd(i,s) - pds(i,r,s)]$$

Equations (5P) and (6P) highlight the role of changes in the relative *competitiveness* of producers from r in the *sth* market. A positive value of $[pd(i,s) - pds(i,r,s)]$, i.e., increased competitiveness of producers from r in the market for i in s, results in increased market share for these firms via (5P). It also lowers their perceived demand elasticity via (6P). Provided this increased market share in s does not come at the expense of markets with a smaller perceived demand elasticity, (2P) indicates that this will cause the total perceived demand elasticity to fall. This raises the optimal markup (3P), and also subsequently price [via (1P)], thus dampening the change in the competitiveness index.

Behavioral Equations in the Perfectly Competitive Sectors

Behavior in the perfectly competitive sectors follows the logic of SALTER, except for the treatment of preferences. In order to focus attention on the distinction between *perfect* and *imperfect* competition, all commodities are aggregated using the same basic unit expenditure function outlined in (4L). However, in the case of the perfectly competitive sector the weights on prices [*N(i,r)*] are exogenously fixed in all simulations. In this case, the expenditure function in (4L) is more appropriately interpreted as capturing the imperfect substitutability between products produced in different regions. This is equivalent to the Armington formulation when the elasticity of substitution between imported and domestic goods equals the elasticity of substitution among imports from different sources.

On the production side, since varieties are no longer distinct, the rationale for fixed costs is eliminated and all inputs are variable. Due to free entry, in the presence of a large number of firms, the industry will operate in the neighborhood of constant returns to scale, and revenues are precisely exhausted on payments to primary factors and intermediate inputs.[3]

Calibration of Imperfectly Competitive Sectors

The Basic Problem

The calibration problem for this model consists of obtaining value for *MKUP(i,r)*, *ET(i,r)* and *E(i,r,s)* which are consistent with one another [(i.e. satisfy (2L) and (3L) given *VSA(i,r,s)*, and which are also compatible with *N(i,r)*, $\Theta(i,r,s)$, and σ (i.e., satisfy (6L)). In a one region model this is not a trivial task. In a multiregion model it can be a very significant task. In order to understand the nature of this problem, it is helpful to outline some of the basic relationships circumscribing such an effort.

[3] Complete documentation of the model developed here is available in electronic appendix, under the file name: "IMPCOMP.TAB".

First of all, note from (6L) that as the number of firms [*N(i,r)*] becomes very large, given $\Theta(i,r,s)$, the perceived demand elasticity [*E(i,r,s)*] approaches σ, which is its upper bound (regardless of the form of inter-firm rivalry). If $E(i,r,s) \cong \sigma$ for all markets s, then:

$$M = M_{\min} = 1/(1-\sigma^{-1}) \tag{7C}$$

This equation provides the *lower bound* on the optimal markup. Prespecified values of $M < M_{min}$ will not be feasible, given σ.

There is no obvious upper bound on *M* in the short run, i.e., in the absence of entry. However, given the structure of the input-output accounts, it seems logical that profits could not exceed value-added, since this measure includes both profits and payments to primary factors (which are potentially fixed costs). With this in mind, we note that:

$$M_{\max} = 1/(1-\alpha) \tag{8C}$$

where α is the share of the value-added in total receipts.

Once firms are permitted to enter the market and dissipate profits, the optimal markup may be deduced from a representative firms's (or the sector's) expenditures on fixed costs:

$$M = 1/(1-\Omega) = 1/(1-\alpha\beta) \tag{9C}$$

where Ω is the share of fixed costs in total costs, and β is the share of fixed value-added in total value-added. Again, presuming that fixed costs involve expenditures solely on primary factors, we have $\Omega = \alpha\beta$, $\beta \leq 1$, and (9C) must obey the maximum provided by (8C).

Anyone familiar with input-output accounts will likely have already anticipated one of the major problems confronting the empirical modeler attempting to calibrate (1L) - (6L) subject to (7C) - (9C). Measured value-added as a share of total costs (α) varies dramatically from year to year. Adams and Higgs have demonstrated this point forcefully in the case of Australian agriculture. While this does not pose a problem for calibration *per se*, in the perfectly competitive model, they show that it has a significant impact on sectoral supply response. Of course, this problem also arises in the case of many other sectors.

To highlight the problem which volatility in value-added can pose for calibration, the reader need only consider what happens when α is extraordinarily small in the benchmark year such that $\alpha < \sigma^{-1}$. In this case, $M_{max} < M_{min}$ and the calibration problem is altogether infeasible! The potential for such infeasibilities is greatly increased in multiregion models where σ assumed is constant across regions, but α varies.

I have chosen values of σ, for this prototype model, based on values for the elasticity of substitution among products from different destinations, as that seems to most nearly match the idea behind (4L). These values are reported in parentheses next to each sector in the left-hand margin of table 1. I have taken the liberty of assigning all non-food manufacturing, sectors the same elasticity of substitution (5.6) in order to keep things simple. However, I also provide an alternative set of calibration results for those sectors where SALTER used a significantly higher elasticity of substitution, namely textiles, clothing, and footwear (when I let 0 = 7.0) and transport equipment (σ = 10.0). The elasticity of substitution among food products is somewhat smaller than for nonfood manufacturing (4.4) as is the substitutability among services outputs (3.8).

Table 1 provides data on the (adjusted) share of value-added in each of seven imperfectly competitive industries, for a six region aggregation of SALTER. I have indicated those entries for which $\alpha < \sigma^{-1}$, in the original data base, such that the two parameters were inconsistent (given the postulated model structure). There were violations in six such cases (only five in the high sigma case). Three of these were for food processing, where value-added tends to be fairly low in most regions. Also, three of the six arose in ROW, where the SALTER-II input-output structure is somewhat questionable.

Some Solutions

Clearly in those cases where $\alpha < \sigma^{-1}$ something must be altered. One possibility is to raise σ. This point is illustrated in table 1, where raising σ for textiles eliminates the RPW violation of this facilitating condition. However, this parameter plays a key role in determining the sensitivity of market shares, and hence model results, to trade reform. Arbitrarily raising the value of this parameter could potentially give qualitatively different results in a trade liberalization experiment. While such a change may indeed be appropriate (it might even be appropriate to vary σ selectively by region), I prefer to adjust α. In particular, value-added is raised to the point where $\alpha < (\sigma^{-1} + \epsilon)$ when ϵ is a small increment (0.02) designed to prevent degenerate outcomes. The increased costs are passed on as increased domestic sales, so that each region remains on its budget constraint after the adjustment . The resulting adjusted shares are displayed in table 1. At the bottom of each column, I report the total adjustment required in each region, as a share of total value-added in that region.

Having eliminated those cases which are altogether infeasible, I move on to the issue of calibrating the optimal markup in each region. There are two alternatives available. The first is to specify the number of firms active in each region. However, from the point of view of developing these markups, we are not interested in the *total* number of firms active in a given sector. Rather, we want an index of the number of varieties of *very specific* products with which a representative firm views itself as competing. This is a rather fuzzy concept. Consequently, I only adopt the approach of prespecifying firm numbers for sectors where the assumed number of firms is very large. For example, in this particular application, I assume that the services sector is characterized by a great variety of products. Therefore, $N(i,r)$ is exogenously set equal to 100. This gives a value of M which approaches its lower bound as dictated by (7C). In the remaining imperfectly competitive sectors, I calibrate the optimal markup to econometric evidence.

Since producers in every region face a common value of σ, regional markups cannot be independently chosen. However, variability in sales shares and firm numbers can lead to considerable variation in M across regions, given σ. Unfortunately estimates of M are not available for most regions of the model. A notable exception is the United States, where such estimates have recently become available for a fairly broad set of industries at the one-digit and two-digit SIC level. (Hall; Domowitz *et al.*).

Table 2 presents calibration results for the North America region based on estimated markups for the United States. Optimal markups are reported in two forms. The first (M^*) expresses the markup as a proportion of revenue (the so-called Lerner index). This is the way Domowitz *et al.* report their results. It also has the virtue of being directly comparable to α, the share of value-added. In particular, (8C) requires that $M^*_{max} \leq \alpha$. The entries in this first column of table 2 show that most values of M^* fall between 0.3 and 0.4.

Comparison of the estimates of M^* in table 2 with the values of α in the North America column of table 1 indicate that $M^* < \alpha$ in every case but food and construction. The Domowitz *et al.* estimate of M^* is slightly greater than the share of value-added in US/Canadian food manufacturing, so it is lowered to 0.30 in order to satisfy (8C). In the case of construction, the discrepancy between M^* and α is larger. However this estimate of M^* is taken from Hall's study and his estimates of M^* are systematically higher than those of Domowitz *et al.* The latter authors show that this is due to Hall's omission of intermediate inputs. Since these are significant in construction (60% of total costs according to table 1 above), perhaps it is not surprising that Hall's estimate requires downward adjustment.

But what about M^* for other regions of this model? One alternative would be to simply assign the same value of M^* to all regions. Quite apart from the fact that we expect the markup to vary according to local conditions, this poses a serious problem for calibration, since $M^*_{US} > \alpha$ for many of the industries/regions in table 1. An alternative involves choosing some other parameter to be held constant across regions. Since the calibration problem is most sensitive to variation in α, I have chosen a parameter which is invariant to α, namely the share of fixed value-added in total value-added (β). Thus calibration of the model for other regions is based on the values of β provided in the fourth column of table 2. These are used, along with α from table 1, to obtain M via equation (9C).

Note that the combination of (7C) and (9C) raise the minimum value of α, when $\beta_{US} < 1$ is used. Thus, rather than the feasibility condition $\alpha > \sigma^{-1}$, we now have the more stringent condition $\alpha\beta_{US} > \sigma^{-1}$ which must be respected. For this reason there arise a set of intermediate cases whereby $\beta < \beta_{US}$ when $\alpha\beta_{US} < \sigma^{-1}$. In order to develop a continuity of markups in this intermediate range, we apply the following formulae for β:

$$\beta = (\sigma^{-1} + \epsilon)/\alpha. \quad \text{whenever } \alpha\beta_{US} \leq \sigma^{-1} \text{ and}$$

$$\beta = \beta_{US}, \text{ whenever } \alpha\beta_{US} > \sigma^{-1}.$$

The results of this cross-regional calibration exercise are displayed in table 3. With the exception of four cases, the share of fixed value-added across regions is set equal to the US value. These values of β, along with α from table 1, permit us to obtain M (or equivalently ET), via (9C). We are now in a position to infer the number of firms in each region. Here we have a choice, since there are two alternative expressions for $E(i,r,s)$ in (6L). First, consider the Bertrand case. Substituting (6L-Bertrand) into (2L) and solving for N, yields:

$$\text{(10C-Bertrand)} \qquad N(i,r) = \{[\sigma - 1]/[\sigma - ET(i,r)]\} \sum_{s \in DEST} SSHR(i,r,s)\Theta(i,r,s) \ .$$

Application of (10C-Bertrand), using the level of markups given in table 4, there are many instances in which the number of firms falls below one. For example, in the US/Canada $N(i,r) < 1$ for the transport equipment sector and it is only slightly greater than one in the cases of textiles/clothing/footwear and other manufacturing. In short, the observed level of markups in the US seem incompatible with the assumption of Bertrand interactions among firms. Most manufacturing markups are *more collusive than is implied by Bertrand behavior.* Consequently, we turn to Cournot behavior.

In the Cournot case, substitution of (6L-Cournot) into (2L) yields an expression which cannot generally be solved for $N(i,r)$. Thus an approximation is required. This means that the *calibrated* value of $ET(i,r)$ will not be exactly equal to its prespecified value. However, this difference is generally quite small, as will be seen momentarily. The nature of the approximation involves defining a "global share" for region r supplies of commodity i, which is just a quantity share weighted sum of the market share:

$$\Theta_G(i,r) \equiv \sum_{s \in DEST} SSHR(i,r,s)\,\Theta(i,r,s) \ .$$

By replacing $\Theta(i,r,s)$ in (6L-Cournot) with $\Theta_G(i,r)$, we obtain an approximation to $ET(i,r)$ which yields the following formula for calibrating the number of firms in any given region:

(10C-Cournot) $N(i,r) = ET(i,r)\{[\sigma - 1]/[\sigma - ET(i,r)]\}\theta_G(i,r).$

This bears the striking resemblance to (10C-Bertrand). Indeed, the calibrated number of firms in the Cournot case is just *ET(i,r)* times the number in the Bertrand case. [Of course when the calibrated *N(i,r)* from (10C-Cournot) is substituted into (6L-Cournot) and the resulting *E(i,r,s)* values are plugged into (2L), the calibrated value of *ET(i,r)* will differ slightly from the Bertrand case, due to the approximation employed here.]

Application of (10C-Cournot) generates the estimated firm numbers in 4. Bear in mind that *N(i,r)* does not represent an estimate of the *total* number of firms in a given region. Rather, it is merely an index of how "competitive" a given market is, i.e., how close the implied value of *ET(i,r)* is to its maximum. Furthermore, *N(i,r)* depends critically on the relationship between σ and *ET(i,r)*. When the perceived demand elasticity approaches its upper bound, the denominator of (10C) approaches zero and the number of firms increases rapidly. This is the case in the food and primary metals sectors in several regions, where value-added is low, leading to a relatively low optimal markup and a high value of *ET(i,r)*. It is also true of textiles and transport equipment in a number for regions, at the lower values of sigma.

Table 5 reports the Lerner Index generated by substituting the values of *N(i,r)* into (6L-Cournot) and using the resulting market-specific perceived demand elasticities to compute the total perceived demand elasticity via (2L). Note that the entries for North America differ slightly from the target values of M^* in the second column of table 2. This is due to the fact that (10C-Cournot) is only an approximation to the true relationship between the number of firms and the total perceived demand elasticity. This approximation also causes M^* to differ in some instances were sigma (σ) is changed, despite the fact that *B* is unchanged.

The above results are all based on estimated US manufacturing markups at the two digit SITC level, along with one-digit results for services and construction. This is broadly compatible with the SALTER data base. Thus, the calibration strategy outlined in the previous section lends itself well to implementation at a more disaggregate level, insofar as it is fully automated. However, as one disaggregates the model further, more adjustments to value added likely to be required. In order to develop a credible empirical model, it will clearly be necessary to obtain estimates of optimal mark-ups for other regions, beginning with Australia.

Unilateral Trade Liberalization in the Australasian Region

Sectoral Support in Initial Equilibrium

The first experiment to be examined in this paper will be a *unilateral* liberalization on the part of Australia and New Zealand, which have been combined into a single "Australasian" region in this particular application. Table 6 reports the *ad valorem* power of the tariff-equivalent distortion implied by the SALTER-II data base at this level of aggregation. These distortions are source-specific and also reflect product-compositional differences which arise when aggregating over commodities with differing rates of protection.

The distortions in table 6 show that textiles, clothing, and footwear, and transport equipment are the most heavily protected sectors in the Australasian region. This is followed by other manufactures and primary metals manufacturing. The resources and agricultural sectors receive little protection from imports. Finally, measured rates of protection on services imports are low due to the difficulty of quantifying trade barriers in these markets. Furthermore, since imports of services (including construction) represent a very small share of domestic use, and since σ is relatively low in these sectors, any changes in levels of protection will have little effect on domestic production.

Table 7 reports the estimated *ad valorem* power of the farm and food sales subsidies [$TS(i,r,s)$] for Australia/New Zealand in the SALTER-II data base, i.e., $PS(i,r,s) = TS(i,r,s) * PFOB(i,r,s)$. In the case of domestic sales $(r=s)$, this is simply equal to the power of the production subsidy afforded the sector. In the case of foreign sales $(r \neq s)$, export subsidies are also included. These subsidies are destination-specific, and once again reflect product-compositional differences as well as targeted subsidies. The level of subsidy on food output is higher than that for agriculture. It is particularly large for sales to the Japanese and ROW markets.

In the unilateral liberalization experiments discussed below, the distortions in tables 6 and 7 (as well as any other export subsidies) small) are removed.

Changes in Industry Output

Table 8 reports the percentage change in industry output, due to unilateral trade liberalization in Australasia under a variety of behavioral assumptions. The first column refers to the case of perfect competition/constant returns to scale. Here, the changes in industry output mirror the sectoral pattern of changes in support. The largest reductions in output come in textiles and transport equipment. (These cuts are magnified when the higher substitution parameters are used. These results are reported in parentheses in table 8.) Output of food also drops significantly. This decline may be attributed to the combined effects of three different forces: (i) higher priced agricultural inputs (following removal of the farm output subsidies), (ii) reduced production/export subsidies for food products, and (iii) reduced prices for competing imports, especially from the EC.

The big expansion in sectoral output, under unilateral liberalization in the presence of imperfect competition, comes in the natural resource extraction sector. This is the least supported of the non-service sectors. Hence, it benefits greatly from trade liberalization, absorbing capital and labor from manufacturing activities and expanding into export markets. As the figure in parentheses indicates, this expansion is even more pronounced when the ease of substitution among differentiated textile and transport products is increased.

Having established this perfectly competitive "benchmark" solution to the unilateral trade liberalization experiment, it is now instructive to turn to the scenarios in which non-primary products are produced under conditions of increasing returns to scale, by imperfectly competitive firms. In this context, there are two alternative closures of interest. The first is a short- to medium-run closure. Here I assume that, while labor and capital are mobile across sectors, the number of firms/varieties in any given market is unchanging. This is termed the "no entry/exit" scenario. With N(i,r) fixed, the percentage change in sectoral output, reported in the second column of table 8, equals the percentage change in output per firm.

A salient feature of the no entry case is the smaller decline in textile and transport product outputs under unilateral liberalization. Furthermore, as the ease of substitution among varieties of those two products increases, the reduction in output under trade liberalization is *diminished* rather than increased. Indeed, comparison of the parenthetic results in columns one and two of table 8 shows that, when $\sigma = 10.0$, the drop in transport equipment output under trade liberalization is *three times as large* under perfect competition as compared to the imperfect competition/no entry scenario. In the case of the textiles, clothing and footwear sector, the first column is twice as large as the second.

The explanation for this difference between the perfect competition and no entry results is found by examining the *procompetitive effect* of tariff reform. This may be deduced from (6P) which describes how the perceived demand elasticity, $e(i,r,s)$, varies as a function of the competitiveness index:

$$ci(i,r,s) = [pd(i,s) - pds(i,r,s)].$$

Let us focus on the domestic market since that dominates sales from Australasian textile and transport product firms (i.e., $SSHR(i,r,r) \cong 1$). When tariffs are reduced, the price of foreign varieties falls relative to that of domestic varieties and domestic firms become less competitive, i.e., $c(i,r,r) < 0$. Equation (6P) shows that this serves to *increase* the perceived demand elasticity for domestic firms in their home market. This causes the total demand elasticity to rise via (2P), which in turn reduces domestic firms' optimal markups via (3P).

The actual decline in optimal markups under unilateral liberalization is reported in the first column of table 9. Note that in all sectors where there is significant tariff reform, $mkup < 0$. (In the cases of food products and services, domestic and foreign prices rise at roughly the same rate, and markups are essentially unchanged.) The largest declines in markups are in the most heavily protected sectors: textiles, transport products, and other manufacturing. Because part of the tariff cut in these sectors is absorbed through reduced profits, the industry does not contract by as much as under perfect competition.[4] As a result of these procompetitive effects in manufacturing, agricultural and natural resources output levels are lower in the new equilibrium than they would be under perfect competition.

The size of the procompetitive effects of tariff reform depend critically on σ, as may be seen from (6P). Furthermore, it may be shown that the procompetitive effect increases in a nonlinear fashion with increasing σ. For example, increasing σ from 5.6 to 10.0 raises *-mkup* from 1.45% to 3.34% for the transport products sector in table 9. This is why raising σ actually lowers the drop in sectoral output under the no entry scenario.

The final column in table 9 reports the changes in industry output under unilateral trade liberalization in the long run, when entry/exit is permitted. Changes in $N(i,r)$ have several important types of effects in this model. First of all, by making outlays on fixed factors responsive to profitability, entry/exit permits the economy to adjust more fully to the new, liberalized environment. As may be seen from table 9, the production of textile, clothing, and footwear products is almost eliminated in this region.[5] Similarly, reductions in the outputs of transport equipment and food products are now greater than under perfect competition.

A second important aspect of the entry/exit scenario is the considerable potential for economywide increases in output per firm. Since $qo(i,r) = n(i,r) + qf(i,r)$, output per firm can increase in an industry where aggregate output is falling, provided $n(i,r) < 0$. This type of industry *rationalization* is an important source of welfare gains under trade liberalization, as is evident from table 10, which provides a detailed analysis of the entry/exit scenario. The first column reports changes in the number of firms, by sector. While firms exit from the transport equipment and construction sectors, output per firm increases. Indeed, longer production runs arise in every sector excepting food and textiles. If we weight output per firm by the sectoral shares in economywide fixed costs (γ) given in table 10, an index of scale changes in the imperfectly competitive sectors may be obtained:

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4 See Hertel (1992) for a theoretical examination of this phenomenon.

5 In the presence of entry, increasing sigma in the textiles industry results in a greater than 100% decline in output and so the high sigma case is not reported.

$$qf^T(r) = \sum_i \gamma(i,r)\, qf(i,r) = 4.3\% \ .$$

This compares quite favorably to the no entry/exit case where $qf^T = 0.06\%$, i.e., essentially no rationalization gains.

In order to understand what drives the economywide increases in output per firm when entry/exit is permitted, it is helpful to add the zero profit condition which determines *n(i,r)*:

(11P) $$ps(i,r) = scatc(i,r) - \Omega(i,r)\, qf(i,r) \ .$$

Here, *scatc(i,r)* is the percentage change in the index of average total costs, holding scale constant. The second term, $\Omega(i,r)\, qf(i,r)$, captures the scale effect on average total costs. If $qf(i,r) > 0$ then the firm is able to spread its fixed costs over more output, thereby lowering average total costs.

Substituting (11P) into (6P) and solving for *qf(i,r)*, we obtain the following expression for the change in output per firm:

(12P) $$qf(i,r) = -\Omega^{-1}\{mkup(i,r) + [avc(i,r) - scatc(i,r)]\}$$

This shows that output per firm can be increased by either one of two mechanisms. The first source of such efficiency gains, declining markups, has already been discussed in the no entry case above. The second source of scale effects in this model is more subtle, and works through the firm's cost structure (see also Horridge). It arises when average variable costs fall, relative to the index of average total costs at constant scale. This is a very likely outcome under trade liberalization, since most trade is in intermediate inputs, and intermediate inputs make up the bulk of variable costs. By lowering tariffs, policy makers implicitly encourage firms to move down their average total cost curve, *even as markups remain unchanged.*

Table 10 provides numerical values for the right-hand-side variables in (12P), based on the *nonlinear solution* to the trade liberalization experiment. Consequently this equation no longer holds for these changes. However, (12P) provides a useful approximation to the underlying nonlinear relationship. First of all, recall that unit expenditure is *decreasing* in the number of firms in the market place. Consequently, if the exit of domestic firms is not offset by foreign entry, *pd(i,r,r)* will rise. This tends to offset the effect of lower prices for foreign varieties. Indeed, in a number of cases the sign of *ci(i,r,r)* and hence *mkup(i,r)* is reversed, with markups *rising* in the cases of food, textiles, transport equipment and construction.

While the addition of a zero profits condition, and the subsequent exit of firms from a number of industries, causes the change in markups to be ambiguous, the second component of (12P) contributes much more consistently to rationalization. In every case excepting food, average variable costs fall more rapidly than the index of average total costs at constant scale. With the exception of textiles, this dominates the effect of increased markups. In sum, an important part of the efficiency gains of trade liberalization in the presence of scale economies and entry/exit, stems from the tendency of lower tariffs to reduce average variable costs relative to fixed costs (or average total costs at constant scale).

Welfare Effects of Unilateral Trade Liberalization

Table 11 reports changes in primary factor prices, terms of trade and welfare for the Australasian region following unilateral trade liberalization. Because the imperfect competition scenarios results in lower levels of agricultural output, land rents are also lower in the wake of unilateral trade liberalization, than would be the case under perfect competition. (All price changes in table 11 are relative to the exogenous price of tradeables supplied by the Non-Australasian regions.) With the exception of returns to capital in the no entry case, unilateral liberalization lowers all factor returns. This reflects the terms of trade deterioration sustained as a consequence of increasing import demands and export supplies.

The terms of trade index in table 11 measures the change in the ratio of an index of prices received relative to prices paid *for all products*, including domestic sales. Since gross sales exceed income earned, a 1.24% deterioration in this terms of trade index translates into a much larger decline in real income. Indeed, this terms of trade loss dominates the efficiency gains from unilateral trade liberalization and aggregate welfare in the region falls in all three cases. This tendency for terms of trade losses to dominate efficiency gains from liberalization is a familiar story in the applied general equilibrium literature (e.g., Brown).

The results in table 11 contradict findings from the ORANI model, whereby such unilateral liberalization gives rise to welfare gains. The reason why terms of trade losses in the standard ORANI model are so small is that the export demand elasticities are an order of magnitude larger than the import demand elasticities. In the context of a global model, this can only be the case if Australians substitution possibilities among similar products are far inferior to those in other regions. This hardly seems plausible. In short, it is hard to argue that unilateral liberalization will not give rise to significant terms of trade losses. Whether or not these dominate efficiency gains will depend on the magnitude of the latter.

The terms of trade losses under imperfect competition are even greater than under perfect competition.[6] However, in the case of entry/exit the benefits from economywide scale effects are sufficient to counteract this and the overall welfare decline from unilateral trade liberalization is lower than for perfect competition.

Multilateral Trade Liberalization

Table 12 reports the percentage changes in industry output under global trade liberalization. Here, all border distortions, along with all farm and food output subsidies, are eliminated as a consequence of these reforms. Two alternative closures are explored in this table: perfect competition/constant returns to scale, and imperfect competition/increasing returns to scale with no entry/exit. Entry/exit results are not reported, due to the tendency of the model to "overspecialize" production under this closure with multilateral liberalization. This problem will be further discussed in the concluding section of the paper.

[6] Brown and Stern assert that the introduction of imperfect competition will dampen these terms of trade losses, but this is not the case in table 11, and this point deserves further attention.

Output Changes Under Perfect Competition

Focusing first on the perfect competition (PC) results, note that Australasia and North America increase agricultural production significantly. The strong surge in US/Canadian farm output is a direct consequence of the fact that exports from this region face the highest bilateral rates of protection of any exporter into the heavily protected Japanese and European markets. Also, North American producers currently compete in a significant way with subsidized EC grain exports in the ROW market. When EC export subsidies are removed, much of the "slack" is taken up by US/Canadian farm exports.

Production of food products, for which agricultural inputs are a critical component, expand in Japan, Korea, and ROW as a result of access to cheaper farm products. Australasian food output expands due to removal of very high bilateral rates of protection in the EC. Manufactured food output in North America actually falls, as a consequence of higher input costs in that region.

Natural resources output falls in all regions except EEC and ROW, while Korea and ROW supply an increased share of the world's textiles, clothing, and footwear demands. The US expands its output of other manufactures, while steel production increases in Japan and the EC. As expected, Japanese auto production increases significantly, while services outputs are little affected (in percentage terms). Capital goods production is constrained to move in lockstep worldwide, due to the fixed portfolio held by the global banking sector.

Imperfect Competition

When scale economies and imperfect competition are introduced, the qualitative changes described above are largely preserved. Indeed, in the absence of entry/exit (NE), most output changes in table 12 are quite similar to those under perfect competition (PC). This is quite different from the unilateral liberalization experiment where there were a number of sign changes for Australasian output. In that case, the differences were caused by changes in the optimal markup of manufacturing firms, which rendered them more competitive, relative to foreign firms. In the case of multilateral liberalization *markups fall* *worldwide* (see table 13). Thus, Australasian manufacturing output benefits less from the presence of procompetitive effects.[7]

The most striking thing about the two sets of results reported in table 12 is the pattern of output changes in Korea. Under perfect competition, only the food and textiles/clothing/footwear sectors expand. When imperfect competition and increasing returns to scale are introduced, expansion in these sectors is much stronger *and* all other non-primary product sectors also expand! In short, multilateral liberalization lends impetus to very strong scale effects in the Korean economy. These in turn permit economywide output to increase substantially, despite fixed endowments of capital and labor.

In order to shed some light on the source of these scale effects, it is useful to focus on a particular industry. Since this phenomenon is most pronounced in the case of Korean production of textiles, clothing and footwear, I have highlighted some pertinent aspects of this industry in table 14. The first column reports the range of *ad valorem* equivalent, bilateral import barriers in the SALTER-II data base. These fall between 1.10 and 1.15 in most cases. Australasia is a striking exception. Tariffs here are more than double those in other regions. Hence, a strong contraction in output is expected.

The next three columns of table 14 report the nonlinear changes in selling price and its two component parts: mkup and avc. Here we see where Korea obtains its strong impetus to increase production. Average variable costs in this industry fall dramatically, due to declining import barriers on intermediate inputs. The subsequent 15.7% price cut permits Korean textile/clothing/footwear products to dramatically increase exports.

Unilateral and Multilateral Liberalization Compared

If one compares the pattern of Australasian output changes in tables 8 and 12, it is quite striking how many sign reversals arise. In the case of imperfect competition/no entry, the only "tradeable" sectors which share a common sign are textiles and autos. This raises a

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[7] In a further simulation (not reported here), I reran the multilateral liberalization experiment under the no entry closure, using the higher values of σ for autos and textiles. Whereas this made a considerable difference for output changes under unilateral liberalization, due to the stronger procompetitive effect, this change has little effect on results when policy reform is multilateral.

serious question about the proper *sequencing* of reforms in this region. Full unilateral liberalization, followed by full liberalization in non-Australasian regions would cause extraordinary adjustment pressures in agriculture, resources, food, primary metals, and other manufacturing. Only in the textiles and autos sectors would such a sequencing result in a unidirectional pattern of adjustment.

Welfare Effects of Multilateral Liberalization

Table 15 reports the factor price and welfare effects of multilateral trade liberalization. Farmland rents receive a tremendous boost in Australasia and North America, where the demand for agricultural output expands. In Japan and Korea, returns to this asset fall. The behavior of land rents in ROW is rather unstable due to the extremely small cost share of this specific factor in the data base. (Under perfect competition farm prices in ROW fall slightly, whereas they rise slightly in the no entry case.)

Returns to labor and capital in most regions rise, relative to the price of savings (the numeraire good). The largest increases are in Korea, where cost reductions fuel a massive expansion of the manufacturing sector. The magnitude of this economywide scale effect in the no-entry case equals a 38.6% average increase in output per firm in manufacturing and services. This dwarfs scale effects in the other regions.

The final row in table 15 reports changes in real income, by region. Note that *in every case the welfare gains from multilateral trade liberalization are larger in the presence of imperfect competition.* (Relaxing the no entry restriction would greatly increase the scale effects of trade liberalization, thereby yielding even larger gains.) Furthermore, whereas not all regions benefit from multilateral trade liberalization in the presence of perfect competition, this is no longer the case in the second set of columns in table 15. Even without free entry/exit, *all regions gain from multilateral trade liberalization in the presence of imperfect competition.*

Summary and Implications for the SALTER Project

This prototype effort has established a number of noteworthy points. First, of all the econometric evidence against marginal cost pricing is very strong indeed. While this effort draws on empirical work in the United States, I am confident that similar research in Australia and elsewhere would come to the same conclusion. Indeed, this type of econometric work should be a high priority of the Industry Commission.

Based on the econometrically estimated US price-marginal cost markups, a relationship between fixed and variable value-added was established. By holding this constant, it was possible to obtain feasible markups which vary with value-added across regions. As further information about markups in individual regions becomes available, this "algorithmic" approach could be supplanted by region-specific evidence. In short, calibration of the full SALTER model would seem to be feasible, although it would likely require adjustment of value-added in some sectors, and perhaps upward adjustment of the elasticity of substitution among differentiated products in some cases. Of course, behavior in some sectors (e.g., agriculture) will be more effectively modeled using the perfectly competitive paradigm.

Two types of policy experiments were explored in this report. Both entail elimination of all border interventions, as well as farm and food production subsidies. In the first experiment, liberalization is a unilateral action taken by the combined Australia/New Zealand (Australasia) region. This experiment is performed under three different closures: perfect competition/constant returns to scale and imperfect competition/increasing returns to scale -- with and without entry/exit.

Under unilateral liberalization the Australasian manufacturing sector contracts, with natural resources output expanding. Textiles and transport products experience particularly sharp declines due to their high level of protection. When imperfect competition/increasing returns to scale features are introduced into the model, a striking thing happens. While manufacturing of food, textiles and transport products still declines, there is now significant expansion in the other manufacturing sectors. The size of this expansion depends on the potential for firm entry/exit. In the long run closure, whereby all excess profits are dissipated via entry/exit, other manufacturing output increases by about 15%.

In the short to medium run, when no entry/exit is permitted, unilateral trade liberalization in the Australasian region is also shown to have a significant *procompetitive effect* on domestic firms' optimal markups. This tends to *dampen* the change in industry output as a result of tariff reform. The size of this procompetitive effect increases more than proportionately with increases in the elasticity of substitution among differentiated products. Indeed, when substitution parameters from the SALTER data base are employed, the short- to medium-run decline in automobile production is *only one-third as large* as in the perfectly competitive model. However, in the long run, once exit of domestic firms has restored profitability in this industry to current levels, output is significantly lower than under perfect competition.

The long run (entry/exit) closure of this prototype model generates significant scale economies for the Australasian economy. Average output per firm increases in all sectors excepting food and textiles, and economywide output per firm increases by 4.3%. this is fueled in large part by a change in the cost structure of domestic firms. Trade reform lowers the cost of imported intermediate inputs, thereby lowering average variable cost, relative to average total cost at constant scale. This in turn forces an increase in output per firm in the new equilibrium.

The second experiment considered in this report is that of multilateral trade liberalization. In this case *all regions* participate in the removal of border measurers and farm/food subsidies. In this case, the pattern of Australasian output changes is markedly different from unilateral liberalization. New food and agricultural production *expand* and natural resources output *contracts*. Furthermore, under imperfect competition, the expansion in manufacturing activity which was evident under unilateral liberalization is reversed. Only in the case of textiles/clothing/footwear and transport products is the unilateral outcome comparable with market signals provided by multilateral liberalization. This raises serious questions about the appropriate sequencing of domestic and international reforms.

In the case of multilateral trade liberalization, the long run (entry/exit) closure of the imperfect competition/increasing returns to scale model gives rise to *overspecialization* in the Australasian region. In particular, the textile/clothing/footwear and transport equipment industries produce at negative output levels in the wake of liberalization. Since this violates the conditions for general equilibrium, these results are not reported here. This tendency towards exaggerated swings in output is inherent in any model with increasing returns to scale. Since econometric evidence supports the presence of scale economies in many sectors, and since excess profits are rarely fully dissipated, future research should explore alternative specifications which are capable of introducing rigidities in the entry/exit decisions of firms.

Finally, comparison of the perfect competition/constant returns and imperfect competition/increasing returns/no entry models' assessments of the benefits of multilateral trade liberalization offers some important insights. First of all, trade liberalization disciplines markups in almost all industries, worldwide. This is directly related to global improvements in output per firm. (Since no entry/exit is permitted in these simulations, these scale gains represent a lower bound on the true gains available.) Consequently the benefits of trade liberalization are greater for the world as a whole, *and for each region individually*, in the presence of imperfect competition/increasing returns. Indeed, the one region that lost from global liberalization under perfect competition, gains in the presence of imperfect competition/increasing returns to scale. The most dramatic gains arise in Korea, where the economywide index of output per firm rises by almost 40% and real income gains from trade liberalization are in excess of twenty percent.

In summary, the prototype model developed in this report suggests that imperfect competition and scale economies are an area well-worth pursuing in the context of the SALTER model of global trade.

References

Adams, P.D. (1984). "The Typical Year Data Base for the Agricultural Sector of ORANI 78." IMPACT Project OP-45, Melbourne

Brown, D.K. (1987). "Tariffs, the Terms of Trade and National Product Differentiation,"*Journal of Policy Modeling*. (Autumn): 503-506.

Brown, D.K. and R.M. Stern (1989). "U.S.-Canada Bilateral Tariff Elimination: The Role of Product Differentiation and Market Structure", Chapter 7, in R.C. Feenstra (ed.) *Trade Policies for International Competitiveness.*

Dixit, A.K. and Stiglitz, J.E. (1979). "Monopolistic competition and Optimum Product Diversity," *American Economic Review*, 67:297-308

Domowitz, I, R.G. Hubbard, and B.C. Petersen (1988). "Market Structure and Cyclical Fluctuations in U.S. Manufacturing," *Review of Economics and Statistics*, 70:55-66.

Hall, R.E. (1988). "The Relation Between Price and Marginal Cost in US Industry," *Journal of Political Economy*, 96:921-947.

Helpman, E. and P.R. Krugman (1989). Trade Policy and Market Structure. Cambridge: MIT Press.

Hertel, T.W. "The Procompetitive Effects of Trade Liberalization in a Small, Open Economy," unpublished manuscript, Purdue University.

Hertel, T.W., M.J. Gehlhar and R.A. McDougall (1992). "Reforming the European Community's Common Agricultural Policy: Who Stands to Gain?" in A. Deardorff and R. Stern (eds.), Analytical and Negotiating Issues in the GATT, Ann Arbor: University of Michigan Press, (forthcoming).

Higgs, P.J. (1986). Adaptation and Survival in Australian Agriculture. Melbourne: Oxford University Press.

Horridge, M. (1987). *The Long-Term Costs of Protection: Experimental Analysis with Different Closures of an Australian Computable General Equilibrium Model*, unpublished Ph.D. dissertation, The University of Melbourne.

Spence, M.E. (1976). "Product Selection, Fixed Costs, and Monopolistic Competition", *Review of Economic Studies* 43:217-236.

Table 1. Adjusted Shares of Value-Added, by Imperfectly Competitive Sector and Region

Sector	Region						
	σ	Australasia	North America	Japan	Korea	EEC	ROW
Food	4.4	0.26	0.31	0.25[a]	0.25[a]	0.32	0.25[a]
				(0.23)	(0.11)		(0.08)
Textiles, Clothing and Footwear	5.6	0.29	0.39	0.31	0.22	0.39	0.20[a]
							(0.17)
High sigma[b]	7.0	0.29	0.39	0.31	0.22	0.39	0.17
Primary Metals	5.6	0.29	0.40	0.38	0.20[a]	0.45	0.25
					(0.17)		
Transport Equipment	5.6	0.27	0.39	0.38	0.26	0.38	0.36
High sigma[b]	10.0	0.27	0.39	0.38	0.26	0.38	0.36
Other Manufacturing	5.6	0.30	0.41	0.37	0.26	0.40	0.41
Construction	3.8	0.43	0.41	0.41	0.37	0.49	0.28[a]
							(0.21)
Services	3.8	0.61	0.68	0.66	0.61	0.71	0.30
Percentage Change in Total Value-Added		0.0%	0.0%	0.2%	2.3%	0.0%	7.5%
High sigma[b]		0.0%	0.0%	0.2%	2.3%	0.0%	7.1%

[a] Denotes value which has been changed from that reported in parentheses.

[b] The "high sigma" rows correspond to calibration outcomes when the elasticity of substitution among varieties is set at a higher level, as suggested by the SALTER parameter file.

Table 2. Calibration Results for North America (USA and Canada)

Industry	σ	*Estimated* M^*	Adjusted M	$M=P/MC$	$SVAF=\beta$	Cournot-Equivalent # *Firms*=N^d
Food	4.4	.332[b]	0.30	1.42	0.95	10
Textiles, Clothing, and Footwear	5.6	.298[a], .316[a],.351[a]	0.30	1.42	0.75	5
High sigma[e]	7.0		0.30	1.42	0.75	4
Primary Metals	5.6	.280[a]	.028	1.39	0.70	6
Transport Equipment	5.6	.289[a]	0.29	1.41	0.74	5
High sigma[e]	10.0		0.29	1.41	0.74	3
Other Manufacturing	5.6	.365[b]	0.37	1.59	0.91	3
Construction	3.8	.545[c]	0.40	1.67	0.98	5

[a] Source: Domowitz *et al.*, table 2.

[b] All manufacturing, Source: Domowitz *et al.*, table 1.

[c] Source: Hall, Table 4, where $M^*=(1-\beta)$ in Hall's terminology.

[d] Rounded off to the nearest whole number.

[e] The "high sigma" rows correspond to calibration outcomes when the elasticity of substitution among varieties is set at a higher level, as suggested by the SALTER parameter file.

Table 3. the Share of Value-Added Which is Fixed (β) by Sector and Region

Sector	Region						
	σ	Australasia	North America	Japan	Korea	EEC	ROW
Food	4.4	0.95	0.95	0.95	0.95	0.95	0.95
Textiles, Clothing and Footwear	5.6	0.75	0.75	0.75	0.91[a]	0.75	1.00[a]
High sigma[b]	7.0	0.75	0.75	0.75	0.75	0.75	0.99
Primary Metals	5.6	0.70	0.70	0.70	1.00[a]	0.70	0.80[a]
Transport Equipment	5.6	0.74	0.74	0.74	0.74	0.74	0.74
High sigma[b]	10.0	0.74	0.74	0.74	0.74	0.74	0.74
Other Manufacturing	5.6	0.91	0.91	0.91	0.91	0.91	0.91
Construction	5.6	0.98	0.98	0.98	0.98	0.98	0.98

[a] Denotes case where $B > B_{US}$

[b] The "high sigma" rows correspond to calibration outcomes when the elasticity of substitution among varieties is set at a higher level, as suggested by the SALTER parameter file.

Table 4. The Cournot Equivalent Number of Firms[a] (*N*) by Sector and Region

Sector	σ	Australasia	North America	Japan	Korea	EEC	ROW
Food	4.4	33	10	83	81	9	86
Textiles, Clothing and Footwear	5.6	14	5	13	17	6	35
High sigma[c]	7.0	8	4	8	18	5	37
Primary Metals	5.6	29	6	7	27	2	36
Transport Equipment	5.6	25	5	5	21	5	7
High sigma[c]	10.0	6	3	3	4	3	4
Other Manufacturing	5.6	6	3	4	6	3	3
Construction	3.8	5	5	5	7	3	53
Services	3.8	100[b]	100	100	100	100	100

[a] Firm numbers have been rounded off to the nearest whole number.

[b] The Cournot equivalent number of firms in the service s sector has been exogenously specified to reflect a lack of market power.

[c] The "high sigma" rows correspond to calibration outcomes when the elasticity of substitution among varieties is set at a higher level, as suggested by the SALTER parameter file.

Table 5. Lerner Index by Sector and Region: $M^* = (P\text{-}MC)/P$.

Sector	Region						
	σ	Australasia	North America	Japan	Korea	EEC	ROW
Food	4.4	0.24	0.29	0.24	0.24	0.30	0.24
Textiles, Clothing and Footwear	5.6	0.22	0.29	0.23	0.20	0.28	0.20
High sigma[a]	7.0	0.22	0.29	0.23	0.16	0.28	0.16
Primary Metals	5.6	0.20	0.28	0.26	0.20	0.28	0.20
Transport Equipment	5.6	0.20	0.28	0.26	0.19	0.27	0.26
High sigma[a]	10.0	0.20	0.26	0.21	0.15	0.23	0.25
Other Manufacturing	5.6	0.26	0.35	0.32	0.23	0.34	0.35
Construction	3.8	0.42	0.40	0.40	0.37	0.48	0.28
Services	3.8	0.27	0.27	0.27	0.27	0.27	0.27

[a] The "high sigma" rows correspond to calibration outcomes when the elasticity of substitution among varieties is set at a higher level, as suggested by the SALTER parameter file.

Table 6. Estimated *Ad Valorem* Power of the Tariff-Equivalent Australia/New Zealand, 1988 Import Barrier

Commodity	Source of Import				
	US/CW	EEC	JAPAN	KOREA	ROW
Agriculture	1.00	1.00	1.00	1.00	1.00
Natural Resources	1.01	1.04	1.01	1.01	1.00
Food	1.04	1.01	1.01	1.09	1.01
Textiles	1.32	1.32	1.32	1.31	1.37
Primary Metals	1.08	1.08	1.08	1.08	1.08
Transport Equipment	1.19	1.19	1.17	1.19	1.19
Other Machinery	1.13	1.13	1.14	1.13	1.12
Construction	1.00	1.00	1.00	1.00	1.00
Services	1.01	1.01	1.01	1.01	1.01

Source: SALTER-II data base except for Construction, where the tariff has been set equal to zero.

Table 7. Estimated *Ad Valorem* Power of the Farm and Food Sales Subsidy: Australia/New Zealand

Destination	Agriculture	Food
AU/NZ	1.03	1.05
US/CN	1.03	1.06
EEC	1.03	1.09
JAPAN	1.03	1.11
KOREA	1.03	1.06
ROW	1.03	1.12

Source: SALTER-II data base.

Table 8. Percentage Change in Industry Output Under Unilateral Australia/New Zealand and Trade Liberalization (High sigma results in parentheses.)

	Behavioral Assumption		
Sector	**Perfect Competition**	**Imperfect Competition**	
		No Entry/Exit	**Entry/Exit**
Agriculture	-1.6%	-4.5%	-3.2
	(-1.2)[a]	(-4.6)	
Natural Resources	16.8	12.3	23.1
	(18.2)	(11.9)	
Food	-11.4	-13.0	-15.3
	(-11.1)	(-13.1)	
Textiles	-31.8	-22.9	-99.6
	(-38.9)	(-19.4)	
Primary Metals	0.4	3.4	12.1
	(0.4)	(3.8)	
Transport Equipment	-19.3	-15.7	-34.0
	(-31.9)	(-10.2)	
Other Manufacturing	-0.2	6.7	14.8
	(0.6)	(6.3)	
Construction	0.3	0.5	1.7
	(0.3)	(0.5)	
Services	0.5	-0.4	2.2
	(0.6)	(-0.4)	
Capital Goods	0.0	0.1	0.2
	(0.0)	(0.1)	

[a] Numbers in parentheses represent outcomes when higher values of σ are used for textile and transport products.

Table 9. Percentage Change in Selected Variables Relative to Exogenous World Prices: Unilateral Trade Liberalization *No Entry* (High sigma simulation results in Parentheses)

Sector	mkup	avc	ps
Agriculture	na	na	-3.24 (-3.12)[a]
Natural Resources	na	na	-2.23 (-2.10)
Food	0.04 (0.05)	-1.80 (-1.71)	-1.75 (-1.66)
Textiles	-1.70 (-3.74)	-9.65 (-10.34)	-11.19 (-13.69)
Primary Metals	-0.11 (-0.11)	-4.57 (-4.50)	-4.67 (-4.60)
Transport Equipment	-0.45 (-3.34)	-8.61 (-9.26)	-9.02 (-12.29)
Other Manufacturing	-1.57 (-1.50)	-6.16 (-6.12)	-7.64 (-7.60)
Construction	0.04 (0.04)	-7.01 (-6.96)	-6.97 (-6.92)
Services	-0.01 (-0.01)	-2.68 (-2.60)	-2.69 (-2.60)
Capital Goods	na	na	-7.65 (-7.85)

[a] Numbers in parentheses represent outcomes when higher values of σ are used for textile and transport products.

Table 10. Percentage Change in Selected Variables Relative to Exogenous World Prices: Unilateral Trade Liberalization *Free Entry* (High sigma simulation results in Parentheses)

Sector	n	qf	γ	Ω^{-1}	mkup	(avc-scatc)
Food	-13.40	-2.24	0.05	4.10	0.42	0.13
Textiles	-98.97	-2.82	0.02	4.51	0.93	-0.28
Primary Metals	6.43	5.29	0.02	4.97	-0.26	-0.72
Transport Equipment	-36.51	4.03	0.03	5.01	0.09	-0.81
Other Manufacturing	2.50	12.04	0.23	3.71	-1.70	-1.31
Construction	-2.22	4.04	0.19	2.38	0.67	-2.15
Services	0.57	1.60	0.46	3.72	-0.01	-0.40

Table 11. Primary Factor Prices and Aggregate Welfare Effects of Unilateral Liberalization, Australia/New Zealand, 1988

	Percentage Change		
Factor Prices	Perfect Competition	Imperfect Competition	
		No Entry	Entry
Land	-7.34%	-10.55%	-10.60%
Labor	-4.17	-0.72	-4.26
Capital	-2.97	0.12	-2.14
Terms of Trade[a]	-1.24	-1.29	-1.55
Scale of Effects	na	0.06	4.30
Real Income (Utility)	-2.25	-2.43	-1.98

[a] The terms of trade reported here represent an index of the prices of *all products sold*, relative to an index of the prices of *all products purchased*, including capital goods, savings, and domestic consumption.

Table 12. Output Changes Under Multilateral Trade Liberalization: Perfect Competition/No Entry Compared

	Region											
	Australasia		North America		Japan		Korea		EEC		ROW	
Sector	PC	NE	PC	NE	PC	NE	PC	NE	PC	NE	PC	NE
Agriculture	21.9%	20.3%	42.6%	43.8%	-37.7%	-34.8%	-26.2%	-19.6%	-2.7%	-4.0%	-4.0%	-0.8%
Resources	-10.4	-8.0	-5.1	-2.5	-13.9	-7.1	-17.0	-4.2	4.1	7.5	0.8	2.3
Food	58.0	54.0	-7.8	-13.3	9.2	18.6	11.8	47.2	-13.6	-15.1	3.7	7.4
TCF	-48.8	-47.5	-15.6	-18.2	-1.3	0.3	126.6	313.0	-1.4	-0.8	3.9	3.2
Primary Metals	-18.2	-15.7	-0.8	3.8	7.7	11.3	-11.9	30.2	18.4	44.0	-5.0	-7.6
Transport Equipment	-39.3	-36.2	-0.9	2.9	28.1	36.1	-14.2	4.6	0.9	2.9	-7.4	-7.6
Other Manufacturing	-15.6	-9.6	5.9	8.0	-0.5	1.0	-8.9	25.7	-1.6	2.8	-1.6	-0.1
Construction	0.2	2.9	0.3	2.6	-0.4	2.0	-0.1	4.6	0.3	2.6	0.2	2.8
Services	0.3	-0.0	-1.7	-2.2	0.1	1.2	-0.4	20.9	1.2	-0.4	1.1	3.8
Capital Goods	0.2	2.9	0.2	2.9	0.2	2.9	0.2	2.9	0.2	2.9	0.2	2.9

Table 13. Percentage Change in Optimal Markups as s Result of Multilateral Trade Liberalization: No Entry/Exit

Industry	Region					
	Australasia	North America	Japan	Korea	EEC	ROW
Food	-0.88	-0.84	-0.07	-0.06	-1.18	-0.03
TCF	-2.92	-4.43	-1.10	-0.23	-2.33	-0.26
Primary Metals	-0.33	-2.12	-1.13	-0.31	-4.50	-0.28
Transport Equipment	-0.96	-1.40	-1.81	-0.30	-1.09	-1.18
Other Manufacturing	-2.88	-2.24	-0.94	-1.52	-2.87	-2.65
Construction	-0.01	-0.00	-0.01	0.01	0.01	0.00
Services	-0.01	-0.038	-0.03	-0.04	-0.01	-0.18

Table 14. **Determinants of Output Changes in the Textiles, Clothing, and Footwear Industry**

Region	Range of *TM(i,r,s)*	avc	mkup	ps	qo
Australasia	1.31 - 1.37	1.2%	-2.9%	-1.7%	-47.5%
North America	1.12 - 1.16	-1.2	-4.4	-5.6	-8.2
Japan	1.11 - 1.13	-0.9	-1.1	-2.0	0.3
Korea	1.12 - 1.13	-15.5	-0.2	-15.7	314.0
EEC	1.07 - 1.10	2.8	-2.3	0.4	-0.8
ROW	1.14 - 1.19	-3.6	-0.3	-3.9	3.2

Table 15. Welfare Effects of Multilateral Trade Liberalization

	Region											
	Australasia		North America		Japan		Korea		EEC		ROW	
Variable	PC	NE	PC	NE	PC	NE	PC	NE	PC	NE	PC	NE
Factor Prices[a]												
Land	74.61%	80.43%	186.74%	206.35%	-74.65%	-70.38%	-52.49%	-35.84%	-2.90%	0.88%	-10.66%	10.33%
Labor	9.13	16.83	-0.22	3.96	6.94	11.07	18.45	22.55	3.73	10.89	1.18	13.29
Capital	8.94	16.04	0.14	4.50	5.67	9.79	12.86	21.38	3.40	10.56	1.10	13.04
Terms of Trade	1.39	1.52	0.20	0.28	0.43	0.34	-0.02	-2.20	0.29	0.21	-0.31	-0.26
Scale Effect	na	-0.16	na	0.41	na	3.21	na	38.60	na	0.19	na	2.41
Real Income	3.08	4.30	0.74	1.07	1.05	2.52	3.89	23.65	0.58	0.59	-0.55	1.84

[a] All price changes are relative to the price of numeraire good -- savings.

Appendix A: Concordance Between the SALTER-II Data Base and the Aggregated Data Base Used in this Study

Table A1. Sector Mapping

New Sectors	Old Sectors
1. Agriculture	1. Paddy rice 2. Wheat 3. Grains, other than rice and wheat 4. Non-grain crops 5. Wool 6. Other livestock
2. Resources extraction and processing	7. Forestry 8. Fishing 9. Coal 10. Oil 11. Gas 12. Other minerals
3. Food processing	13. Meat products 14. Milk products 15. Processed rice 16. Beverages and tobacco 17. Other food products
4. Textiles, clothing, and footwear	18. Textiles 19. Wearing apparel 20. Leather, etc.
5. Primary ferrous metals	26. Primary ferrous metals
6. Transport industries	29. Transport industries
7. Other manufacturing	21. Lumber and wood 22. Pulp, paper, etc. 23. Petroleum and coal products 24. Chemicals, rubber, and plastics 25. Non-metallic mineral products 27. Non-ferrous metals 28. Fabricated metal products nec 30. Machinery and equipment 31. Other manufacturing
8. Construction	37. Construction
9. Other services	32. Electricity, water and gas 33. Trade and transport 34. Ownership of dwellings 35. Other services (private) 36. Other services (government)

Table A2. Regional Mapping

New Regions	Old Regions
1. Australasia	1. Australia 2. New Zealand
2. North America	3. Canada 4. USA
3. Japan	5. Japan
4. Korea	6. Korea
5. EC	7. EC
6. ROW	8. ASEAN 9. ROW