The Fate of Agriculture Under Trade Liberalization: Challenging Conventional Conclusions

by

Thomas W. Hertel*
Purdue University
and
IMPACT Project

---

* The author is an Associate Professor in the Department of Agricultural Economics, Purdue University, W. Lafayette, Indiana. He is currently a visiting Fulbright Senior Research Fellow with the IMPACT Project, at the University of Melbourne. This was prepared as an invited paper to the 1991 Annual Conference of The Australian Agricultural Economics Society held in Armidale, NSW, February 11-14. The author would like to thank Mark Horridge for numerous stimulating conversations on this topic, and for comments on an earlier draft of this paper.

Introduction

Despite the high profile farm and food policies in the Uruguay Round of GATT negotiations, liberalization of international agricultural trade remains an ellusive goal. This is especially disheartening to the hundreds of agricultural economists who have spent the last four years analysing the consequences of such a move. Inertia and the entrenched interests of those who might lose from agricultural reform appear to have carried the day over dispassionate analysis and broad international consensus about the need for change. To many of those who have devoted their careers to the analysis of domestic farm policies this state of affairs was surely the expected outcome. Nevertheless, as a relative newcomer to this field, I remain optimistic about the longrun potential for reform. I also believe that there is much more that agricultural economists can do to further this process of rationalization in the global allocation of food production. This is a theme to which I will return in the concluding section of the paper.

Rather than analyzing the current GATT round in the body of this paper, I would like to take advantage of the present lull in negotiations in order to step back and examine some of the basic assumptions under which many of us have been operating. Over the past decade, quantification of the likely consequences of international agricultural trade liberalization has advanced from single commodity an is to multicommodity models, and finally to economywide, general equilibrium models. In the last four years the pace of work in this area has been rapidly accelerated in an attempt to deliver models with greater coverage and finer disaggregation of economic activity. The combination of increased policy relevance and financial support has facilitated numerous breakthroughs in the very information-intensive business of modelling international agricultural trade. As such it strikes me that 1991 is a very good time to step back and assess some of the conclusions which are part of the current "conventional wisdom" embodied in these models.

I will make no pretense of providing a comprehensive survey of existing work in this area. This is available elsewhere (see, for example, Goldin and Knudsen). Instead I have selected three points which I believe to be highly relevant, and often overlooked. I begin by posing the question: Do we always predict the correct sign of the likely change in agricultural output following economywide trade liberalization? There is some reason to believe we may not. I then turn to two points which are pertinent to the likely changes in individual commodity outputs and farm factor returns following agricultural trade liberalization.

Agriculture in the Context of Across-the Board Trade Liberalization

The conventional conclusion which I would like to challenge in this section may be summarized as follows:

(C1) In those cases where agriculture is relatively lightly protected (or even taxed), across-the-board trade liberalization will cause this sector to expand.

The intuition behind this conclusion is based on the standard, perfectly competitive, general equilibrium model. In this environment, a tariff cut reduces profitability in all sectors at initial equilibrium prices. Domestic factor prices must adjust to restore zero profits, and primary factors will tend to move into those sectors in which this cut in profitability is smallest. In the case of Australia, one such expanding sector is expected to be agriculture. However, this finding seems to be rather sensitive to the assumption of perfectly competitive behaviour. This theme will now be explored in some detail.

A Review of the Evidence: The conventional wisdom of (C1) has been borne out in numerous simulations of the ORANI model of the Australian economy (e.g., Higgs). Horridge has aggregated this model up to eight sectors and his results for an incremental, across-the-board tariff cut are presented at the top of Table 1. [These results correspond roughly to a 12.5% reduction in protection for all sectors.] In Horridge's standard, perfectly competitive, computable general equilibrium (CGE) framework, both agriculture and food manufacturing expand, in spite of the fact that their absolute level of protection is cut.

These results are essentially unaltered when Horridge replaces the standard assumptions with a specification in which domestic firms produce a differentiated product. Firms are subsequently assumed to mark-up their price (P) above marginal cost (MC) according to the profit maximizing formula: $(P - MC)/P = (1/\eta)$, where $\eta > 0$ is the perceived demand elasticity for a representative domestic firm. A critical point in this imperfectly competitive environment involves the individual firm's conjectures about their competitors' behaviour. Horridge invokes the Betrand assumption whereby firms calculate η based on the assumption that competitors' prices will remain unchanged. In summary, Horridge's study

Table 1: A Summary of Empirical Estimates of the Impact of Across-the-Board Trade Liberalization on Selected Sectors: Percentage Change in Industry Output

Sector	Perfect Competition	Imperfect Competition	
--- Horridge's Analysis of the Australian Economy (partial liberalization)[a] ---			
	PC	Monopolistic Competition Domestically	
Resource-based Industries	+1.25	+1.27	
Food Manufacturing	+0.52	+0.56	
--- Devarajan and Rodrik's Analysis of the Cameroon[b] (Cournot conjectures)--			
	PC	no entry	entry
Food Crops	-3.2	+0.8	+1.0
Cash Crops	+14.3	-11.1	-10.9
Food Processing	+1.9	+25.8	+23.6
--- Brown and Stern's Analysis of Canada - U.S. Free Trade[c] ----			
	PC	Monopolistic Competition	Market Segmentation
Canadian Agriculture	+0.5	-4.8	-11.2
Canadian Food Manufacturing	-0.3	-1.8	-4.2
U.S. Agriculture	-0.3	0.0	+1.2
U.S. Food Manufacturing	-0.0	0.0	+0.2

Notes:

(a) Source: Horridge, Tables 5.4.1 and 5.4.2. Results based on a model in which domestic products are differentiated, first among one another, and secondly from inpurts. Increasing returns to scale and free entry are assumed.

(b) Source: Devarajan and Rodrik, Tables III.1A, III.2 and III.3A. Results based on a model in which foreign and domestic products are differentiated, but domestic products are homogenous. Domestic firms operate based on Cournot conjectures.

(c) Source: Brown and Stern, Tables 7.1 -7.6.

supports, rather than challenges, the robustness of (C1) to changes in the assumption of perfect competition.

Another recent study, this time for the Cameroon, poses a much stiffer challenge to (C1). In this work, Devarajan and Rodrik begin with a perfectly competitive CGE model, very similar in structure to the ORANI model. The consequences for agricultural and food production of across-the-board tariff removal in this framework are reported in column one of the second part of Table 1. With the exception of food crops output, which is destined almost exclusively for domestic use, the relatively less-protected sectors are the ones which expand. Thus, as expected, this baseline counterfactual simulation is supportive of (C1). Note that cash crops production expands strongly, since this output is largely destined for very price elastic export markets in which Cameroonian products now become more competitive.

The authors' next step is to introduce imperfect competition into the manufacturing and construction sectors. They argue that such considerations are particularly relevant in many developing countries where domestic markets are small, entry may be restricted, and production is often concentrated in the hands of only a few favoured firms. Like Horridge, Devarajan and Rodrik choose a specification which embodies the familiar Armington assumption. However, rather than treating domestic firms as producing differentiated products, thereupon competing on the basis of price, they choose to model them as Cournot competitors in a homogenous domestic product market. While this difference may appear minor, it turns out to have important implications for the impact of tariff reform on the perceived demand elasticity of domestic firms. (This will be explored in depth below.)

Using this Armington-Cournot specification, coupled with increasing returns to scale (the latter doesn't affect the *qualitative* nature of their results), the authors find that across-the-board trade liberalization now gives rise to a very different pattern of output changes. With two minor exceptions all of the imperfectly competitive sectors now expand. The authors attribute this to the "pro-competitive" effects of tariff reform, whereby a tariff reduction increases the perceived demand elasticity for these firms, thus reducing their optimal markup and moving firms down their average total cost curves.

Devarajan and Rodrik's results for the three agriculture-related sectors are also reported in Table 1 (for both the entry and no entry cases). They show a dramatic reversal in the fate of cash crops, and hence aggregate agricultural output when manufacturing and construction are imperfectly competitive. Rather than absorbing additional resources, agriculture releases labour and capital to the increasingly competitive manufacturing sectors This striking result is altered very little when entry and exit are permitted. Before proceeding with a thorough examination of the mechanism behind this finding, let us turn to one final empirical study of trade liberalization.

The last part of Table 1 reports selected results from a study by Brown and Stern in which those authors employ a three region, CGE model to analyze the implications of alternative behavioural assumptions for the predicted outcome of the Canada -

U.S. Free Trade Agreement. This study embodies two important differences from the studies discussed above. First of all, both the model and the experiment are fundamentally multiregional. In particular, two of the three regions liberalise tariffs on one another's products. Secondly, the authors depart from the conventional Armington-type differentiation of domestic and imported products. Rather, they assume that products are differentiated only by firm. Thus domestic and foreign products are treated symmetrically in the household preference structure. Consumers choose among all products available in the marketplace, regardless of origin, on the basis of price. As in the Horridge study, each differentiated product is produced by a separate firm, which must purchase a fixed factor composite in order to enter the market. Coupled with the assumption of constant returns to scale in the variable inputs, this gives rise to declining average total costs.

Brown and Stern compare model predictions under three alternative behavioural assumptions. Like the previous authors they provide a baseline experiment in which perfect competition (and hence Armington-type product differentiation) is assumed. Results for U.S. and Canadian outputs from agriculture and food manufacturing are reported in the first column of Table 1. The changes here are very small, with a slight shift of agricultural production from the U.S. to Canada. This follows from the fact that agricultural tariffs between the two countries are comparable, whereas initial equilibrium nonagricultural tariffs are somewhat higher in Canada.

The perfectly competitive results of Brown and Stern are contrasted with those in which firms are modeled as monopolistically competitive. The latter assumption gives rise to much stronger intersectoral resource movements, with Canadian agriculture now contracting as it loses resources to selected manufacturing enterprises. These manufacturers reduce their markups and become more competitive through the subsequent rationalization of industry structure.

These departures from the perfectly competitive baseline are even more dramatic when the authors invoke the assumption that the Canadian and U.S. markets are segmented, such that firms may price differentially in each of these countries. Now Canadian farm output falls by 11.6%, rather than experiencing a modest increase, as was the case under perfect competition. Clearly this study provides added fuel for the challenge to (C1). I now turn to the problem of sorting out the underlying determinants of this challenge to the conventional wisdom about the fate of agriculture under across-the-board trade liberalization.

A Simple Model: In order to make sense of the contradictory evidence on (C1), as presented in Table 1, it is useful to reduce the question at hand to its "barest bones." In its simplest form, the essence of this problem may be captured with a two sector model. Sector 1, which may be thought of as agriculture, is an aggregation of all activities which operate roughly in accordance with the perfectly competitive paradigm. This may be due to either: (1) a small optimal scale of production relative to market demand, so that the optimal number of firms is very large, or (2) relatively free entrance and exit in the absence of significant fixed costs. In any case, output price in this sector equals marginal cost, and industry average total cost is not affected by changes in the number of firms, i.e. locally constant returns to scale apply.

The second sector in this stylized economy is imperfectly competitive. Here significant (recurrent) fixed entry costs, coupled with constant marginal costs give rise to increasing returns to scale. Firms markup price over marginal cost according to the inverse of the perceived demand elasticity as noted above. For the time being I will assume no entry/exit from this sector. This reduces the dimensions of the general equilibrium solution. Furthermore, it does not appear central to the Cameroon results [which in turn pose the stiffest challenge to (C1)].

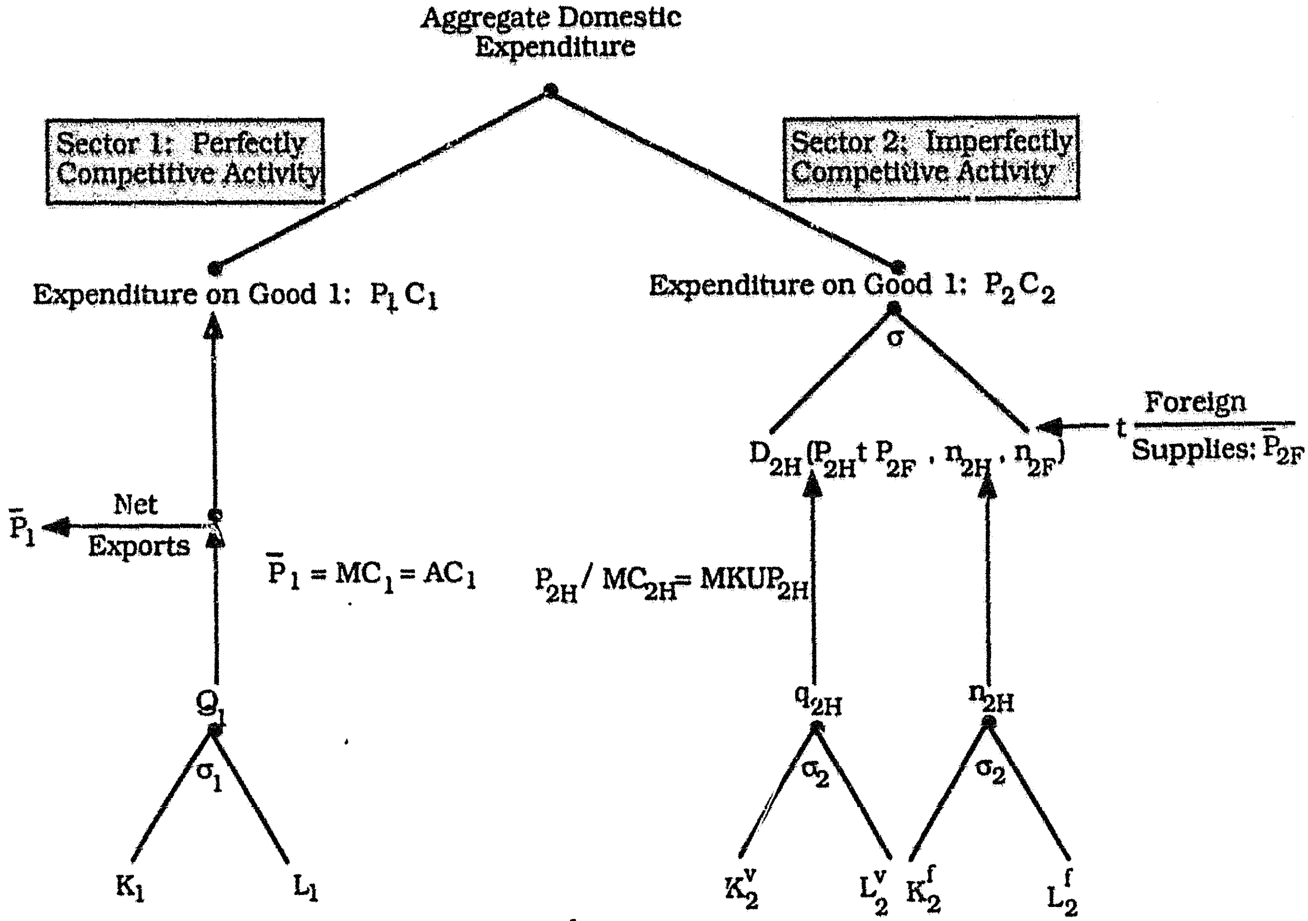
Essential features of this stylized, two sector economy are portrayed in Figure 1. Postulation of a Cobb-Douglas utility function (following the Cameroon and Canada-U.S. models) results in constant domestic expenditure shares for each of the two goods. However, composite good two is made up of many individual varieties. The demand for a representative home firm's output (D_{2H}) is a function of the consumer prices of competing products (P_{2H} and $P_{2F}t$, where t is one plus the *ad valorem* tariff on imports) It also depends on the number of varieties available ($n_{2H} + n_{2F}$). The ease of substitution among alternative varieties is governed by the value of σ. I assume that markets are not segmented and that the domestic market is small enough to have a negligible impact on the marginal cost, pricing and entry decisions of foreign firms. This fixes P_{2F}.

Since good two is not exported, domestic consumption (C_2) represents an aggregation of domestic production ($Q_2 = n_{2H}\, q_{2H}$) and imports ($n_{2F}\, D_{2F}$). Domestic firms combine both variable and fixed inputs (labour and capital) using a unique elasticity of substitution (σ_2). They markup price over marginal cost ($MKUP_{2H} = P_{2H}/MC_{2H}$), based on their perceptions of domestic market conditions. Sector 1 is only indirectly affected by the tariff on imports of good 2. [It is a net exporter of a homogenous product at an exogenous world price ($\bar{P}_1$).]

In the context of Figure 1, the conventional hypothesis (C1) is that when the tariff is removed, capital and labour will leave sector 2 for sector 1 (full employment is assumed). Thus we expect that $(\hat{Q}_1/\hat{t}) < 0$. That is, proportional changes in the manufactures' tariff on the one hand, and agricultural output are on the other, inversely related. (Note that a change in the tariff on good two is a special case of the original problem whereby rates of protection are differentially altered.) This conventional hypothesis can be thoroughly explored in the context of this model since its analytical solution is tractable. Furthermore, this solution may be expressed in such a way as to facilitate sensitivity analysis with regard to market structure and firm behaviour. Thus, while the treatment of sector 2 in Figure 1 follows the Brown and Stern specification, we will also be able to look at the implications of adopting the approaches of either Horridge, or Devarajan and Rodrik.

Manipulation and solution of the equations underlying Figure 1 yields the following expressions for changes in sectoral output, assuming no entry/exit in sector 2 (i.e. $\hat{n}_{2H} = 0$):[1]

1 A complete mathematical exposition of this model is available in Hertel (1991b).



Resource Constraints

$$\bar{K} = K_1 + K_2^v + K_2^f$$

$$\bar{L} = L_1 + L_2^v + L_2^f$$

Budget Constraint: $E = \bar{P}_1 \; C_1 + P_2 \; C_2 + \bar{P}_1 \, Q_1 + P_{2H} n_{2H} q_{2H} + (t-1) \, n_{2F} D_{2F}$

Figure 1: The Structure of a Stylized, Two Sector Economy

$$(\hat{Q}_2/\hat{t})\Big|_{\hat{n}_{2H}=0} = (\hat{q}_{2H}/\hat{t}) = (-\Delta_1/D)\,\{(\eta_{HF} - \beta_{HF})\,d_H\}$$

$$(\hat{Q}_1/\hat{t})\Big|_{\hat{n}_{2H}=0} = (\Delta_2/D)\,\{(\eta_{HF} - \beta_{HF})\,d_H\} \qquad (1)$$

where $\Delta_1, \Delta_2 > 0$ are both intensity-weighted averages of the two sectoral elasticities of substitution in production, and $D < 0$ is the determinant of the matrix of coefficients premultiplying endogenous variables in the general equilibrium system. When the term in brackets {•} in positive, (C1) will find support here. That is: $(\hat{Q}_2/\hat{t}) > 0$ and $(\hat{Q}_1/\hat{t}) < 0$. The sign of this term hinges on the difference between the uncompensated cross-price elasticity of demand for a representative domestic product in sector 2, with respect to a change in the power of the tariff (η_{HF}), and the partial elasticity of the markup with respect to this tariff ($\beta_{HF} > 0$). The term $d_H > 0$ is simply the denominator in β_{HF}.[2]

The uncompensated cross-price elasticity of demand may be expressed in terms of the share of total good 2 expenditure going to imports: $\theta_{2F} = (1 - \theta_{2H})$, and the elasticity of substitution among varieties within the good 2 composite (σ). In particular:

$$\eta_{HF} = \theta_{2F}(\sigma - 1) \ .$$

Thus when $\sigma < 1$, then $\eta_{HF} < 0$ and (C1) must be contradicted (β_{HF} is always positive). However, it seems to make little sense to assume

2 All derivations are based on a marginal perturbation of the tariff away from an initially undistorted equilibrium ($t = 1$). This facilitates the algebraic treatment of income. I will operate on the presumption that perturbations from a distorted initial equilibrium will have the same qualitative properties.

that differentiated goods in sector two (e.g., automobiles) substitute less well for one another than they do for good 1 (e.g., food). (The latter substitution elasticity is unity under the Cobb Douglas assumption.) For this reason I assume that $\sigma > 1$, unless otherwise stated. I will return to this point again below, when the empirical results in Table 1 are more closely scrutinized.

Before analyzing the markup elasticity (β_{HF}) in greater detail, another striking feature of the solution given in (1) should be pointed out. If one invokes the partial equilibrium (PE) assumptions that $\hat{E} = \hat{MC}_{2H} = 0$, then the ensuing solution becomes:

$$(\hat{Q}_2/\hat{t}) \Big|^{PE}_{\hat{n}_{2H}=0} = [(\eta_{HF} - \beta_{HF})\, d_H] \; .$$

Comparing this solution with that in (1) shows that the general equilibrium solution to this problem introduces no qualitative ambiguity. This follows from the fact that the coefficient $(-\Delta_1/D)$ in equation (1) is always positive.

The term $[(\eta_{HF} - \beta_{HF})\, d_H]$ also serves to highlight the critical difference between the perfectly competitive and imperfectly competitive models. In the former case, the optimal markup is always one so that $\beta_{HF} = 0$. By introducing a non-trivial markup which varies as a function of the tariff, the following ordering is established:[3]

3 Since the determinant (D) in (1) involves parameters representing the optimal markup in sector 2 and the share of fixed costs in total costs it is not strictly correct to set $\beta_{HF} = 0$ without altering this determinant. Thus $\hat{Q}_1^{PC}$ should be interpreted as an imitation of perfect competition. That is, a local perturbation

$$
\begin{aligned}
(\hat{Q}_2^{PC}/\hat{t}) \Big|_{\hat{n}_{2H}=0} &> (\hat{Q}^{IM}/\hat{t}) \Big|_{\hat{n}_{2H}=0} \\
(\hat{Q}_1^{PC}/\hat{t}) \Big|_{\hat{n}_{2H}=0} &< (\hat{Q}_1^{IM}/\hat{t}) \Big|_{\hat{n}_{2H}=0}
\end{aligned}
\qquad (2)
$$

where the superscripts refer to perfectly competitive (PC) and imperfectly competitive (IM) treatments of sector 2. Thus it may be concluded that *in the absence of entry, the presence of imperfect competition in the nonagricultural sector reduces the expected gains in agricultural output when nonagricultural protection is reduced.* Furthermore, this difference can be directly attributed to the "procompetitive" effect of a tariff cut on the imperfectly competitive sector. I turn next to a detailed analysis of this phenomenon.

Procompetitive Effects of Tariff Reform: Table 2 presents expressions the elasticity of the optimal markup, with respect to the tariff, under a variety of assumptions about market structure and firm conduct. The first two entries correspond to the preference structure outlined in Figure 1. Case I is where individual firms calculate their optimal markup on the presumption that competitors will hold their price constant. This is the formulation employed by Brown and Stern. In contrast, it is competitors' quantity which is conjectured to remain unchanged in Case II. (This is the approach taken by Norman in a recent article on this topic.) The elasticity of a representative domestic firm's optimal markup with respect to a change in the tariff (β_{HF}) is a function of: (a) the elasticity of

---

from a distorted initial equilibrium in which the non-unitary markup is left unaltered.

Table 2: The Elasticity of the Optimal Markup with Respect to a Change in the Power of the Tariff ($\beta_{HF} = \hat{MKUP}_{2H} / \hat{t}$).

CASE	Postulated Market Structure and Conduct	Markup Elasticity	Domestic Firm's Perceived Demand Elasticity
I	Symmetric Differentiation of Domestic and Foreign Products, Bertrand conjectures	$\beta_{HF}^{B} = \frac{(1-\sigma)^2 \theta_{2H} \theta_{2F}}{n_{2H} \eta_H^B (\eta_H^B - 1)}$	$\eta_H^B = \sigma - (\sigma-1) \theta_{2H}/n_{2H}$
II	Symmetric Differentiation of Domestic and Foreign Products, Cournot Conjectures	$\beta_{HF}^{C} = \frac{(1-\sigma)^2 \theta_{2H} \theta_{2F}}{[n_{2H} + \theta_{2H} (\sigma - 1)] (\eta_H^C - 1)}$	$\eta_H^C = \sigma[1 + (\sigma-1) \theta_{2H}/n_{2H}]$
III	Armington Structure with Cournot Conjectures Among domestic Firms	$\beta_{HF}^{AC} = \frac{(1-\sigma)^2 \theta_{2H} \theta_{2F}}{(\eta_H^{AC}/n_{2H}) (\eta_H^{AC} - 1)}$	$\eta_H^{AC} =$ [illegible]$_{H}[\sigma - \theta_{2H} (\sigma-1)]$
IV	Armington Structure with Differentiated Domestic Products	$\beta_{HF}^{AB} = \frac{(1-\sigma)^2 \theta_{2H} \theta_{2F}}{n_{2H} \eta_H^{AB} (\eta_H^{AB} - 1)}$	$\eta_H^{AB} = [\theta_{2F} (\sigma - 1)/n_{2H} + \sigma_D (1-1/n_{2H}) + 1/n_{2H}]$

Notation:

- $\sigma =$ The elasticity of substitution between all products in the case of symmetric product differentiation (Cases I and II). In the Armington models (Cases III and IV), this is the elasticity of substitution between foreign and domestic goods only.
- $\sigma_D =$ The elasticity of substitution among domestic goods within the composite domestic good. (Case IV only).
- $\theta_{2j} =$ The share of total good 2 expenditure spent on home ($j = H$) and foreign ($j = F$) goods.
- $n_{2H} =$ The number of domestic firms in the industry.

Source: Hertel, 1991b.

substitution between domestic and foreign products (σ), (b) the product of the shares of home and foreign goods in total expenditure on good two ($\theta_{2H} * \theta_{2F}$), (c) the number of domestic firms (n_{2H}), and (d) the perceived demand elasticity facing a representative domestic firm ($\eta_H > 0$). (The latter term differs among cases I-IV and is thus assigned a superscript.)

It can be shown (Hertel, 1991b) that $\eta_H^C > \eta_H^B$ and $\beta_{HF}^C > \beta_{HF}^B$ so that, given identical values for σ, θ_{2H}, θ_{2F}, and n_{2H}, the Cournot model results in a larger optimal markup and also stronger procompetitive effects. Furthermore, for $\sigma > 1$ it can be shown that $\eta_{HF} > \beta_{HF} > 0$ for both Cases I and II. Finally, $\sigma < 1 \Rightarrow \eta_{HF} < 0 < \beta_{HF}$. Thus we may conclude, for the simple model outlined in Figure 1, that the only way to violate (C1) is to choose a value of $\sigma < 1$, such that foreign and domestic products in sector 2 are *gross complements*. Conversely, as long as $\sigma > 1$, it is impossible for the procompetitive effect to reverse conventional wisdom when products are symmetrically differentiated.

The Empirical Evidence Revisited: This brings us back to the findings of Devarajan and Rodrik. How could the sign of the change in cash crop agriculture be reversed by the introduction of these procompetitive forces? In order to sort this matter out, the model outlined in Figure 2 needs to be slightly modified. In particular, let σ now represent the Armington elasticity of substitution between domestic and imported goods. Furthermore, assume that domestic goods are homogeneous, but domestic producers recognize their market power and markup their prices based on Cournot conjectures. This is the specification employed by Devarajan and Rodrik.

The only difference in the no-entry solution to this model, and the solution given in (1), is the form of the denominator of β_H (i.e. d_H). However, bear in mind that the role of σ is now substantially different, since it is now an "Armington" elasticity. Can we now say anything about the possibility of violating (C1)? Since $\beta_{HF}^{AC} > 0$, then $\sigma < 1 \Rightarrow \eta_{HF} < 1$ is still a sufficient condition for $(\hat{Q}_2/\hat{t}) = -(\Delta_2/\Delta_1)\ (\hat{Q}_1/\hat{t}) < 0$, but is it also a necessary condition? This cannot be asserted, since we require $\sigma > 2$ for $(\eta_{HF} - \beta_{HF}^{AC})$ to be inambiguously positive (see Hertel 1991b).

At this point it is necessary to consider Devarajan and Rodrik's choice of values for σ (see their Table II.1, column 4). Of the six imperfectly competitive sectors, *four have values of σ which are less than one!* In the context of the simple model outlined above, it is hardly surprising that (C1) is violated. In fact, it would be surprising if this were not the case.[4]

The final case examined in Table 2 corresponds to Horridge's specification in which domestic varieties of good 2 are differentiated from one another, but they are separable from foreign

---

4 The reader may wonder why, if $\sigma < 1$, Devarajan and Rodrik's perfectly competitive model predicts an expansion of the cash crops sector under trade liberalization. The answer lies in the fact that unlike the model in figure 1, *all* sectors are treated as producing differentiated products. Furthermore the value of σ for cash crops is 0.9 which means that it too is a gross complement with imports. By contrast $\sigma = 1.5$ for food crops in their model. This means domestic and imported food are gross substitutes, which explains why that sector contracts in the perfectly competitive environment, despite the relatively low tariff (see table II.1, columns 4 and 5).

varieties.[5] This means that the optimal mix of domestic varieties is invariant to the tariff. A change in the tariff only affects domestic firms' perceived demand elasticities insofar as it alters the aggregate expenditure on imports. This separability has important implications for the markup elasticity, which is now labeled β_{HF}^{AB} to reflect the combination of Armington product differentiation and Bertrand assumptions.

Horridge's perceived demand elasticity (η_{HF}^{AB}) contains two elasticities of substitution: σ and σ_D. The former determines the price elasticity of import demand, and this tends to be small. Horridge's assumed values for σ (based on the ORANI model's parameter file) range from 0.4 to 3.0. By contrast, σ_D is chosen to calibrate to plausible optimal markups and is thus an order of magnitude larger. The specified values for σ_D fall between 5.0 and 38.0. Coupling this information with the expression for β_{HF}^{AB}, it can bee seen that the denominator will be dominated by σ_D, which does not appear in the numerator. Thus β_{HF}^{AB} will tend to be quite small, even for a relatively small number of firms. (This stands in sharp contrast to the other markup elasticities in this table. For cases I-III, both the numerator and denominator increase in proportion to σ^2.) For this reason, optimal markups in the Horridge model are expected to change very little. Indeed, this is what he finds. The absence of such procompetitive effects means that there will be little

---

5 Since Horridge holds utility rather than expenditure constant when computing the perceived demand elasticities in his model, the expression in table 2 is slightly different from his. However, the omission of an income effect from η_H^{AB} does not substantively alter the conclusions reached in the text.

difference between the perfectly competitive and imperfectly competitive outcomes in the absence of entry.

Adding Entry: What about when entry is permitted? Considerable insight into the free entry case may be obtained by simply examining how the subsequent zero profit condition now works together with the optimal markup equation. This two equation system is provided in (3) below:

$$\hat{P}_{2H} = \hat{MC}_{2H} + \hat{MKUP}_{2H}$$

$$\hat{P}_{2H} = \hat{ATC}_{2H}\Big|_{\hat{q}_{2H}=0} - \gamma_{2H}\,\hat{q}_{2H} \qquad (3)$$

The first of these equations is simply the proportionately differentiated version of the markup equation given in Figure 1. The second equation is derived by totally differentiating and rearranging the individual firm's zero profit condition. This has been done in a manner which partitions the change in average total costs into that attributable to input price effects $\left(\hat{ATC}_{2H}\Big|_{\hat{q}_{2H}=0}\right)$ and that caused by changes in the scale of production $(-\gamma_{2H}\,\hat{q}_{2H})$. Here the parameter $0 < \gamma_{2H} < 1$ is the share of a firm's fixed costs in total costs.

If factor intensities in variable and fixed costs are identical, or if factor prices are held constant, then $\hat{MC}_{2H} = \hat{ATC}_{2H}\Big|_{\hat{q}_{2H}=0}$. Consequently equations (3) imply: $\hat{q}_{2H} = -\gamma_{2H}^{-1}\,\hat{MKUP}_{2H}$. In this case changes in individual firms' length of production run, and hence the potential rationalization gains from tariff reform, are linked exclusively to changes in the optimal markup. But we have already examined in some detail (Table 2) the partial elasticities of these markups with respect to change sin the tariff. With reference to Horridge's Australian study, it is particularly relevant to note that β_{HF}^{AB} is quite small, regardless of the number of domestic firms. While Horridge does not assume identical factor intensities in fixed and variable costs, it is the case that $\hat{ATC}\Big|_{\hat{q}_{2H}=0} \equiv \hat{MC}_{2H}$ in his model. Thus, $MKUP_{2H} \equiv 0$ leads to $\hat{q}_{2H} \equiv 0$ and it is not surprising that his perfectly competitive results differ little from those based on the Armington/Bertrand structure.

In addition to the zero profits condition, the entry assumption adds another term to the expression for the proportional change in the representative domestic firm's markup. This term captures the effect which new entrants have on existing firms' perceptions of their individual demand elasticities. In general, it works in the opposite direction of the tariff effect. Indeed the partial equilibrium solution ($\hat{MC}_{2H} = \hat{E} = 0$) to the above model (Case I) shows that these effects are precisely offsetting. In particular:

$$\hat{n}_{2H}\Big|_{PE,B} = (\theta_{2F}/\theta_{2H})\,(\sigma - 1)\,\hat{t}$$

Thus $\hat{M}_{2H} = \hat{P}_{2H} = \hat{q}_2 = 0$ and the only partial equilibrium effect of the tariff is to increase the number of domestic firms in the industry. Since this will occur at the expense of sector 1, the conventional conclusion (C1) is once again supported.

Multilateral Liberalization: Up to this point all of the discussion has referred to the consequences for a small economy of unilateral, across-the-board trade liberalization. When world market conditions are substantially affected so that foreign firms alter their pricing decisions, or when more than one country is involved in the liberalization exercise, things become more complex. In this regard, return to the Brown and Stern model which is based on Case I in Table 2 [along with equation (4), since they permit free entry]. The findings above indicate that this model would likely yield no ambiguity in a unilateral experiment, since they restrict σ to be greater than one. However, the authors' results for Canadian agriculture *are* qualitatively altered when they introduce this form of imperfect competition and simulate the effects of Canada-U.S. Free Trade. From this perspective we must view (C1) as remaining vulnerable to challenge when the liberalization is not solely unilateral.

Synthesis: A detailed analysis of unilateral, across-the-board trade liberalization indicates that, for plausible parameter values (i.e. $\sigma > 1$), (C1) is robust to a variety of departures from the perfectly competitive paradigm. However, introduction of imperfectly competitive behaviour in the import competing sectors may significantly dampen the degree to which an export-oriented agricultural sector might expand as a result of across-the-board trade liberalization. The magnitude of this "procompetitive" effect depends importantly on the way in which foreign and domestic products are differentiated, and the nature of the imperfectly competitive firm's conjectures. Futhermore, when more than one country is involved in trade liberalization it *is* possible that the conventional wisdom -- based on the perfectly competitive paradigm -- may be reversed.

Agricultural Trade Liberalization: Consequences for Commodity Supplies

The second conventional conclusion which I would like to challenge in this paper may be stated as follows:

(C2) When some agricultural commodities not supported, complete elimination of agricultural subsidies will be followed by a contraction in output of the subsidized commodity and a simultaneous *expansion* in production of the unsupported commodities.

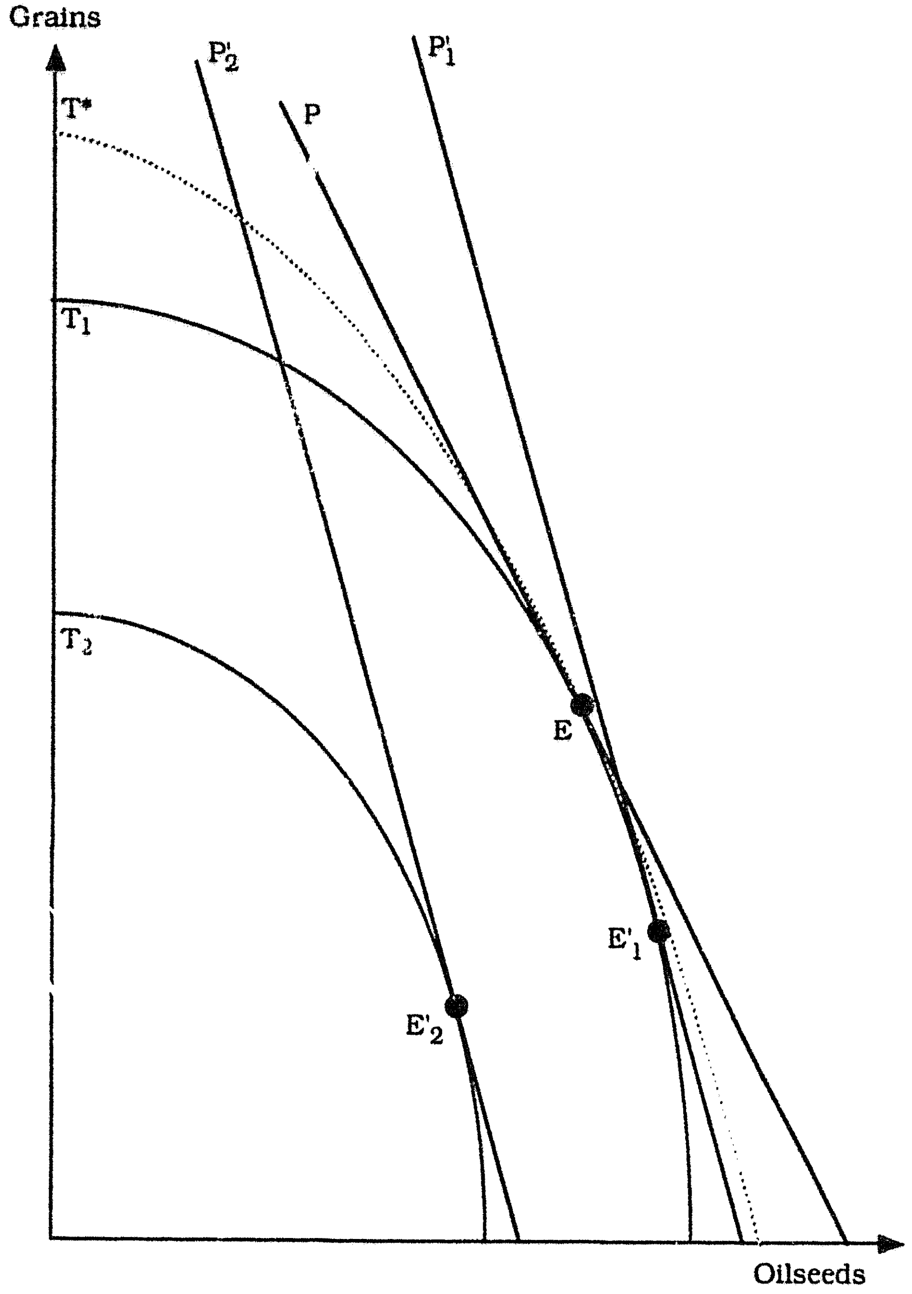
This conclusion may seem rather innocuous at first, but I believe it is a point which deserves challenging in many cases.[6]

Consider the case of grain and oilseed production in the United States. Traditionally grain production has been supported by means of deficiency payments on output, among other things.[7] In contrast, oilseed producers have received relatively little support. Thus U.S. agricultural liberalization might be presumed to lead to a reduction in grains output and an increase in oilseeds production. This is the thrust of (C2). This conclusion is also compatible with movement around a fixed transformation frontier, such as that denoted by T_1 in Figure 2. Here the supply of inputs to agriculture is fixed (i.e. we are looking at the very short run) and the reduction in

6 In fact I have done so whenever the opportunity has presented itself! The discussion in this section follows closely Hertel (1990).

7 Of course grains producers have generally been required to simultaneously idle acreage. The combined effects of these conditional payments is quite complex and likely varies with the level of voluntary participation. For the sake of a clear, concise exposition, I will abstract from this type of program complexity.

Figure 2: Implications of a Reduction in the Support Price for Grains



Source: Hertel (1990), p. 32.

grains support price shifts the producer price line from P to P_1', causing a movement along T_1 from E to E_1'.

As the time horizon lenghthens, provided the new relative price ratio persists, resources will leave the farm sector. This causes the transformation frontier to shift inward to T_2. The absolute size of this contraction effect increases as the number of potentially variable inputs increases. In the long run, it is reasonable to argue that virtually all inputs are somwhat variable in supply. As a consequence, farmers would leave the sector, the capital stock would fall, and some land would move into other uses. It is conceivable that the shift from T_1 to T_2 would be large enough to cause a reduction in both grain and oilseeds output (e.g. E_2'). This would imply a cross-price elasticity of supply which was *positive*, not negative! We will call this the case of "gross complementarity", whereby the qualifier "gross" indicates that it includes both contraction and substitution effects. Of course, these arguments are fully suymmetric and apply equally to the case where a relative price increase for grains results in an increased longrun supply of oilseeds.

While the result of gross complementarity may at first seem rather implausible, theoretical work reveals this to be the "normal case" in the long run. That is, it follows from a fairly weak set of restrictions on technology (Sakai). Recent empirical work also supports this finding. For example, in a study of Australian agricultural supply response, Lawrence and Zeitsch find that crops and livestock are gross complements, when all inputs except for operator and family labour are permitted to adjust optimally. Ball has verified this phenomenon in the case of U.S. agriculture, using a finer disaggregation of outputs.

This challenge to (C2) has important implications for the analysis of agricultural trade liberalization using many of the existing models. Most of the reduced form, partial equilibrium models of agricultural embody (C3), that is, products are assumed to be substitutes in production over the time horizon for which the simulation is presumed to apply.

In fact, those trade models based on Koyck-lag types of supply equations will even exascerbate this problem. This derives from the fact that they constrain the ratio of own- to cross-price elasticities to remain equal in the short and long runs. Thus increased own-price responsiveness in supply necessarily implies that products which are shortrun substitutes must remain substitutes in the long run. Furthermore, they must actually become **stronger substitutes** as time passes. In terms of Figure 2, this means that, rather than shrinking inward over time to T_2, the implied long run transformation frontier becomes flatter, as is portrayed by T^*. This has dramatically different implications for longrun agricultural ouput in the wake of trade liberalization.

Factor Incidence of Agricultural Trade Liberalization

The third conventional conclusion which I would like to challenge here pertains to the shortrun consequences of trade liberalization for shadowprices or "rental rates" on those factors of production which are immobile. For the sake of covenience I will aggregate all outputs into a single composite product. In this case, the consequences of agricultural trade liberalization may be summarized in the form of an exogenous shock to producer prices. If world prices rise by more than the producer subsidies forgone, the farm sector will be better off. The question of interest is how these rents will be shared among the fixed factors. If the new producer price is lower than it was prior to liberalization, we wish to know how the resulting losses will be shared. While this point has not been discussed as extensively as the previous two conclusions, I would summarize the conventional wisdom as follows:

(C3) The burden of an exogenous shock to the farm sector will be shared equally among fixed factors of production.

Before proceeding to challenge this conclusion, two assumptions are made. First of all, assume that all non-fixed factors are in perfectly elastic supply. They will bear none of the burden of such a shock, since they will move freely into alternative uses at virtually unchanged wages (and of course conversely for the case of an increase in demand). Secondly, it is assumed that remuneration to factors which cannot exit or enter agriculture is based on their marginal value product. This is surely not always the case, but it would tend to apply if these fixed factors have a variety of opportunities for employment within the farm sector. For example, while a hired farm worker cannot immediately obtain a job in manufacturing, he can often move from one farm to another.

In order to analyze (C3), it is useful to consider the simple case in which there are two fixed factors: labour (L) and nonlabour (N) fixed inputs. (There are presumably also nonlabour inputs which are variable in supply.) Formulation of a simple partial equilibrium model permits us to solve for the proportionate change in relative rental rates for these two fixed factors:[8]

$$\hat{P}_L/\hat{P}_N = \mu_{NL}/\mu_{LN} \quad . \tag{4}$$

Here μ_{LN} is the Morishima elasticity of substitution between L and N. (Since this is an assymmetric elasticity, the ordering of subscripts is of critical importance.) Blackorby and Russell provide a thorough discussion of this concept. It measures the proportionate change in the optimal labour/nonlabour input ratio following a one percent change in (P_L/P_N) *owing to a perturbation of* P_L.

The Morishima elasticity of substitution is closely related to several more familiar concepts. In particular:

$$\mu_{ji} = \eta_{ij} - \eta_{jj} = (\sigma_{ij} - \sigma_{jj})\, c_j \quad .$$

where η_{ij} is the ordinary (output constant) cross-price elasticity of demand, σ_{ij} is the Allen partial elasticity of substitution between i and j, and c_j is the cost share of input j. In the familiar case of a constant elasticity of substitution production function, it can be shown that $\mu_{ij} = \mu_{ji} = \sigma$.[9] Applying this result to equation (4) yields precisely (C3). That is, the incidence of an exogenous shock to the farm sector is borne equally by the two fixed factors of production. Of course in general $\mu_{ij} \neq \mu_{ji}$ so that the incidence will not be equal.

Tables 3A and 3B present some recent evidence on estimated Morishima elasticities of substitution for Australia and the

---

8 Readers interested in more details are referred to Hertel (1991a).
9 Blackorby and Russell argue that the Morishima elasticity of substitution is the natural multi-input generalization of Hicks' two input substitution elasticity.

Table 3A: Morishima Elasticities of Substitution in Australian Agriculture.

	Land	Operator. Labor	Capital	Livestock	Hind Labor	Services	Materials
Land	--	0.07	0.27	0.05	0.17	0.17	0.37
Operator. Labor	-0.00	--	0.01	0.02	0.04	0.02	0.04
Capital	0.29	0.26	--	0.30	0.25	0.33	0.20
Livestock	0.04	0.09	0.18	--	0.17	0.10	0.24
Hind Labor	0.22	0.25	0.18	0.12	--	0.33	0.22
Services	0.64	0.62	0.95	0.65	0.87	--	1.23
Materials	1.12	1.02	0.73	1.16	0.95	1.35	--

Source: Calculated from Table 3 of Lawrence (1990) by applying the formula: $\mu_{ji} = (\eta_{ij} - \eta_{jj})$.

Table 3B: Morishima Elasticities of Substitution in U.S. Agriculture.

	Land	Durable Equipment	Buildings	Labor	Feed	Chemicals	Other
Land	--	0.22	0.21	0.20	0.25	0.26	0.27
Durable Equipment	0.34	--	0.40	0.19	0.45	0.42	0.52
Livestock & Buildings	0.42	0.50	--	0.48	0.52	0.48	0.58
Labor	0.11	-0.07	0.23	--	0.19	0.01	0.58
Feed	0.33	0.42	0.34	0.23	--	0.33	0.12
Chemicals	0.52	0.52	0.49	0.42	0.50	--	0.60
Other	0.97	1.10	1.02	1.17	0.78	1.19	--

Source: Calculated from Table 4 of Hertel (1989) by applying the formula: $\mu_{ji} = (\sigma_{ij} - \sigma_{jj}) c_j$.

Note: Tables 3A and 3B have been extracted from Hertel (1991a).

United States. The clear asymmetry of these matrices indicates strong potential for differential factor market incidence of an exogenous shock. Inspection of the Morishima elasticities in Table 3A indicates that the elasticities in the operator labour row are particularly small, relative to other values in the table. This means that optimal input intensities in Australian agriculture are relatively insensitive to changes in the shadow price of operator labour, i.e. $\mu_{oplabour,k}$ is small, relative to other values in the table.

Because operator labour is very likely to be in fixed supply in the short- to medium run, and because Australian agriculture appears quite insensitive to movements in its shadow price, this factor price will move disproportionately with shocks to sectoral product prices. For example, when paired with land virtually all of the impact of a price shock will be reflected in $\hat{P}_{oplabour}$, since $\mu_{oplabour, land} \cong 0$.

It is instructive to contrast the above findings with those based on a set of estimated Morishima elasticities of substitution for U.S. agriculture, as reported in Table 3B[10]. Inspection of the rows in Table 3B shows that labour (this time an aggregate of both operator labour and hired labour) is once again the input with the smallest values. That is, optimal labour/nonlabour intensities in U.S. agriculture are also relatively insensitive to changes in the shadow price of labour. Furthermore, a comparison of $\mu_{labour,k}$ with $\mu_{k,labour}$ indicates that, regardless of the factor k with which it is paired, the

10 Unfortunately, the input categories are not the same. Furthermore, there are several critical differences in the way the two data sets were constructed. Thus any comparisons should be made with some caution.

return to U.S. farm labour will always exhibit a disproportionate movement in response to a product price shock.

In summary, (C3) must be strongly challenged based on the evidence from both Australian and U.S. agriculture. Furthermore, this evidence points to disproportionate movements in the short-run rental rate on farm labour, relative to other potentially fixed factors of production.

Concluding Observations

My concluding observations may be viewed as a counterpoint to the fourth, and final, conventional conclusion.

(C4) Given the small (and diminishing) share of agriculture in aggregate economic activity in the industrialized market economies we can afford to continue indefinitely with the current configuration of farm and food policies.

While many agricultural economists would disagree with this statement, I would argue that this has been the conventional belief held by the majority of consumer and producer groups in these economies. Indirect evidence of this abounds. Until the recent interest on the part of environmental groups, the U.S. farm bill was largely written by farm groups, with little direct concern on the part of others. Similarly, the debate over agricultural reform under the Uruguay Round has focussed almost exclusively the potential distribution of gains and losses among agricultural producers.

There have been some attempts to attract greater interest, on the part of nonagricultural interest groups, in the costs of current agricultural policies (Stoeckel *et al.*; OECD). These studies have basically disaggregated the components of the changes in producer surplus following trade reform. While this has helped call attention to the widespread costs of farm policies, it has not captured the full costs of the currently distorted system of agricultural trade. I believe that the collapse of the current GATT Round under the weight of disputes over agricultural reform offers concrete evidence of the far greater, indirect costs of farm policies.

This recent disagreement is only one of a long line of agricultural trade disputes between the U.S. and the E.C. Because of the special place of farmers in the perceived social fabric of industrialized economies, as well as the unique role of food in national security, human life and health, farm and food policy is a particularly volatile topic. Thus the intensity of these disagreements is vastly out of proportion to the overall role of agriculture in international trade, and, as we have seen, it has the potential to derail many other potential reforms. Consequently, a full assessment of the social costs of the current configuration of agricultural policies should extend beyond the sum of producer, consumer, and taxpayer surpluses derived from their removal. It should also include the cost of forgone agreements in other areas, due to the failure to reach a consensus in the GATT's Negotiating Group on Agriculture.

In summary, I believe that international agricultural trade will only be liberalized if nonagricultural interest groups become involved in the process. To convince them of the importance of such reforms, economists need to go further in quantifying the forgone nonagricultural benefits if agricultural trade tensions persist. When viewed in this light, the industrialized market economies, indeed the global trading system, can hardly afford the current configuration of farm and food policies. Of course the flip-side of this coin involves measuring the potential gains from trading-off liberalization of agricultural and nonagricultural policies. This should be high on our agenda for future research.

REFERENCES

Ball, V.E. (1988). "Modeling Supply Response in a Multiproduct Framework", *American Journal of Agricultural Economics*, 70(4).

Blackorby, C. and R.R. Russell (1989). "Will the Real Elasticity of Substitution Please Stand Up? (A Comparison of the Allen/Uzawa and Marishima Elasticities)", *American Economic Review*, 79(4): 882-888.

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

Devarajan, S. and D. Rodrik (1989). "Pro-Competitive Effects of Trade Reform: Results from a CGE Mode of Cameroon", *NBER Working Paper* No. 3176, Cambridge Massachusetts.

Higgs, P. (1989). "The Taxation of Austrlaian Agriculture Through Assistance to Australian Manufacturing". Chap. 10 in A.B. Stoeckel, D. Vincent and S. Cuthbertson (eds.), *Macroeconomic Consequences of Farm Support Policies*, Durham: Duke University Press.

Goldin, I and O.Knudsen (eds.) (1990). *Agricultural Trade Liberalization: Implications for Developing Countries*, Paris: OECD.

Hertel, T.W. (1989). "Negotiating Reductions in Agricultural Support: Implications of Technology and Factor Mobility", *Americal Journal of Agricultural Economics*, 71(3): 559-573.

Hertel, T.W. (1990). "Agricultural Trade Liberatlization and the Developing Countries: A Survey of the Models", Chp. 1 in I. Goldin and O. Knudsen (eds.) *Agricultural Trade Liberalization: Implications for Developing Countries*, Paris: OECD.

Hertel, T.W. (1991a). "Factor Market Incidence of Agricultural Trade Liberalization: Some Additional Results", *IMPACT Project Working Paper* (forthcoming).

Hertel, T.W. (1991b). "Why Alternative Approaches to Modeling Imperfect Competition are Critical for the Predicted Consequences of Trade Policy", *IMPACT Project Preliminary Working Paper* (forthcoming).

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

Lawrence, D. and J. Zeitsch (1989). "Estimating Generalised McFadden profit and Aggregator Functions for Australian Agriculture", ESB-52, Industries Commission Canberra.

Lawrence, D. (1990). "A Generalised McFadden Cost Function for Australian Agriculture". Contributed paper to the 34th Annual Conference of the Australian Agricultural Economics Society, Brisbane, 12-15 February.

Norman, V.D. (1990). "Assessing Trade and Welfare Effects of Trade Liberalization: A Comparison of Alternative Approaches to CGE Modeling with Imperfect Competiton", *European Economic Review*, 34: 725-751.

OECD (1990). *Modeling the Effects of Agricultural Policies*, Economic Studies Special Issue, Winter 1989-90, Paris.

Sakai, Y. (1974). "Substitution and Expansion Effects in Production Theory: The Case of Joint Production", *Journal of Economic Theory*, 9: 255-274.

Stoeckel, A.B., D. Vincent, and S. Cuthbertson (eds.) (1989). *Macroeconomic Consequences of Farm Support Policies*, Durham: Duke University Press.