PITFALLS IN THE USE OF AD VALOREM EQUIVALENT REPRESENTATIONS OF THE TRADE IMPACTS OF DOMESTIC POLICIES

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Abstract

Numerical simulation exercises to analyze the impacts of potential changes in non-tariff policies commonly use *ad valorem* equivalent tariff treatment even though estimated impacts using explicit model representation and *ad valorem* equivalent treatments will differ. The difficulty for modellers is that the detail and subtlety embodied in a wide array of policy interventions means that some simplification is appealing, but no meaningful general propositions exist in the theoretical literature as to the sign or size of the differences in predicted effects. All that can seemingly be done is to investigate the differences case by case, but even here the findings are sensitive both to the particular form of model used as well as the model parameterization employed. As a result, there is relatively little in the literature that provides guidance as to how serious the pitfalls may be, and how misleading *ad valorem* tariff equivalent treatment is. Here I draw on three examples of numerical modelling where explicit representation of policy interventions are used. The picture that emerges is one of large quantitative and even qualitative differences in predicted impacts. These examples suggest that where interventions differ from a tariff, *ad valorem* representation should be undertaken in numerical trade modelling only with substantial caveats.

JEL Code: F00, F02, F10, F15.

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Introduction

It is widely acknowledged that the complexity of domestic policy interventions which influence trade flows and are now the subject of substantial international negotiation are different in their effects from those of tariffs that are widely analyzed by trade theorists. This is especially the case in such areas as services, competition policy, environmental regulation, product standards, professional accreditation, movement of persons and transportation regulation. It also applies to those areas of agricultural policy where the trade impacts are often significant, despite the commitments in the Uruguay Round to tariffy all border measures relating to agricultural trade.

Despite such acknowledgements, however, it remains commonplace in numerical simulation exercises to analyze the impacts of potential changes in these policies using *ad valorem* equivalent tariff treatment even though estimated impacts using explicit model representation and *ad valorem* equivalent treatments will differ. The difficulty for modellers is that the detail and subtlety embodied in this wide array of policy interventions means that some simplification is appealing. In addition, no meaningful general propositions exist in the theoretical literature as to the sign or size of the differences in predicted effects. All that can seemingly be done is to investigate the differences case by case, but even here the findings are sensitive both to the particular form of model used as well as the model parameterization employed. As a result, there is relatively little in the literature that provides guidance as to how serious the pitfalls may be, and how misleading *ad valorem* tariff equivalent treatment is.

Given the importance of this issue for modelling, this is the issue addressed in this paper. In recent years, I have been involved in a number of numerical simulation exercises where explicit representation of policy interventions are used and compared to *ad valorem* equivalent modelling, and I draw on these three examples to discuss in broader terms what can be involved. The picture that emerges is large quantitative and even qualitative differences in predicted impacts. I suggest that in the absence of other firm guidance, these examples suggest that where interventions differ from a tariff, *ad valorem* representation be undertaken in numerical trade modelling only with substantial caveats.

2. Geographical Extension of Free Trade Zones as Trade Liberalization[1]

The first example of comparison of explicit model representation and *ad valorem* equivalent modelling draws on a recent paper by Ng and Whalley (henceforth referenced as NW) which analyzes the geographical extension of pre-existing free trade zones as a form of trade liberalization. NW assess how this form of trade liberalization compares to more conventional trade liberalization involving the lowering of national tariffs covering the whole economy in which zones are absent. The assumption is that countries exist (China being one example) where it is administratively feasible to operate movable internal trade barriers, and that some mechanism exists for the progressive enlargement of free trade zones within these countries.

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[1] This section draws on Ng and Whalley who compare their approach to earlier literature on free trade zones such as Hamada; Rodriguez; and Young.

This can be through the sequential addition of cities or portions of an economy to a pre-existing free trade (or export processing) zone.

NW's paper was motivated by the form that progressive liberalization will take during the implementation period for China's WTO accession commitments in key service areas such as banking, insurance, and telecoms (Whalley). For these service items, protection through a tariff is not feasible as there is no customs clearance for international trade in the relevant service. Prior to WTO accession, China's domestic markets in these areas were protected by regulatory arrangements which relied on licences and limits on the extent of foreign participation (typically, the degree of ownership in joint ventures). Since licences are inherently discrete instruments of protection, they have been converted into continuous instruments of progressive liberalization in these service areas by allowing for an expansion in their geographical coverage over the five-year implementation period (allowing more cities over time where foreign presence is allowed). Limits on allowable foreign participation (and ownership) are also to be progressively raised over time.

NW assumes that such schemes are possible to implement even though in reality they may be hard to administer. China, Vietnam and other countries with strong administrative control mechanisms and embedded provincial structures seem to fit this characterization. NW do not explicitly consider intertemporal intermediation services in their model due to the added complexity this implies, but instead limit themselves to trade in goods. NW do emphasize that the themes of their analysis of trade in goods, almost certainly applies to trade in services as well.

NW consider cases where the size (and hence the border) of the free trade zone can be varied inside an economy and numerically evaluate the welfare implications of increasing the size of free trade zones and compare this to conventional forms of trade liberalization such as a reduction in a national tariff. They evaluate the welfare impacts of the two types of trade policy changes (*ad valorem* national tariff reduction, expansion of the geographical size of a trade zone) where there are observationally equivalent impacts of the two policies in the sense of implied identical changes in trade volumes.

To do this, NW calibrate a numerical general equilibrium trade model of a small open economy to a base case free trade equilibrium data set. They then introduce both a free trade zone and a tariff and compare the outcome of an expansion in the size of the zone to that generated by an observationally equivalent reduction in a national tariff in a model without trade zones. Figure 1 presents a flow chart from NW setting out their procedures.

In NW's first experiment, the tariff applies to international trade for only a portion of the economy and also applies to trade internally between the free trade and protected zones. Trade policy changes involve variations in the size of the free trade zone while the tariff rate in the tariff zone remains unchanged. In analysis using a conventional nationally based tariff with no free trade zone, the tariff applies only at the national border and the rate is varied on all country trade.

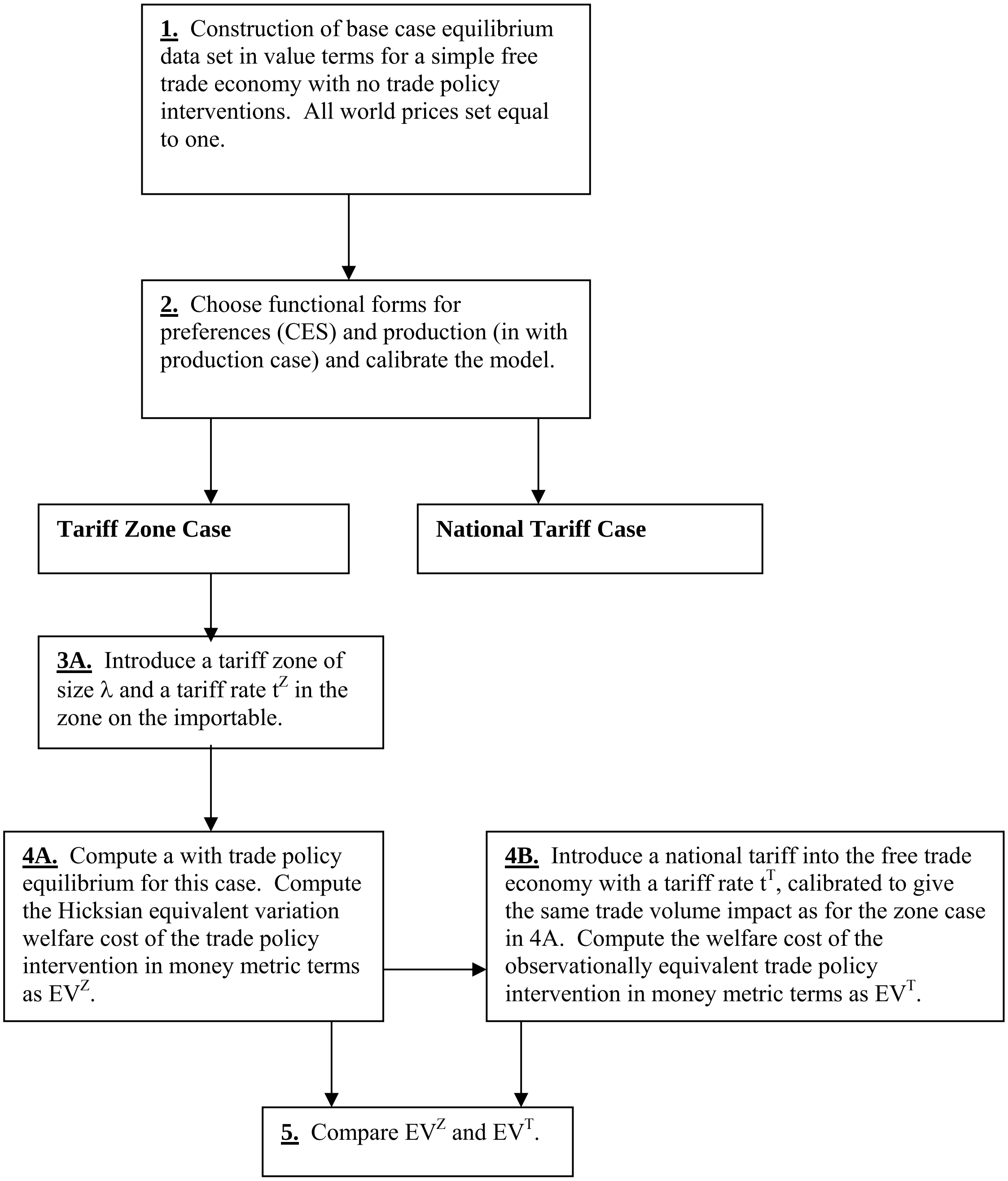

Figure 1: Flow Chart Outlining the Procedures Used by Ng and by Whalley in Constructing Observationally Equivalent Numerical Experiments Comparing National and Zone Based Trade Policy Changes

The numerical simulations of NW show that the welfare changes of observationally equivalent trade policy changes differ significantly across the two cases (by factors of over 2). There is a larger gain from the first type of liberalization, reflecting both the use of a higher tariff rate on a smaller portion of trade, and the reduction in distortions across the divide between the free trade zone and the rest of the economy. NW explore the size of these differences both for pure exchange economies where and models with production. Larger differences occur in the case where production is allowed due to added distortions have to do with the location of mobile factors across the two zones.

To illustrate NW's approach, consider a simple single-country pure exchange trade model with both international barriers to trade and internally movable barriers and fixed endowments of traded goods. Assume a zone within the economy can be defined in which international trade can occur, while trade between the zone and the rest of the economy involves the same tariff as applies to international trade. No tariffs apply in the free trade zone, while in the tariff zone there are *ad valorem* tariffs both on international trade and trade between the zones. For simplicity non-traded goods are excluded from the analysis.

To simplify matters, the relative size of the two zones are represented by the relative endowments of goods in each zone (expressed in proportional terms). Thus, if the economy wide endowment is ten units of good one and 20 units of good two, and consumers in the free trade zone have six units of good one and 12 units of good two, while those in the tariff zone have four and eight units, the tariff zone is treated as covering 40 percent of the whole country. A simple treatment is to normalize the size of the whole economy to one. In the example above, the sizes of the free trade and tariff zones are 0.60 and 0.40 respectively. Because the relative size of the two zones are allowed to vary, it further simplifies things to assume that all consumers in both zones have identical homothetic preferences.

If Y_i defines the aggregate endowment of good i for the whole economy, and λ is the size of the tariff zone (and (1-λ) of the free trade zone), the aggregate endowments of goods in each zone are given by:

$$Y_i^T = \lambda Y_i \qquad \text{and} \qquad Y_i^F = (1-\lambda)Y_i \qquad (i = 1,\ldots,N); \quad 0 \le \lambda \le 1 \qquad (1)$$

where superscript T stands for the tariff zone and F for the free trade zone.

To facilitate welfare analysis of alternative trade policies, the relative sizes of the free trade and tariff zones are assumed to also reflect the relative sizes of the population in the zones. There are therefore λ and 1-λ consumers in the tariff and free trade zones respectively, and λ can change. A further simplifying assumption is that the aggregate endowments of each good in each zone are evenly distributed.

All consumers are assumed to have identical CES preferences:

$$U = \left[\sum_i (\alpha_i)^{\frac{1}{\sigma}} (X_i)^{\frac{\sigma - 1}{\sigma}} \right]^{\frac{\sigma}{\sigma - 1}} \qquad (i = 1,..., N) \qquad (2)$$

where α_i is the consumption share of good i; X_i is the quantity of good i; σ is the elasticity of substitution, in this economy, utility-maximizing demands for goods depend upon the amount of income spent in each zone. Since consumer prices differ across the zones, the aggregate demands in each zone are:

$$X_i^j = \frac{\alpha_i I^j}{(P_i^j)^\sigma \sum_i \alpha_i (P_i^j)^{1-\sigma}} \qquad (i = 1,..., N); \quad (j = F, T) \qquad (3)$$

where X_i^j is the aggregate demand for good i in zone j, I^j is the income spent in zone j, and P_i^j is the price of good i in zone j.

The income in each zone I^j is given by:

$$I^F = \sum_{i=1}^N P_i^j y_i^F + \gamma^F R \qquad \text{and} \qquad I^T = \sum_{i=1}^N P_i^j y_i^T + \gamma^T R \qquad (4)$$

where γ^j denotes the share of national tariff revenue R collected in the tariff zone accruing to zone j; $\sum_{j=F,T} \gamma^j = 1, \quad \gamma^j \geq 0.$[2] Hence, the aggregate demand of good i for the whole economy is the sum of the aggregate demands in each zone:

$$X_i = X_i^F + X_i^T \qquad (i = 1,..., N) \qquad (5)$$

Defining the net imports of each good in the tariff zone as $M_i^T = X_i^T - Y_i^T \quad (i = 1,..., N)$; P_i^W as the world price of good i; and t_i as the tariff on good I; the national tariff revenue, R, is given by:

$$R = \sum t_i P_i^W \max(M_i^T, 0) \qquad (6)$$

The aggregate net import of each good for the whole country, M_i, is given by the sum of net imports for each good entering each zone:

$$M_i = \sum_j M_i^j \qquad (i = 1,..., N); \quad (j = F, T) \qquad (7)$$

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[2] In the numerical experiments it is assumed that the tariff revenue collected in the tariff zone is only distributed to that zone. In this case, $\gamma^F = 0$ and $\gamma^T = 1$.

Since the country is modelled as a small open price-taking economy with no non-traded goods, it is simple to characterize an equilibrium. Given world prices of goods, any excess demands for goods are absorbed by imports from (or exports to) the world market. Trade balance is implied by Walras' Law, which automatically follows from utility maximizing behaviour subject to budget constraints. Given λ, an equilibrium for this economy can also be easily computed. Alternatively, given a target tariff revenue R^* and a tariff rate t in the tariff zone, λ can be endogenously determined as the relative size of the two zones needed to meet the revenue requirement and the tariff rate.

Trade liberalization in this economy can involve the geographical expansion of the free trade zone, a change in the tariff rate, or some combination of these. If we increase the size of the free trade zone from $1-\lambda$ to $1-\lambda'$ for a given tariff rate (where $\lambda > \lambda'$), the size of the free trade zone increases while the tariff zone shrinks.

To evaluate the welfare impacts on consumers located in each area of the economy; first compute a general equilibrium before and after a trade policy change (i.e. such as the change from λ to λ' respectively) and obtain consumption of each good in both the free trade and tariff zones before and after the trade policy change. Since endowments are evenly distributed within each zone and the relative sizes of zones reflect relative population sizes, it is easy to compute consumption before and after liberalization. Second, compute the Hicksian money metric welfare measures of the welfare changes for consumers located in each area. The welfare change for the whole economy is then computed by summing these money metric measurements which are expressed as a percentage of the economy-wide pre-change income.

NW begin by calibrating a conventional single-country price-taking trade model without trade policy interventions to a free trade base case data set. In the case of a pure exchange economy, the model is as described above, with the size of the tariff zone set equal to 0 (i.e. $\lambda=0$).

They then evaluate the welfare impacts of two types of trade policy change. In the first case (the tariff zone case), they introduce a tariff zone of size λ equal to 0.55 and a tariff rate t^Z of 0.6 in the zone for the importable. They then compute an equilibrium for this case, and compare it to the original free trade equilibrium to generate a money metric measure of the welfare impact of the trade policy change. NW then introduce an observationally equivalent national tariff (t^T) into the free trade calibrated model giving the same impact on trade volumes as in the tariff zone case. This trade-impact equivalent national tariff rate is calculated to be about 0.30 for both the pure exchange and the with production cases. They then compute a money metric measure of the welfare impact of this intervention.

NW's results show that the welfare costs of imposing a geographically restrictive tariff scheme (the tariff zone case) are almost two times larger than those from a conventional national tariff with observationally equivalent trade effects (the national tariff case). This reflects both the use of a higher tariff rate on a smaller portion of trade, and the introduction of distortions across the divide between the free trade zone and the tariff zone when modeling the tariff zone case. On the other hand, there is a relatively lower national tariff applying at the national border and there are no internal distortions within the country. Thus, the welfare impacts of observationally equivalent trade policy changes differ across the two cases.

NW conclude from our analysis that if trade liberalization is achieved through geographical expansion of free trade zones, policy analyzes which study such liberalization in national tariff equivalent terms can be highly misleading. Although more complex intertemporal and spatial models are needed to study the services liberalizations associated with Chinese WTO accession (banking, telecom, transportation), the analysis nonetheless suggests that analyzing liberalization of this form in tariff equivalent terms (as is typically done in the modelling literature) is not a satisfactory way to proceed.

3. Border Delays and Trade Liberalization[3]

The second case study of explicit trade barrier representation and *ad valorem* equivalent modelling draws on work dealing with border delays reported in a recent paper by Cudmore and Whalley (henceforth referenced as CW). The motivation for this study is that in a number of lower income and transitional economies it is common for there to be significant delays at the border when achieving customs clearance (Hare; and Wolf and Gurgen). This can be due to complex customs formalities, which sometimes are continually changing, capacity constraints to process imports given limited facilities, and/or corruption at the border. In some African economies, there are reported delays of 3-6 months to achieve customs clearance, although this is perhaps extreme.

The thrust of CW is to argue that if such delays are significant and the length of the delay is endogenously determined, then trade liberalization through tariff reductions that increase the length of the queue can be welfare worsening. Tariff reductions, as have occurred in recent years in the CIS states, may thus be bad policy if customs clearance issues are not first addressed. CW show this for a small open economy case in a simple general equilibrium model where there is a physical constraint on the volume of imports which can be admitted. They then analyze extensions where corruption occurs, and finally where some imports are perishable. CW apply their analysis to data on Russian trade for the late 1990s, with the results emphasizing the themes that not only is it best to deal with border and administrative delays first before engaging in trade liberalization, but also the quantitative orders of magnitudes for the costs involved can be large.

CW formalize the interactions between border delays and trade liberalization in a simple pure exchange economy, which is small and a taker of prices on world markets and engaged in trade. For expositional simplicity goods are assumed traded (these features can be changed in further numerical application); the world prices for the N goods are given by the $\bar{\pi}_i^w$; tariff rates t_i apply to imports ($t_i = 0$ for exports), and CW assume the direction of trade is predetermined.[4]

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[3] This section draws on Cudmore and Whalley.

[4] This is a standard assumption in most theoretical trade models, although numerically the direction of trade can change when trade policies change. See Abrego, Riezman, and Whalley for a recent discussion of the likelihood of this assumption being false in comparisons between free trade, customs unions, and Nash equilibria.

In this economy, domestic prices depart from world prices on the import side both due to tariffs and per unit queuing costs at the border $T^q(\pi)$. For simplicity, CW assumes these costs are the same for all goods, and that units for goods are denominated in comparable physical terms (e.g. tons). Thus, if M goods are imported and $(N\text{-}M)$ exported, and the direction of trade is unchanged,

$$\pi_i^d = \overline{\pi}_i^w(1+t_i)+T^q(\pi) \quad (\text{i=1}\ldots\ldots\ldots\text{M}). \tag{8}$$

T^q is assumed to be indexed and so is homogeneous of degree one in π and is endogenously determined.

The economy has market demand functions, $\xi_i(\pi^d, R, Q)$, and non-negative endowments, w_i, for each of the N goods, where π^d denotes the N dimensional vector of domestic commodity prices. R defines tariff revenues, and Q represents the aggregate endogenously determined queuing costs (denominated in units of the good being imported). These demand functions are non-negative, continuous, homogeneous of degree zero in π^d and satisfy Walras Law, i.e., at all price vectors π^d

$$\sum_{i=1}^{N} \pi_i^d\left(\xi_i(\pi^d, R, Q) - w_i\right) = 0\ . \tag{9}$$

Assuming there is a single representative consumer in this economy, its budget constraint is given by

$$\sum_{i=1}^{N} \pi_i^d \xi_i(\pi^d, R, Q) = \sum_{i=1}^{N} \pi_i^d w_i + R - \sum_{i=1}^{M} T^q(\pi)(\xi_i - w_i). \tag{10}$$

For simplicity, border delays are assumed to reflect a constraint on the volume of imports that can be processed over the period of time covered by the model (e.g. one year). Thus, for now, consider this to be a physical constraint rather than one reflecting corruption or other considerations. If $\overline{C}$ represents the administratively determined physical capacity constraint on imports, then

$$\sum_{i=1}^{M} \left(\xi_i(\pi^d, R, Q) - w_i\right) \leq \overline{C} \tag{11}$$

where R denotes tariff revenues $\sum_{i=1}^{M} \overline{\pi}_i^w t(\xi_i - w_i)_i$, and $Q = \sum_{i=1}^{M} T^q(\pi)(\xi_i - w_i)$ denotes the total queuing costs.

In this model, if the capacity constraint on imports is binding then per unit queuing costs $T^q(\pi^w)$ are determined in equilibrium along with domestic prices π^d, tariff revenues, and domestic demands ξ_i. The effect of tariff liberalization will be to lower tariff revenues and increased queuing costs. In the case where tariff rates are uniform across commodities, tariff reductions simply generate a corresponding increase in queuing costs. Since the latter use real resources, tariff reducing trade liberalization will typically be welfare worsening.

This simple model is then extended by Cudmore and Whalley in a number of ways which capture additional mechanisms through which border delays and trade liberalization can interact. One is the presence of corruption. Another elaboration is differential impacts of queuing on different commodities if perishable commodities are more adversely affected by queuing than non-perishable commodities. Differential impacts of border delays across commodities are the end result with added distortionary costs.

Using this simple framework, CW make some calculations using Russian data to explore the possible quantitative orders of magnitude involved with analysis of trade liberalization that incorporates border delays. The delays reported in the Russian case appear to be lengthy and a major restraint on trade. CW's calculations serve to underline the point that if tariff reforms occur with no attention being paid to administrative considerations and border delays, liberalization can be welfare worsening rather than welfare improving as is usually the case in conventional models. Importantly, CW suggest that there are costs rather than benefits from trade liberalization in such cases and they can be substantial. Here again, analyzing trade liberalization using conventional tariff based models can also be misleading, and in this specific case the sign might even be wrong.

4. US Wheat Programmes and Programme Participation

A final case study of *ad valorem* treatment and explicit trade barrier representation is provided by Whalley and Wigle (henceforth referenced as WW) who argued that modelling agricultural programmes involves surprising complexities, and that overly simple *ad valorem* modelling can again be misleading. They illustrated this by discussing the modelling of price supports paid to US wheat farmers in the late 1980s. At this time price support for producers of wheat (as well as corn, grain, sorghum, oats, barley, and rye) in the United States were largely provided through commodity loans and deficiency payments (USDA). These jointly had the effect of raising prices received by farmers.

Under the Commodity Loan programme, the Commodity Credit Corporation (CCC) made non-recourse loans to farmers using commodities (wheat) as security, stored either on the farm or in commercial warehouses. These loans matured on demand, but on or before the loan's maturity date farmers had the option of regaining possession of their crop by paying off the loan plus any accrued interest, or forfeiting the stored commodities to the CCC as full payment of the loan. This component of price supports effectively operated through the setting of the loan rate.

Deficiency payments were based on the difference between the target price and the higher of the national average market price and the loan rate. This difference was multiplied by the established yield of each farmer's land to determine their total deficiency payment. Prior to 1985, established yields were frequently recalculated using a five-year moving average of the preceding years' yields on a farm-by-farm basis. Under this system, subject to a lag, higher yields implied higher deficiency payments. In effect, marginal output received the support (target) price. One of the major changes in the 1985 Farm Bill was an attempt to "decouple" deficiency payments from output by fixing established yields.

However, acreage set asides coexisted with these two methods of price support as a condition for receiving support. To receive deficiency payments on their harvested acreage, or to gain access to non-recourse loans, farmers were required to reduce their planted acreage by a specific percentage of their base acreage. The aim of these set-aside requirements was to reduce surplus production thought to be generated by the price supports. However, the joint effect of deficiency payments, loans, and set asides on output and prices, and hence, on market prices was uncertain. Producers participating in the programme planted a reduced acreage but faced a higher price, giving ambiguous effects on production. Increasing the target price would increase yields of programme participants, but could also increase participation, reducing planted acreage.

To assess the net effect, it was necessary to analyze farm participation decisions. In deciding whether or not to participate in support programmes, individual farms compared their profits from participating in both the price support and set-aside programmes with their profits if they did not participate. This is illustrated in Figure 2. Thus, if P^W is the target price of wheat designated under price supports, P^Z the price of non-land inputs used by all farms and λ the set aside rate; the participation decision for farm *i* involved the comparison of the profit functions π_i^N, π_i^P for farm *i* under participation *(P)* and non-participation *(N)*. If, for farm *i,*

$$\pi_i^N\left(P^W, P^Z\right) > \pi_i^P\left(P_T^W, P^Z, \lambda\right) \tag{12}$$

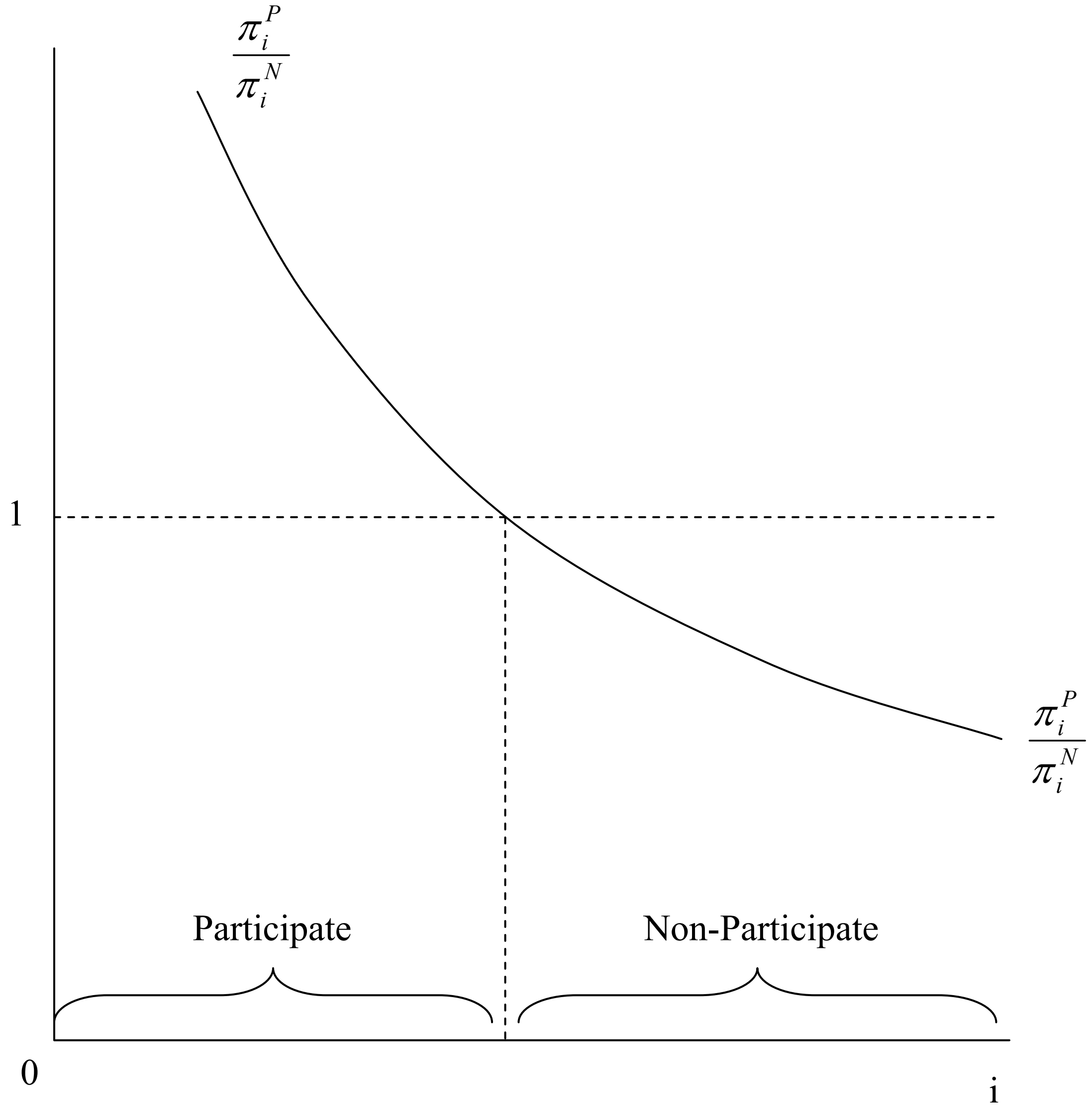
then farm *i* would choose not to participate in the set-aside programme, and would only participate if the inequality is reversed.

Typically farms differed in a range of characteristics, including the crop in which farms had a comparative advantage, land quality, and the ease with which land and other inputs could be substituted. Typically, for any given level of target and market prices and set-aside rates, it would pay some farms to participate and others not.

If farms are ranked by their relative profits from participating and non-participating and are indexed by the subscript *i,* the distribution of participant and non-participant farms is described by the relative profit functions. Changes in programme parameters, such as P_T^W and λ, will shift these relative profit functions, changing the number of participant farms. This emphasizes the importance of capturing endogeneity of programme participation in any modelling of the impacts of agricultural supports.

Whalley and Wigle analyzed the effects of price supports and set asides for wheat in the United States on both output and the terms of trade, using a numerical general equilibrium model of global trade in wheat reported in Trela, Whalley and Wigle, and into which they embedded a richer treatment of both farm behaviour and programme supports in the United States. In WW, the US wheat sector was assumed to be made up of a number of types of farms, producing a distribution both of average yields, and participating and non-participating farms in the model.

Figure 2: Distribution of Farms Between Participants and Non-Participants in United States Voluntary Crop Programs (Whalley and Wigle)



For analytical convenience, WW assumed that farms differ only in the elasticity of substitution between land and non-land inputs in production. In doing so, WW abstracted from differences in land quality across farms, location (and thus transportation costs in shipping crops), and difference in comparative advantage across crop types between farms. The production technology for each farm type, *i,* was assumed to be constant returns, and to take the constant elasticity of substitution (CES) form,

$$g_i = B\left[\delta \bar{L}_i^{-\rho_i} + (1-\delta) z_i^{-\rho_i}\right]^{-\frac{1}{\rho_i}} \tag{13}$$

where g_i is the output of farm type *i,* L_i and Z_i are land and non-land inputs, δ is a share parameter, *B* a units term taken to be identical across all farms, and

$$\sigma_i = \frac{1}{1-\rho_i} \tag{14}$$

is the elasticity of substitution between inputs. Wheat-producing land *(L)* and other inputs (*Z*) were assumed to be the sole inputs in the production of wheat by any farm.

Since acreage available to each farm, L_i, was fixed, producers faced a two-level optimization problem. They must first compare their profit under participation in the commodity programme (including any set-aside provisions), to their profit outside the programme. Given their participation decision, they then optimize on non-land inputs and outputs.

The profit functions from participation and non-participation are given by (15) and (16):

$$\pi_i^P = P_T^W \bar{y}_i (1-\lambda) \bar{L}_i - P^Z \bar{Z}_i + T_i \tag{15}$$

$$\pi_i^N = P^W \hat{y}_i \bar{L}_i - P^Z \bar{Z}_i \tag{16}$$

where:

π_i^N farm i, assuming it does not non-participate in support programmes; π_i^P farm i, assuming it does participate in support programmes; P^W is the free (world) market price for wheat; P_T^W is the US target price for wheat; y_i, $\bar{y}_i$ are the optimal yields under non-participation and participation decisions, respectively; $\bar{L}_i$ is the total acreage available for farm I; p^Z is the price of other inputs; Z_i, $\bar{Z}_i$ are the total amounts of other inputs used under non-participant and participant decisions, respectively; A is the proportional set-aside requirement; and T_i is the lump sum "paid diversion" received by farm *i* (equal to the rental value of a pre-specified proportion of land set aside when complying with set-aside requirements).

In this formulation, farm profits equal the returns to land net of input costs.

Participating farms were assumed to receive the target price for incremental output, although in some model experiments they varied the degree to which deficiency payments were coupled to current yields.

Using (13), input demands for non-participating farms are given by

$$\hat{z}_i = \left\{ \frac{1}{\delta} \left[B(1-\delta)\frac{P^W}{P^Z} \right]^{\left[\frac{\rho_i}{\rho_i - 1}\right]} + \frac{(\delta - 1)}{\delta} \right\}^{\frac{-1}{\rho}} L_i \tag{17}$$

and their optimal yield is

$$\hat{y}_i = \delta\left[(1-\delta)B\right]^{\frac{-1}{1-\rho_i}} \left[\frac{P^W}{P^Z} \right]^{\frac{\rho_i}{1-\rho_i}} \overline{L}_i \tag{18}$$

For participants, their input demands are given by

$$\overline{z}_i = \left\{ \frac{1}{\delta} \left[B(1-\delta)\frac{P_T^W}{P^Z} \right]^{\left[\frac{\rho_i}{\rho_i - 1}\right]} + \frac{(\delta - 1)}{\delta} \right\}^{\frac{-1}{\rho_i}} (1-\lambda)\overline{L}_i \tag{19}$$

and their optimal yield is

$$\overline{y}_i = \delta\left[(1-\delta)B\right]^{\frac{-1}{1-\rho_i}} \left[\frac{P^W}{P^Z} \right]^{\frac{\rho_i}{1-\rho_i}} (1-\lambda)\overline{L}_i \tag{20}$$

Given the programme parameters P_T, and knowing the market price of wheat P^W, and the input price P^Z, it is possible to solve for the optimal yields and input demands under participation and non-participation. This allows for a comparison of the two profit functions (15) and (16), and a determination of the participation decision. This, in turn, allows input demand and outputs to be calculated.

Whether farms choose to participate in any configuration of programme supports and set asides depends on the level of programme support, the way marginal cost functions change as land is idled to comply with set asides, and the lump sum costs which set-aside requirements cause. WW assumed that the elasticity of substitution between inputs across farms is uniformly distributed over a pre-specified interval. Farms with higher elasticities of substitution had higher average yields, and, given that land is a fixed factor for each farm, these farms had more shallowly sloped marginal cost functions. The parameter values they used in the model along with the data to which the model is calibrated, implied that low elasticity (high yield) farms participated in programme support, while high elasticity farms did not.

WW used the model for counterfactual equilibrium analysis, by calibrating the model to a 1981 microconsistent equilibrium data set, and then computing counterfactual equilibria for a variety of policy changes. They compared results under two different model treatments. In the first, all policies in all countries are treated in *ad valorem* form as price wedges (PSEs), while in the second, US Commodity programmes are fully modelled as described above (with endogenous voluntary participation). WW analyzed the effects of US intervention in the wheat market. Under explicit programme modelling, output rose when programmes were abolished because the increase in production from the extra acreage planted more than offset the fall in production due to the decrease in prices received by producers originally in the programme. In the *ad valorem* subsidy case, the output of the US wheat sector fell when the subsidy was eliminated so long as the world price did not rise by more than the subsidy.

The theme again is the difference between *ad valorem* equivalent modelling, and explicit policy representation, with the difference in representation possibly leading to a difference in the direction of change.

5. Conclusion

While all economic analysis inevitably involves a simplification from a more complex reality, and hence representing trade and other policy non-tariff interventions in *ad valorem* equivalent form is clearly wrong when judged by an absolute standard, we unfortunately usually do not know how misleading this treatment might by when we employ it (as we widely do in policy analysis).

Here I present three case studies where numerical modelling results allow a comparison between the results from explicit policy representation and *ad valorem* equivalent model representation in observationally equivalent models. Significant differences in size of effect, and in some cases in sign appear in the results. I suggest these results indicate some caution when using ad valorem equivalent treatment both in analyzing agricultural trade liberalization and trade liberalization of other forms.

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