Partial vs. General Equilibrium Analysis of Trade Policy Reform

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Abstract. *A standard, multiregion general equilibrium (GE) model is developed and contrasted with typical partial equilibrium (PE) models of agricultural trade for two trade policy reform experiments In the case of reforms affecting both food and nonfood sectors, the PE model has difficulty predicting changes in patterns of food production and trade When the shock is sector-specific, however, PE models perform very well In this case, the major benefit of GE analysis is its ability to draw the link between agricultural and nonagricultural interests in trade policy*

Keywords. *General equilibrium, trade policy*

Over the past decade, there has been a tremendous demand for quantitative analysis of agricultural trade The Uruguay Round of the GATT negotiations has focused international attention on the consequences of domestic farm policies for world trade in farm and food products Demand for agricultural analysis has largely been met with partial equilibrium models of agricultural trade (Tyers and Anderson, 1986, Roningen and Dixit, 1989, OECD, 1987) [1] However, multiregion general equilibrium models, with varying degrees of agricultural detail, have also entered the debate (Burniaux and others, 1988, Burniaux and van der Mensbrugghe, 1990, Harrison and others, 1989, Horridge and Pearce, 1988, McDonald, 1989 McDougall and others, 1991, Nguyen and others, 1991) In this paper, I will develop a fairly standard multiregion, general equilibrium model of agricultural trade, illustrating how it differs from a "typical" partial equilibrium model in its predictions of the consequences of trade policy reform

The 1992 stalemate in the GATT negotiations over an acceptable package of agricultural reforms motivated the two policy experiments in this article The controversial reform of the European Community's Common Agricultural Policy (CAP) occasions the first experiment, which liberalizes all *non-CAP* farm and food policies as well as nonfood trade interventions A comparison of partial and general equilibrium predictions of the subsequent change in the global pattern of food sales shows sizable discrepancies between the two This serves to highlight the difficulty of using a partial equilibrium model to analyze the consequences of a multisectoral shock

The starting point for the second experiment is the new equilibrium following reform of non-CAP policies At this point, the only trade distortions remaining in the model are those due to EC food policies The second policy experiment, which involves reform of the CAP, is a sector-specific shock, so partial equilibrium analysis provides a good approximation to the general equilibrium changes in the global food system Indeed, since it is a single-region shock, a one-region partial equilibrium model provides a fairly accurate assessment of changes in the EC food sector However, by including other regions and sectors in the analysis, one can derive important policy information essential for illustrating the benefits of international reform of farm and food policies

Structure of the Global Data Base

The global data base used in this study is built upon data developed by the Australian Industry Commission in support of the SALTER model of world trade (Jomini and others, 1991, Dee and others, 1992) [2] The basic structure of this data base is displayed in figure 1 At the top is a variable representing the Value of Output for tradeable commodity i, located in region r, evaluated at Agents' (producers') prices VOA(i,r) (For a data set with 3 industries and 9 regions, there would be 27 components in this matrix) The SALTER data base tracks the distribution of output in each industry/region across all other

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[1] One of the more comprehensive collections of work in this area may be found in the volume edited by Goldin and Knudsen Sources are listed in the References section at the end of this article

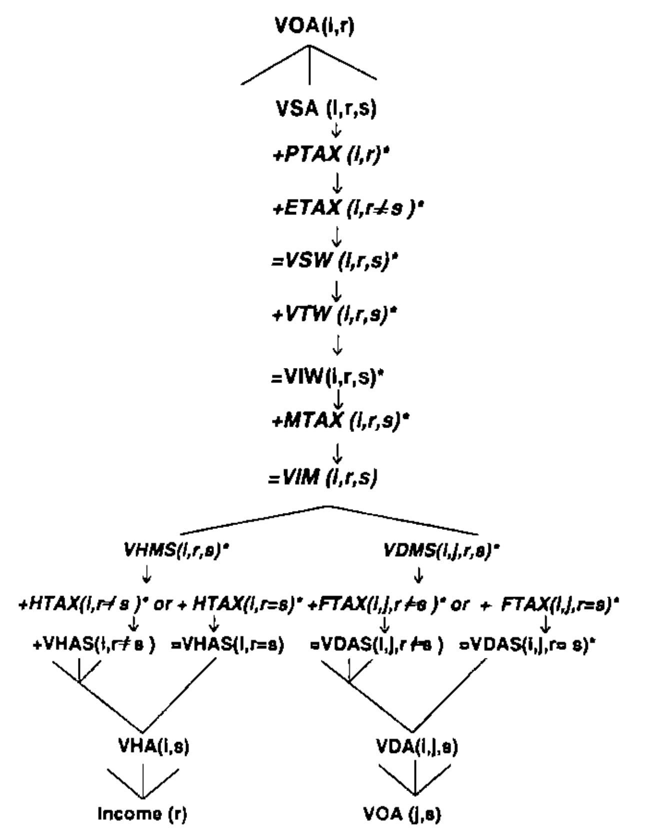
[2] Specifically, the SALTER I data base was used Due to limitations of this early release, a number of modifications were required to ensure proper closure of the model These are discussed in Hertel, Gehlhar, and McDougall (1992) The associated data base program is implemented using GEMPACK (Codsi and Pearson, 1988) This program is available from the author upon request Dept of Ag Econ , Purdue University, West Lafayette IN 47907 Telephone (317) 494-4199

regions VSA(i,r,s) (fig 1) represents the Value of Sales of commodity i from region r to region s at Agents' prices These bilateral trade flows are crucial for analyses of regional trading arrangements or product differentiation and imperfect competition Bilateral flows also introduce market share as a key determinant of interregional gains from policy reform in foreign markets

To move from producer prices to world market prices, VSA(i,r,s) must be adjusted for any producer taxes/subsidies [PTAX(i,r)] and export taxes [ETAX(i,r,s)] The SALTER data base permits export taxes to vary by destination For example, a country may engage in targeted export subsidies, or the export tax rate may vary due to *compositional* differences in exports of products within category i, which are themselves taxed at equal but varying rates Finally, export taxes/subsidies do not apply to domestic sales, so that ETAX(i,r,r) = 0

The addition of production and export taxes yields the Value of Sales i from r to s, evaluated at World prices For exports ($r \neq s$), these sales are equal to observed trade flows on an f o b basis By adding bilateral transport and insurance costs, VTW(i,r,s), one arrives at the Value of *Imports* at World prices, VIW(i,r,s) Once bilateral tariff rates are accounted for, one obtains the value of imports at domestic market prices (Duty rates vary across sources for the same three reasons export taxes vary by route)

Figure 1
Key concepts in the global data*



*Basic data are provided in italics All other variables are inferred from these data

A special feature of the SALTER data base is that it tracks imports to particular uses [3] This gives rise to the Value of Household purchases at Market prices by Source VHMS(i,r,s) Similarly, the Value of Derived demands at Market prices by Source is denoted VDMS(i,j,r,s) Household and firm taxes on traded goods also vary by source Once these are accounted for, one obtains purchases at agents' prices by source VHAS(i,s,r) and VDAS(i,j,r,s) When summed over sources, they yield total purchases of i VHA(i,r) and VDA(i,j,r)

In addition to the information in figure 1, the SALTER data base includes purchases of endowment commodities (land, labor, and capital) by sector, as well as regional savings and investment levels Furthermore, SALTER distinguishes between private and public household demands However, in this article, I aggregate all final demand into a single composite While the resulting model is inappropriate for the analysis of alternative fiscal policies, the emphasis here is on the interregional incidence of trade policy reforms Aggregating public and private demands obtains an unambiguous measure of regional welfare Also, the resulting model is considerably simplified For many other purposes, disaggregation of regional households is essential, and this can be accomplished in a manner similar to that shown below for firms

Model Structure

It is "accounting" (as opposed to behavioral) equations in an applied general equilibrium (AGE) model that make it general equilibrium in nature [4] For this reason, these equations provide the logical starting point in this exposition, and their conditions formally characterize the difference between partial and general equilibrium analyses

Accounting Relationships

The data base overview (fig 1) reflects many of the accounting relationships embodied in the global

[3]*Sourcing* of imports is assumed to be the same for all purchasers of a given commodity

[4]The term "accounting" refers to equations that must hold if the social accounting matrix underpinning the model is to balance For a more extensive discussion of the link between social accounting matrices and AGE models see Hanson and Robinson (1991) and Reinert and Roland-Holst (1992)

AGE model Consider first the market-clearing conditions for tradeable commodities (TC)

$$QO(i,s) = \sum_{s\varepsilon R} QS(i,r,s), \quad \forall i\varepsilon TC, \ r\varepsilon R \tag{1}$$

This states that the total output of i in region r must be accounted for by regional sales Multiplying both sides by producer prices, we obtain

$$VOA(i,r) = \sum_{s\varepsilon R} VSA(i,r,s) \quad \forall i\varepsilon TC, \ r\varepsilon R \tag{2}$$

This highlights a fundamental point about accounting equations in an AGE model They can always be expressed in terms of value flows, evaluated at appropriate prices

Once commodity i from region r has reached market s, it must be distributed across uses, including intermediate demands in sectoral production (PC) and final demand Here another market-clearing condition is required, namely

$$VIM(i,r,s) = \sum_{j\varepsilon PC} VDMS(i,j,r,s) + VHMS(i,r,s), \quad \forall i\varepsilon TC, \ r,s\varepsilon R \tag{3}$$

Market-clearing conditions for nontradeable endowment commodities (EC) are also evaluated at domestic market prices The value of the total availability of endowment i in region r is denoted VOM(i,r), whereas the value of demands for i in the production of j is given by VDM(i,j,r), so the market-clearing condition becomes

$$VOM(i,r) = \sum_{j\varepsilon PC} VDM(i,j,r), \quad \forall i\varepsilon EC, \ r\varepsilon R \tag{4}$$

The next important accounting relationships in the AGE model are the zero-profit conditions, most naturally expressed in value terms at agents' prices Here, the value of output must be exhausted by purchases of all inputs

$$VOA(j,r) = \sum_{i} VDA(i,j,r), \quad \forall j\varepsilon PC, \ r\varepsilon R \tag{5}$$

Equation 5 applies to all produced commodities (includes investment goods) in all regions [5]

The next accounting relationship in the model provides for the computation of regional income This is the most complicated expression in the entire model since it must take account of changes in tax/subsidy expenditures in all distorted markets This may be expressed as follows

$$\begin{aligned} Y(r) = & \sum_{i\varepsilon EC} VOA(i,r) \\ & + \sum_{i\varepsilon EC} VOM(i,r) - VOA(i,r) \\ & + \sum_{i\varepsilon TC} \sum_{j\varepsilon PC} \sum_{k\varepsilon R} (VDAS(i,j,k,r) - VDMS(i,j,k,r)) \\ & + \sum_{i\varepsilon TC} \sum_{k\varepsilon R} (VHAS(i,k,r) - VHMS(i,k,r)) \\ & + \sum_{i\varepsilon TC} \sum_{k\varepsilon R} (VIM(i,k,r,) - VIW(i,k\ r)) \\ & + \sum_{i\varepsilon TC} \sum_{k\varepsilon R} VSW(i,r,i) - VSA(i,r,k)) \end{aligned} \tag{6}$$

The first right-hand-side (RHS) component of equation 6 captures factor payments, that is, endowment income, at household agents' prices, in each region Note that all such income earned within a region accrues to households in that same region Cross-ownership of factors could be introduced if data were available

The second RHS term captures the revenue collected through income taxes in r This may be rewritten in terms of an explicit *ad valorem* tax rate, $\tau(i,r)$, by noting that the household's supply price of endowment i is given by

$$PS(i,r) = (1 - \tau(i,r))PM(i,r) = TS(i,i)PM(i,r),$$

so that

$$\begin{aligned} VOM(i,r) - VOA(i,r) &= [(1 - TS(i,r))]PM(i,r)QS(i,r) \\ &= \tau(i,r)PM(i,r)QS(i,r) \end{aligned} \tag{7}$$

Thus, the fiscal implications of all tax/subsidy programs may be captured by comparison of the value of a given transaction at agents' vs market (or market vs world) prices In this manner, equation 6 also captures the revenue from commodity taxes paid by firms and households, import duties, and export/production taxes

Note that any of the value discrepancies in a given region may arise due to quantitative restrictions instead of taxes For example, in the case of a quota on imports of i into s from r

$$VIM(i,r,s) - VIW(i,r,s) = (TT(i,r,s) - 1) \, PIW(i,r,s)QIW(i,r,s) > 0, \tag{8}$$

which represents the associated quota rents In this instance, QIW(i,r,s) is exogenous and TT(i,r,s) is endogenous Again, these quota rents are

[5] This condition also applies to the provision of international transport services

assumed to accrue to the region administering the quota

Because most economies are heavily distorted, a global consistency check is important to ensure that all rents and tax and subsidy payments have been captured Equations 2-6, coupled with the exhaustion of income on final demand, imply that one of the accounting equations is redundant This is Walras's Law It is simply an implication of tracking flows through the economy in an exhaustive manner The centrality of Walras's Law in AGE analysis is just another manifestation of the importance of social accounting in this line of work

The equation omitted in this article's model is the market-clearing condition forcing global savings to equal global investment Households are assumed to purchase a homogeneous savings commodity The price of this commodity also serves as the numeraire in this model Equilibrium in other markets implies equality of global savings and investment, which provides an important check on the model's consistency Errors in logic and/or implementation invariably show up here when such a model is first implemented empirically Such a consistency check is not available in partial equilibrium models

A general equilibrium framework should not preclude selective partial equilibrium (PE) analyses Indeed, many problems are best addressed in a PE framework However, a general equilibrium framework subsequently specialized to a PE model forces precision in PE assumptions This discipline can result in stronger partial equilibrium analyses, because the researcher is absolutely clear about what is left out

Consider how equations 2-6 would be altered to obtain a "typical" partial equilibrium model of agricultural trade Equation 2 the market-clearing conditions for tradeable commodities, determines equilibrium world prices for food and nonfood commodities alike If a partial equilibrium model is to exogenize nonfood prices, then the nonfood market-clearing conditions must be dropped Partial equilibrium models also treat income as an exogenous variable Upon fixing Y, we must eliminate equation 6

Equation 5 poses a puzzle for the PE specialization These zero-profit conditions serve to determine sectoral output in general equilibrium Having fixed nonfood prices, it hardly makes sense to constrain nonfood sectors to operate at zero profits Thus, in specializing equations 2-6 to a multiregion, partial equilibrium model, I omit equation 5 for the nonfood sectors and explicitly fix nonfood output levels at their initial values The derived demand for farm products in nonfood uses will now show no expansion effect in the nonfood sectors' intermediate demands for food (We cannot eliminate these nonfood uses of farm products altogether without destroying the commodity balance as described by equations 2 and 3)[6]

Finally, turn to the market-clearing conditions for the endowment commodities (equation 4) These primary-factor, market-clearing conditions link individual sectors, thereby constraining their general equilibrium supply response However, in partial equilibrium, I assume that the opportunity cost of labor and capital in agriculture is exogenous over the medium term Implementation of this assumption leads to the elimination of equations in equation 3 that are associated with market clearing for the regional endowments of labor and capital services However, without some sector-specific rigidities, partial equilibrium supply response would be infinitely elastic (assuming constant returns to scale at the industry level) Thus, farmland is treated as a sector-specific agricultural input, thereby "tying down" longrun supply response

These partial equilibrium assumptions may be summarized as follows nonfood output levels and prices are exogenous, income is exogenous, and nonland primary factor rental rates are exogenous They will be invoked to illustrate the difference between partial and general equilibrium analyses of trade liberalization

While the accounting relationships (equations 2-6) are most conveniently expressed in value terms, it is attractive to write the behavioral component of the model in terms of percentage changes in prices and quantities Indeed, it is these percentage changes that we are usually most interested in Expressing this nonlinear model in percentage changes does not preclude a solution to the true nonlinear problem Solution of nonlinear AGE models via a linearized representation (Pearson,

[6]This would seem to be an important distinction between the partial equilibrium model developed here and the traditional PE models of agricultural trade In the latter case nonfood intermediate demands are often lumped together with final demand This can be an important distinction if either the price responsiveness of these two demands is quite different or policies influencing the two sources of demand are different

1991)[7] involves successively updating the value-based coefficients via the formula $dV/V = d(PQ)/PQ = p + q$, where the lower case p and q denote percentage changes in price and quantity

Linearization of accounting equations (2-6) involves totally differentiating them so they appear as appropriately weighted price and quantity changes For example, the tradeable market-clearing condition becomes

$$QO(i,r)qo(i,r) = \sum_{s \varepsilon R} QS(i,r,s)qs(i,r,s), \qquad (9)$$

where the lowercase variables are again percentage changes Multiplying both sides by the common price, PS(i,r), yields equation T1 (table 1) Here, the coefficients are now in value terms It is never necessary to actually compute price and quantity levels (P and Q) under this approach

The next two equations in table 1 are also market-clearing conditions and have a similar structure However, the common price is now a domestic market price, and so the value weights are evaluated at market prices, rather than agents' prices

Equation T4 is the zero-profit condition Since firms are assumed to maximize profits, the quantity changes drop out when equation 5 is totally differentiated in the neighborhood of an optimum This leaves an equation relating input prices to output prices, where these percentage changes are weighted by values at agents' prices

The final equation, T5, in table 1 is quite lengthy in linearized from However, it is also rather instructive Its interpretation is aided by considering the following equations, which link commodity prices in the model

$$ps(i,r) = pme(i,r) + to(i,r), \qquad \forall i \varepsilon EC, r \varepsilon R \qquad (10)$$

$$pde(i,j,r) = pme(i,r) + td(i,j,r), \qquad \forall i \varepsilon EC, r \varepsilon R \qquad (11)$$

$$pds(i,j,r,s) = pms(i,j,r,s) + tds(i,j,r,s), \qquad \forall i \varepsilon TC, j \varepsilon PC, r,s \varepsilon R \qquad (12)$$

$$phs(i,r,s) = pms(i,r,s) + ths(i,r,s), \qquad \forall i \varepsilon TC, r,s \varepsilon R \qquad (13)$$

$$pms(i,r,s) = pcif(i,r,s) + tm(i,r,s) + [1 - \delta(r,s)]tv(i,s), \qquad \forall i \varepsilon TC, r,s \varepsilon R \qquad (14)$$

[7] This type of nonlinear solution procedure is now the default option in GEMPACK For a complete comparison of the linearized and levels approaches to AGE modeling, the reader is referred to Hertel, Horridge, and Pearson (1992)

$$ps(i,r) = pfob(i,r,s) + ts(i,r,s) + [1 - \delta(r,s)]tx(i,r), \qquad \forall i \varepsilon TC, r,s \varepsilon R \qquad (15)$$

The second (and third) terms on the right-hand-side of equations 10-15 represent percentage changes in the level of policy interventions in various markets, expressed as one plus the *ad valorem* equivalent of the distortion in question In other words, $to(i,r) = dTO(i,r)/TO(i,r)$, where $TO(i,r) = PS(i,r)/PME(i,r)$ When these distortions are treated as *exogenous*, unless they are shocked, price linkage is complete

The interventions in equations 10-15 are as follows to(i,r) denotes income taxes, td(i,j,r) refers to primary factor taxes on firms, tds(i,j,r,s) and ths(i,r,s) are commodity taxes, tm(i,r,s) and tv(i,s) are import duties where the latter is source-generic, and ts(i,r,s) and tx(i,r) are the destination-specific and destination-generic sales (export) taxes [$\delta(r,s)$ is the Kronecker delta] There is one "price linkage" omitted from equations 10-14, namely the f o b-c i f link This gap depends on the price of transport services, as follows

$$VIW(i,r,s)pcif(i,r,s) = VSW(i,r,s)pfob(i,r,s) + VTW(i,r,s)pt \qquad (16)$$

The rate of change in *pt* is determined by the cost of transport services exports from each region

Having established the linkage between prices in this model, consider the effect of omitting some component of equation T5, say, income taxes How will this affect our welfare analysis of trade policy reform? Given the presence of income taxes in the initial equilibrium data base, VOM(i,r) > VOA(i,r), if the experiment in question does not alter the *rate* of income taxation, then $to(i,r) = 0$ and $\alpha = ps(i,r) = pme(i,r)$ $\forall i \varepsilon EC$ This means the two terms in square brackets [•] (equation T5, second RHS term) change at the same rate If this change is positive, then omission of this term will lead to an understatement of income tax revenues and a subsequent understatement of disposable income and household welfare in the new equilibrium In sum, even when distortions are not affected by a given policy experiment, it is important to acknowledge this presence in the economy if an accurate welfare analysis is to be provided

Behavioral Equations

Firms are assumed to maximize profits subject to a separable, constant returns-to-scale technology This pattern of separability is dictated by the limited availability of common parameters across diverse regions of the world In particular, value-

Table 1—Accounting equations expressed in linearized form

(T1) $VOA(i,r)qo(i,r) = \sum_{s\epsilon R} VSA(i,r,s)qs(i,r,s)$	$\forall i\epsilon TC\ r\epsilon R$
(T2) $VIM(i,r,s)qs(i,r,s) = \sum_{j} VDMS(i,j,r,s)qds(i,j,r,s)$	$\forall i\epsilon TC,\ r,s\epsilon R$
(T3) $VOM(i,r)qo(i,r) = \sum_{j} VDM(i,j,r)qde(i,j,r)$	$\forall i\epsilon EC,\ r\epsilon R$
(T4) $VOA(j,r)ps(j,r) = \sum_{i\epsilon EC} VDA(i,j,r)pde(i,j,r) + \sum_{i\epsilon TC} VDA(i,j,r)pd(i,j,r)$	$j\epsilon PC,\ r\epsilon R$
(T5) $Y(r)y(r)$	$\forall r\epsilon R$

$$= \sum_{i\epsilon EC} VOA(i,r)[ps(i,r) + qo(i,r)]$$

$$+ \sum_{i\epsilon EC} (VOM(i,r)[pme(i,r) + qo(i,r)] - VOA(i,r)[ps(i,r) + qo(i,r)])$$

$$+ \sum_{i\epsilon EC} \sum_{j\epsilon PC} (VDA(i,j,r)[pde(i,j,r) + qde(i,j,r)] - VDM(i,j,r)[pme(i,j,r) + qde(i,j,r)])$$

$$+ \sum_{j\epsilon PC} \sum_{i\epsilon TC} \sum_{s\epsilon R} (VDAS(i,j,s,r)[pds(i,j,s,r) + qds(i,j,s,r)])$$

$$+ \sum_{i\epsilon TC} \sum_{s\epsilon R} (VHAS(i,s,r)[phs(i,s,r) + qhs(i,s,r)] - VHMS(i,s,r)[pms(i,s,r) + qhs(i,s,r)])$$

$$+ \sum_{i\epsilon TC} \sum_{s\epsilon R} (VSW(i,r,s)[pfob(i,r,s) + qs(i,r,s)] - VSA(i,r,s)[ps(i,r) + qs(i,r,s)])$$

$$+ \sum_{i\epsilon TC} \sum_{s\epsilon R} (VIM(i,s,r)[pms(i,s,r) + qs(i,s,r)] - VIW(i,s,r)[pcif(i,s,r) + qs(i,s,r)])$$

added is assumed separable from intermediate input demands Furthermore, within the intermediate input structure, firms are assumed to first decide on the optimal sourcing of imports, thereafter substituting composite imports for domestic production This is the so-called Armington approach Finally, composite intermediate inputs and value-added are combined in fixed proportions

This technology is reflected in the equations provided in table 2 The first equation, T6, describes changes in the demand for endowment commodities (qde) due to substitution and expansion effects Linear homogeneity in value-added implies that qde increases at the same rate as value-added (qva) if relative prices are unchanged Changes in the *composition* of value-added are governed by the elasticity of substitution (σ_{VA}), applied to the changes in the price of individual components relative to their composite The latter is obtained via equation T7

Equation T8 describes the demand for intermediate inputs, by source, with $\delta(r,r) = 1$ and $\delta(r,s) = 0$ when $r \neq s$ This permits distinction between domestic sourcing and foreign sourcing The former depends only on the relative price of domestic goods vs composite imports [pdm(i,j,s) – pds(i,j,s,s)], weighted by the share of imports (θ_m) and the appropriate substitution elasticity Import sourcing is conditional on the overall level of imports (qdm) as well as relative prices of imports from different sources The elasticity of substitution among imports, σ_m, governs the responsiveness of import composition Like the demand for domestic intermediate goods, qdm depends on total intermediate demand (qd) and substitution between domestic and import goods

Equations T10 and T11 create composite price indices for imports and the composite intermediate good Finally, equation T12 reflects the assumption of fixed coefficients in the derived demand for intermediate goods and value-added The overall activity level in each sector is determined by the zero-profit condition given in equation T4

The linearized representation of producer behavior (table 2) facilitates intuition regarding the effects of a trade policy shock Consider, for example, a

Table 2—Producer behavior in the model

(T6) $qde(i,j,r) = \sigma_{VA}(j)[pva(j,r) - pde(i,j,r)] + qva(j,r)$	$\forall j \varepsilon PC,\ r \varepsilon R$
(T7) $[\sum_{i \varepsilon EC} VDA(i,j,r)]pva(j,r) = \sum_{i \varepsilon EC} VDA(i,j,r)pde(i,j,r)$	$\forall j \varepsilon PC,\ r \varepsilon R$
(T8) $qds(i,j,r,s) = \delta(r,s)\{qd(i,j,s) + \theta_m(i,j,s)\,\sigma_D(i)\,[pdm(i,j,s) - pds(i,j,s,s)]\} + [1 - \delta(r,s)]\{qdm(i,j,s) + \sigma_m(i)\,[pdm(i,j,s) - pds(i,j,r,s)]\}$	
(T9) $qdm(i,j,s) = qd(i,j,s) + [1 - \theta_m(i,j,s)]\,\sigma_D(i)[pds(i,j,s,s) - pdm(i,j,s)]$	$\forall i \varepsilon TC,\ j \varepsilon PC,\ s \varepsilon R$
(T10) $pdm(i,j,s) = \sum_{r \neq s} \theta(i,j,r,s)\, pds(i,j,r,s)$	$\forall i \varepsilon TC,\ j \varepsilon PC,\ s \varepsilon R$
(T11) $pd(i,j,r) = \theta_m(i,j,r)pdm(i,j,r) + [(1 - \theta_m(i,j,r)]pds(i,j,r,r)$	$\forall i \varepsilon TC,\ j \varepsilon PC,\ s \varepsilon R$
(T12) $qva(j,r) = qd(i,j,r) = qo(j,r)$	$\forall i \varepsilon TC,\ j \varepsilon PC,\ r \varepsilon R$

Definitions
$\theta(i,j,r,s) \equiv VDAS(i,j,r,s)/\sum_{r \neq s} VDAS(i,j,r,s)$, and $\theta_m(i,j,s) \equiv \sum_{r \neq s} VDAS(i,j,r,s)/VDA(i,j,s)$

reduction of the bilateral tariff on imports of i from r into s ($tm(i,r,s) < 0$) This lowers pms(i,r,s), and hence pds(i,j,r,s), via price linkage equations 14 and 12 Firms immediately substitute away from competing imports according to (T8) Also, the composite price of imports falls via (T10), thereby increasing the aggregate demand for imports through (T9) Cheaper imports lower the composite price of intermediates through (T11), which causes excess profits at current prices, via (T4) Provided the zero-profit condition is included in the model, this induces output to expand, which in turn generates an expansion effect via (T12) Of course, in a partial equilibrium model whereby nonfood sectors' activity levels are exogenous, the latter effect will only be present in the case of the food sectors

The expansion effect induces increased demands for primary factors of production via (T6) In the partial equilibrium closure, labor and capital are assumed to be forthcoming in perfectly elastic supply from the nonfood sectors, so pde(i,j,r) is unchanged for i = labor, capital However, in the general equilibrium model, this expansion generates an excess demand via the endowment market-clearing condition (T3), thereby bidding up the prices of these factors, and transmitting the shock to other sectors in the liberalizing region

Now turn to region r, which produces the goods for which tt(i,r,s) is reduced Equation T2 may be used to determine the implications for total sales of i from r to s, given the responses of individual production sectors ($j \varepsilon PC$) and the aggregate household to the tariff shock Equation T1 dictates the subsequent implications for total output qo(i,r) (That is, this market-clearing condition must have been eliminated, and ps(i,r) fixed, under the PE closure) At this point, the equations in table 2 again come into play, with (T12) transmitting the expansion effect back to intermediate demands and to region r's factor markets

Households are treated as utility-maximizing entities, resulting in the following set of behavioral equations, expressed in linearized form

$$qh(i,r) = \sum_{k \varepsilon HC} \eta_P(i,k,r)ph(i,k) + \eta_I(i,r)y(r) \quad \forall i \varepsilon HC,\ r \varepsilon R \qquad (17)$$

Here, $\eta_P(\,)$ is an uncompensated cross-price elasticity of demand, and $\eta_I(\,)$ is an income elasticity of demand These elasticities are functions of consumers' underlying preference parameters as well as the value flows, VHA(i,r) The precise nature of this relationship depends on the form of utility function assumed

In this article, commodities have been aggregated so that consumers purchase three consumption goods and savings Given the highly aggregate nature of this example, I have chosen to use a Cobb Douglas utility function In this special case, $\eta_P(i,i,r) = -1$, $\eta_P(i,j,r) = 0$, and $\eta_I(i,r) = 1$ However, in more general cases, η_P and η_I will vary with the value flows (that is, with changing prices and quantities)

Aggregate welfare in each region is measured in terms of utility Given the Cobb Douglas assumption, changes in utility are derived as follows

$$u(r) = \sum_{i \in HC} [VHA(i,r)/Y(r)]qh(i,r) \quad (18)$$

These utility changes may be converted to equivalent variations based on information about income levels in initial equilibrium

The sourcing of consumer demands, qhs(i,r,s), in this model follows precisely the same approach as for firms Thus, equations T8-T11 are repeated for the three traded commodities As noted above, savings is a homogeneous product, supplied by the global banking sector

A global banking sector is established to intermediate between global savings and investment This activity assembles a fixed portfolio of regional investment goods [qo(capital goods,r)] and sells shares in this homogeneous savings commodity to households in all regions [qh(savings, r)] As noted above, equality of global supply and demand for savings is implied by Walras's Law, and offers a consistency check on the entire model

The other global activity required in this model is international transport services These services are provided via a Cobb Douglas production function that utilizes transport services exports from each region A zero-profit condition, analogous to equation 5, guarantees that the full cost of international transportation services is reflected in the price changes, pt, which determine international transport margins via equation 16

Results of Two Experiments

Experiment 1 Multilateral, Multicommodity Liberalization of Non-CAP Trade Policies The first experiment with this highly aggregated model involves removal of all non-CAP farm and food policy distortions, as well as tariffs and all export taxes on mining and manufacturing products [8] Because the CAP is left in place, it insulates the EC's food sector Specifically, a variable import levy maintains a constant relative price for domestic and imported food, while a variable export subsidy fixes the level of aggregate food output

Table 3 reports the difference between partial and general equilibrium model predictions of the subsequent change in food products trade [9] (Diagonal elements refer to domestic sales) As discussed above, the partial equilibrium model is obtained as a special case of the full general equilibrium model by fixing (a) the rental rates for labor and capital, (b) income, and (c) nonfood tradeable output and prices in all regions I focus here on the differences in the PE and GE outcomes to draw attention to the added value obtained by analyzing this experiment using the full general equilibrium model

The differences in table 3 are reported in two forms volumes and percentage changes Volumes are measured in 1988 U S dollars, evaluated at agents' prices in initial equilibrium They are not comparable across rows (that is, across suppliers) Thus, no column sum is provided However, the row sum (summation across destinations) equals the total difference in predicted post-liberalization output in each of the regions owing to the use of a partial equilibrium model to analyze this multilateral trade liberalization question These discrepancies are also reported (in parentheses) as a percentage of the initial quantity sold to each destination

Consider first the entries in the column headed "total " Positive numbers indicate that the partial equilibrium analysis of this cross-sectoral, multilateral shock overstates the *level* of food output in the liberalized environment in the case of New Zealand, Japan, Korea, ASEAN, and ROW (rest-of-the-world) countries Negative entries indicate that the PE approach understates the *level* of liberalized food output in other cases, namely Australia, Canada, and the United States (The CAP insulates EC agriculture so that its food output is fixed in both experiments) Note, however, that the sign of these differences does not indicate whether the new output level is above or below its initial equilibrium value This information is conveyed by the presence or absence of an asterisk In those cases where general (and partial) equilibrium food output falls under multilateral liberalization (Australia, Canada, Japan, and Korea), an asterisk appears Consequently, an asterisk appended to a negative entry implies that the partial equilibrium model overstates the change in output Since this change is negative, the PE model understates the new *level* of food output in these regions On the

[8] Details on the initial policy interventions are provided in Dee and others (1992), and Jomini and others (1991) They are not present in the residual region (ROW), so this liberalization experiment only applies to the non-ROW regions Agricultural interventions are drawn from the OECD's PSE data base Market price support is achieved via border interventions while producer payments are introduced as output subsidies

[9] The model is implemented using the GEMPACK software package (Codsi and Pearson (1988) Pearson 1991)) A copy of the algebraic code and a complete electronic appendix is available from the author upon request All results in this section have been independently verified by Karen Chyc

Table 3—Difference in predicted farm and food sales volumes due to partial equilibrium assumptions in the presence of multilateral trade liberalization[1,2]

Source	Australia	New Zealand	Canada	United States	Japan	Korea[1]	European Community	ASEAN	Rest of the World	Total	Nonfood Manufacturers[3]	Services[3]
Australia	−212*	−15	−26	−170	−182	−7*	−144*	−55	−311*	−1127*	2017	−1316
	(−0 5)	(−8 0)	(−9 6)	(−14 5)	(−6 7)	(−1 8)	(−7 4)	(−4 6)	(−6 9)	(−2 3)	(1 4)	(−0 4)
New Zealand	17	177	15	33	15*	−0*	−0*	49	57*	366	1374	73
	(5 9)	(1 8)	(12 1)	(4 9)	(3 0)	(−0 5)	(−0 0)	(12 0)	(2 7)	(2 4)	(5 0)	(0 1)
Canada	−0*	−0*	−598*	−121*	−36*	−2*	−29*	−1*	−144*	−937*	−4685	−5869
	(−0 8)	(−3 7)	(−0 9)	(−3 9)	(−2 0)	(−1 0)	(−3 1)	(−0 9)	(−2 6)	(−1 2)	(−1 5)	(−1 0)
United States	2*	−0*	18*	−1427*	183	−113	−87*	12*	−118*	−1530	37256	−16018
	(1 7)	(−0 1)	(0 5)	(−0 3)	(2 0)	(−6 3)	(−1 7)	(1 0)	(−0 5)	(−0 3)	(1 5)	(−0 3)
Japan	0	−0	−0	−11	1042*	−1*	−9	0*	−16	1003*	−55308	−2187
	(1 2)	(−3 4)	(−0 9)	(−4 4)	(0 2)	(−3 3)	(−5 0)	(0 3)	(−2 9)	(0 2)	(−3 4)	(−0 0)
Korea	0*	0*	0*	5*	12*	936*	0*	1*	10*	969*	−13551	1435
	(2 6)	(2 8)	(1 9)	(2 2)	(0 7)	(2 0)	(0 6)	(1 4)	(1 6)	(1 9)	(−8 0)	(0 8)
European Community	1	−2	−11	−163	−67	−7*	2069*	3	−1822*	0	13710	−7851
	(0 2)	(−4 3)	(−2 0)	(−6 5)	(−3 6)	(−1 9)	(0 2)	(0 4)	(−3 0)	(0 0)	(0 4)	(−0 1)
ASEAN	22	2	8	28	25*	−1*	−72	3820*	119	3953	−8265	2405
	(5 6)	(2 9)	(2 7)	(0 9)	(0 8)	(−0 1)	(−1 7)	(4 0)	(1 6)	(3 4)	(−5 5)	(1 7)
Rest of the World	37	8	90	535	370	32	461	166	1350	3052	19642	1835
	(9 3)	(7 0)	(6 1)	(4 8)	(6 6)	(4 2)	(1 2)	(6 3)	(0 1)	(0 4)	(0 7)	(0 0)

[1]Difference = Partial equilibrium prediction − General equilibrium prediction

[2]Volumes are defined as the quantity that may be purchased for one dollar in initial equilibrium at agent prices

[3]Partial − General equilibrium prediction = − General equilibrium prediction since the partial equilibrium framework holds nonfood output constant by assumption

*Indicates that liberalized food sales are lower than those in initial equilibrium Thus, a negative entry in the total column, for example indicates that partial equilibrium output falls by more than general equilibrium output An asterisk accompanying a positive entry means that PE output falls by less than the GE estimate

other hand, the combination of a positive entry and no asterisk means that the PE model overstates both the increase in output *and* its new level Applying this logic to the total column subjects the partial equilibrium model to charges of overshooting the change in food output for Australia, New Zealand, Canada, ASEAN, and ROW countries In the case of the United States, Japan, and Korea, the partial equilibrium model understates the change in food output owing to non-CAP liberalization

These discrepancies between the PE and GE results stem from two sources First, the partial equilibrium model fails to acknowledge the supply response constraints imposed by fixed factor endowments Thus the general equilibrium food supply response is smaller than its partial equilibrium counterpart, with the magnitude of this discrepancy being roughly proportional to the share in endowments of mobile primary factors used in agriculture The food sector's supply increase in New Zealand, ASEAN, and ROW countries is constrained in general equilibrium, and the partial equilibrium framework exaggerates the degree to which food output is likely to expand under multilateral liberalization

This argument also works in reverse The presence of general equilibrium factor market constraints tends to dampen the output reduction in economies where the decline in firm output is sufficient to depress labor and capital prices This is reflected in the cases of Australia and Canada, where food output falls following liberalization and there is a negative entry in table 3 In the remaining cases, this line of reasoning is violated In other words, the GE changes are larger and the PE model understates the change in output

The second source of divergence between the PE and GE results explains why the PE model might understate GE changes Recall that the liberalization experiment involves not only food liberalization, but also shocks to mining and manufacturing trade policies In particular, tariffs and export taxes/subsidies are removed These nonfood shocks are not reflected in the PE model results, as that framework assumes that all nonfood output and price levels are fixed Thus, to the extent that manufacturing trade liberalization has an impact on the pattern of food output and sales, this will also cause a divergence in the PE and GE predictions for the food sector

The last two columns in table 3 report the *negative* of the total and percentage changes in volume of output in nonfood manufacturing and mining output, and in services (The partial equilibrium prediction is zero, so this entry is $(0 - \beta)$ where β is the GE model's predicted change) The very strong increase (8 percent) in GE manufacturing output in Korea explains why the PE model underpredicts the decline in Korean food output under non-CAP liberalization As manufacturing activity expands, the cost of labor and capital to the food sector rises, thereby forcing a further decline in output The same is true of Japan The United States also shows a PE food response lower than its GE counterpart Here, food output is projected to rise, and nonfood manufacturing output falls Consequently, scarce factors are released for use in agriculture, such that the U S general equilibrium food supply response is greater than in partial equilibrium

Table 3 also breaks down the sources of these discrepancies in sales predictions These are proportionately much larger than the output discrepancies (With the exception of Australia, the largest absolute changes are along the diagonal, because domestic sales represent the bulk of most regions' total output) The most extreme compositional change is provided by EC food sales Here, PE and GE predictions are constrained to be equal in total, since the CAP insulates output in both cases Yet, the PE and GE results exhibit sizable discrepancies in composition In particular, the PE model overpredicts domestic food sales in the EC by $2 billion To understand this, note that by fixing (a) the price of imported food relative to domestic food, and (b) food output, the PE model effectively holds the price of domestic food paid by consumers constant Since manufacturing prices in the EC are constant by assumption, there is no incentive for households to change their consumption mix Indeed, with income fixed, aggregate EC food consumption is unaltered

By contrast, in the general equilibrium multilateral liberalization experiment, EC manufacturing prices fall relative to internal food prices Thus, households shift consumption toward nonfood items, causing domestic food sales to fall To maintain the same level of output, the EC must increase its export subsidy Since the bulk of initial EC food exports go to ROW countries, the largest increment of the PE-GE difference crops up there However, on a percentage basis, EC food sales to the United States are most severely overstated by the PE experiment, a discrepancy equal to 7 percent of initial food sales from the EC to the United States

This first experiment was chosen to highlight the inadequacy of partial equilibrium models for handling simultaneous shocks to both agriculture *and* nonagriculture This is clearly a problem in the case of multicommodity trade negotiations, be they bilateral or multilateral However, some trade policy shocks will involve only the food sector, in which case the partial equilibrium model is capable of providing a much better approximation

Experiment 2 Reform of the CAP The first experiment removed all trade distortions other than the CAP, allowing experiment 2 to estimate the impact of eliminating the CAP In effect, this experiment estimates the additional gains to be had by including the CAP in an overall package of multilateral reforms [10] Of course, with all other farm and food policies already removed, world food prices are now higher and the CAP is less distortionary than in the initial equilibrium

Table 4 reports the estimated changes in food, manufacturing, and services output levels owing to reform of the CAP, for a variety of model specifications The first set of columns are the predicted output changes based on solution of the full general equilibrium multiregion (GEMR) model As in table 3, volumes are defined in terms of the value of production, evaluated at initial equilibrium agents' prices, so they are not additive across rows Nevertheless they do give an idea of the relative magnitude of the changes induced by CAP reform The first column, headed F (food), shows that the quantity of EC food production falls by $86 2 billion, while other regions increase food output The United States and ROW countries experience the largest absolute increases, while the percentage increase (parentheses) is largest for New Zealand

The columns under GEMR headed M and S report the changes in manufacturing and services output as a result of CAP reform The entries here are opposite in sign, and their sum is similar in absolute value to the food output changes This reflects the fact that each economy has finite resource base If more food is to be produced, this will come at the expense of other activities The increase in EC nonfood output is quite substantial, reflecting the fact that the CAP represents a significant distortion of the nonfood economy

The second set of columns (2) in table 4 corresponds to the partial equilibrium multiregion model (PEMR) introduced above Here, nonfood prices and output are fixed by assumption, hence the zeros under the M and S columns Also, income and rental rates for labor and capital are fixed As before, the latter assumption exaggerates the food sector's supply response and thus leads to a tendency to exaggerate output changes This is most pronounced in the case of New Zealand,

[10]See Hertel, Gehlhar, and McDougall (1992) for a detailed analysis of this experiment

Table 4—Estimated changes in nonservice output levels following CAP reform under alternative assumptions

Region	Alternative assumptions											
	1 GEMR			2 PEMR			3 GESR			4 PESR		
	F	M	S	F	M	S	F	M	S	F	M	S
Australia	2,173	–2,084	–265	2,594	0		0	0	0	0	0	0
	(4 5)	(–1 6)	(–0 1)			0						
New Zealand	2,754	–1,826	–536	4,703	0	0	0	0	0	0	0	0
	(15 7)	(–7 0)	(–1 2)									
Canada	2,345	–1,780	–171	2,409	0	0	0	0	0	0	0	0
	(3 8)	(–0 6)	(–0 0)									
United States	11,740	–7,975	–147	12,296	0	0	0	0	0	0	0	0
	(2 3)	(–0 3)	(–0 0)									
Japan	1,104	–954	–34	998	0	0	0	0	0	0	0	0
	(0 4)	(–0 1)	(–0 0)									
Korea	91	–146	7 5	83	0	0	0	0	0	0	0	0
	(0 3)	(–0 1)	(0 0)									
European Community	–86,238	42,835	19,717	–94,194	0	0	–89,989	46,075	19,762	–97,527	0	0
	(–10 9)	(1 5)	(0 5)									
ASEAN	2,549	–2,716	–289	2,929	0	0	0	0	0	0	0	0
	(2 3)	(–1 8)	(–0 2)									
Rest of the World	24,181	–21,034	–2,304	25,109	0	0	0	0	0	0	0	0
	(3 01)	(–0 8)	(–0 1)									

GEMR = Full general equilibrium model predictions
PEMR = Nonfood output and prices fixed, labor and capital rental rates and income fixed
GESR = Non-EC outputs prices, and incomes fixed
PESR = All output levels and prices fixed except for EC food, all incomes, labor, and capital rental rates fixed

where CAP reform generates a strong demand for food output However, this overshooting effect is also evident in the EC

The final two groups of columns in table 4 refer to predictions based on single-region models of the EC alone They are attained by fixing all output levels, prices, and incomes in non-EC regions [11] This is reflected in the predominance of zeros in all three columns The results under GESR are based on a single-region, general equilibrium model whereby EC income, nonfood output, and domestic prices are endogenous This type of model has been a popular one for analyzing the economywide effects of unilateral trade liberalization of farm and food policies [12] A comparison of entries in the EC row of table 4 shows that this framework is somewhat more successful than PEMR in predicting the likely changes in food output However, it too overshoots for both food and nonfood output changes

The fourth set of columns, headed PESR, illustrate the value of a single-region, partial equilibrium model for estimating the effect of CAP reform on the EC food sector The estimated change in food output using this simple model provides a fair approximation to the GEMR solution Of course, the impetus for reform of the CAP has come from producers in other countries who feel that their output levels have been adversely affected Given this interest in the international implications of farm policies, it has become common to analyze such unilateral agricultural policy shocks in a multilateral framework But why hasn't this line of reasoning been carried to its logical conclusion, namely the displacement of models of the PEMR class with GEMR models? Certainly the changes in nonfood output displayed in column 1 are comparable in absolute magnitude

The answer to this question lies in the fact that the percentage changes associated with the numbers in the M and S columns of table 4 (see parentheses) are much smaller than those pertaining to the food sector Until recently, nonfood groups have taken little notice of food policies Thus the U S Farm Bill is largely left to the farm lobby (subject to certain budget constraints) and the debate over agricultural trade reform was long left to the GATT's Negotiating Group on Agriculture However, the stumbling of the Uruguay Round owing to an unresolved agricultural dispute has revealed yet again the difficulty of achieving farm policy reform without nonfarm input Outside pressure and some prospect for offsetting gains must be brought to bear on this process

[11]Note however, that fixing output levels does not eliminate the price responsiveness of imports in the rest of the world, as governed by equations T8-T11

[12]For U S applications see Kilkenny and Robinson (1990) as well as the Hertel Thompson and Tsigas (1989) and Robinson, Kilkenny, and Adelman (1989) papers in Stoeckel and others (eds) That volume also contains similar applications for Australia, Germany, the EC Korea, and Japan

The difference between negotiating over agricultural trade in isolation and negotiating in the context of a broader agenda is evidenced in the difference between columns grouped under headings 1 and 2 in table 4 If negotiators look only at agriculture (PEMR), it is clear that reform of the CAP translates into a big cut in EC food output "in favor" of the other regions When one looks at the GEMR results, it is clear that (a) good things can happen in the EC, that is, nonfood producers become more competitive and output rises, and (b) the purported output "gains" in the other regions are perhaps less dramatic then they might first appear, as they come at the expense of diminished nonfood output Indeed, the total volume of U S exports to the EC actually falls when the CAP is reformed (Hertel, Gahlhar, and McDougall, 1992) since the EC is more important as an outlet for U S manufacturers (sales of which decline to the EC) than for food (sales of which rise to the EC) Nonfood interest groups have not paid more attention to agricultural policies because most models/analyses of these policies do not report variables of interest to the nonfood sector By quantifying these economywide costs, we can contribute to the mobilization of a broader constituency for CAP reform

Of course, the ultimate advantage of the AGE framework lies in its ability to trace everything back to households While I have not emphasized the welfare dimension of these experiments, the ability to summarize results in the form of changes in well-being of people is a powerful tool It goes a long way towards debunking the mercantilist arguments that have confounded those seeking to reform international trade

Summary and Conclusions

This article has highlighted the importance of accounting equations in multiregion, applied general equilibrium analysis General equilibrium modelers are social accountants This exhaustive accounting has several important benefits First of all, the absence of "leakages" assures us that welfare analyses based on the model will be complete Furthermore, by tracking everything back to household utility, welfare analysis is also simplified A second benefit of this closed system of social accounts is the consistency check offered by Walras' Law This is an invaluable tool in verifying the internal consistency of an AGE model, and it is not available to partial equilibrium modelers Finally, by exhaustively documenting all economic linkages, however small, the AGE modeler who chooses to conduct partial equilibrium analysis is able to make explicit the precise nature of the PE assumptions to be employed In short, experience with AGE models can make you a stronger PE modeler

To illustrate the differences between partial and general equilibrium analysis, a simple nine-region, three-commodity AGE model was used to analyze two policy experiments under a variety of assumptions The first experiment involved liberalization of both food and nonfood policies In this case, the partial equilibrium model was substantially in error in a number of its predictions about the pattern of changes in food production and trade This was directly attributable to the absence of any mechanism for incorporating nonfood shocks into a partial equilibrium model of farm and food trade

The second experiment involved a food-specific shock, namely reform of the EC's Common Agricultural Policy Here, a partial equilibrium approach was quite successful in approximating the general equilibrium changes in food output However, by remaining silent on the likely effect on nonfood output, the PE model missed an important part of the story, namely the fact that the CAP represents a substantial "tax" on EC nonfood exports By endogenizing nonfood activity, *AGE analysis serves as a continual reminder that ultimately agricultural and nonagricultural interests in trade cannot be separated* The policy relevance of this point cannot be overstated The avenue to substantial global agricultural reform requires involvement on the part of nonagricultural interest groups A dismantling of the wall of protection and subsidies erected around the farm and food sectors in many industrialized economies is unlikely without pressure from these quarters

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