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ENDOGENOUS PARTICIPATION IN AGRICULTURAL SUPPORT PROGRAMS
AND AD VALOREM EQUIVALENT MODELLING

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Ad Valorem Equivalent Modelling

ABSTRACT

This paper argues that a price wedge treatment of agricultural supports can seriously misrepresent their welfare and quantity effects. We make our point by focusing on pre-1985 US wheat programs, but features of programs in many other countries lead to comparable problems with the ad valorem approach. This line of argument raises questions over the current approach in the multilateral trade negotiations of negotiating on producer subsidy equivalents (PSEs), or some other subsidy-like measure.

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I. Introduction

Numerical models of the effects of domestic agricultural support programs usually treat them as subsidizing production, in effect introducing a series of ad valorem distortions or price "wedges" between foreign and domestic prices.² The purpose of this paper is to argue that a price wedge treatment of agricultural supports can seriously misrepresent their welfare and quantity effects. We make our point by focusing on pre-1985 US wheat programs³, but features of programs in many other countries lead to comparable problems with the ad valorem approach.⁴ This line of argument raises questions over the current approach in the multilateral trade negotiations of negotiating on producer subsidy equivalents (PSEs), or some other subsidy-like measure.

The essence of the argument in the US wheat case is that since commodity programs are voluntary, producers who receive deficiency payments must also comply with acreage limitations. Farms who are already participating in support programs will increase output if price supports increase. But at the same time, previously non-participating farms will be encouraged to enter the program if price supports increase, and they will set aside land which was previously in use. Thus, rather than simply subsidizing output, the program as a whole may have production incentive or disincentive effects, depending on the relative strength of the price effects for farms already participating, and the land set-aside effects for new program participants.

It is, therefore, misleading to represent these programs as equivalent to an ad valorem subsidy which unambiguously increases output, as is done in price wedge models. The welfare costs of support programs will be mismeasured by an approach using an ad valorem treatment, since the resources idled as a

result of the set-asides are not explicitly modelled. What is needed to capture the effects of programs on output and welfare is to explicitly model the program participation decision of farms.

Generating unambiguous analytical results from models with set-asides and endogenous participation decisions is something that the existing literature has been unable to do. Coyle et al. (1985) calculate the costs of set-asides, but use exogenously specified participation responses. De Goerter (1986) also analyzes the effects of set-asides, demonstrating that there are no simple qualitative analytical results. Nowhere, to our knowledge, are the marginal effects of these programmes and the implications for output and welfare fully discussed.

We use a numerical general equilibrium model⁵ in which set-asides are explicitly modelled, along with endogenous participation decisions of farms. We use data for 1981 to which we calibrate the model. This allows us to analyze the joint impact of US price supports and set-asides on US wheat output, and calculate the social cost of these programs.

Our numerical results show, in contrast to what is predicted by conventional price wedge models, that removing price supports for wheat given 1981 program characteristics reduces rather than increases output, because of the impact on participation decisions and associated set asides. Comparing our welfare evaluations of the social cost of program supports to those obtained using the same data in a traditional "price wedge" model, shows that results are sharply different.

II. US Wheat Programs and Program Participation

Supports for producers of wheat (as well as corn, grain sorghum, oats, barley, and rye) in the US are largely provided through Commodity Loans and deficiency payments. These jointly have the effect of raising prices received by farmers.

Under the Commodity Loan Program, the Commodity Credit Corporation (CCC)⁶ makes non-recourse loans to farmers using commodities (wheat) as security, stored either on the farm or in commercial warehouses. These loans mature on demand, but on or before the loan's maturity date farmers have the option of regaining possession of their crop by paying off the loan plus any accrued interest, or forfeiting the farm or warehouse-stored commodities to the CCC as full payment of the loan. This component of price supports effectively operates through the setting of the loan rate.

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

Acreage set asides coexist with these two methods of price support as a condition for any farm receiving support. To receive deficiency payments on their harvested acreage, or to gain access to non-recourse loans, farmers are

required to reduce their planted acreage by a specified percentage of their base acreage.

The aim of these set-aside requirements is to reduce surplus production thought to be generated by the price supports.⁷ However, the joint effect of deficiency payments, loans, and set-asides on output is uncertain. Producers participating in the program plant a reduced acreage but face a higher price, giving ambiguous effects on production. Increasing the target price will increase yields of program participants, but may also increase participation reducing planted acreage. To assess the net effect, it is necessary to analyze farm participation decisions.

To decide whether or not to participate in support programs, individual farms compare their profits from participating in both the price support and set-aside programs with their profits if they do not participate. Thus, if L_i represents the land available to farm i , P^w the free market price of wheat, P_T^w 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 involves 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 ,

$$\pi_i^N(P^w, P_Z) > \pi_i^P(P_T^w, P_Z, \lambda) \quad (1)$$

then farm i will chose not to participate in the set-aside program, and will only participate if the inequality is reversed.

Farms differ in a range of characteristics, including the crop in which farms have a comparative advantage, land quality, and the ease with which land and other inputs can be substituted. Typically, for any given levels of target and market prices and set-aside rates, it will pay some farms to participate and others not.⁸

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 as represented by Figure 1. Changes in program 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 program participation in any modelling of the impacts of agricultural supports.

The 1985 Farm Bill (which we do not analyze here) differs from the 1981 program in several ways. The 1985 Farm Bill attempts to decouple production decisions from target price by fixing established yields at historical values. In this way, producers neither gain nor lose future deficiency payments by changing current yields. Since the acreage base for wheat is frozen new producers cannot qualify for the program benefits. And while in previous programs, land set-aside had to be left fallow or be assigned to some other conservation use, some of the set-aside acreage can now be planted to other crops.⁹

III. A Numerical General Equilibrium Model Capturing Price Supports, Set Asides, and Endogenous Participation Decisions

To analyze the effects of price supports and set asides for wheat in the US, we use a numerical general equilibrium model of global trade in wheat which we have used elsewhere (see Trela, Whalley and Wigle (1987)). Into this model we embed a richer treatment of both farm behaviour and program supports in the US. We first describe how US wheat production, program supports, and set asides are treated in this new version of the model, and then briefly summarize the rest of the model.

US Wheat Production, Program Supports and Set Asides

The United States wheat sector is 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. As an analytical convenience, we assume that farms differ only in the elasticity of substitution between land and non-land inputs in production. We thus abstract from differences in land quality across farms, location (and thus transportation costs in shipping crops), and differences in comparative advantage across crop types between farms.

The production technology for each farm type, i , is assumed to be constant returns, and to take the CES form,

$$g_i = B \left[\delta L_i^{\frac{1-R_i}{\sigma_i}} + (1-\delta) z_i^{\frac{1-R_i}{\sigma_i}} \right]^{\frac{\sigma_i}{1-R_i}} \quad (2)$$

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 $\sigma_i = \frac{1}{1-R_i}$ is the elasticity of substitution between inputs.

Wheat-producing land (L) and other inputs (Z) are assumed to be the sole inputs in the production of wheat.

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

The profit functions from participation and non-participation are given by (3) and (4):

$$\pi_i^P = P_T^w y_i (1-\lambda) L_i - P_i^Z Z_i + T_i \quad (3)$$

$$\pi_i^N = P_T^w y_i L_i - P_i^Z Z_i \quad (4)$$

where:

π_i^N is the profit of farm i , assuming it does not non-participate in support programs

π_i^P is the profit of farm i , assuming it does participate in support programs

P^w is the free (world) market price for wheat

P_T^w is the US target price for wheat

y_i^- , y_i^+ are the optimal yields under non-participation and participation decisions, respectively

L_i^- is the total acreage available for farm i

P^Z is the price of other inputs

Z_i^- , Z_i^+ are the total amounts of other inputs used under non-participant and participant decisions respectively

λ 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 are assumed to receive the target price for incremental output, although in some later experiments we vary the degree to which deficiency payments are coupled to current yields.

Using (2), input demands for non-participating farms are given by

$$\hat{z}_i = \left\{ \frac{1}{\delta} \left(B(1-\delta) \frac{P^W}{P^Z} \right) \left(\frac{R_i}{R_i - 1} \right)^{-1} + \frac{(\delta-1)}{\delta} \right\} \cdot L_i \quad (5)$$

and their optimal yield is

$$\hat{y}_i = \delta \left[(1-\delta)B \right] \left(\frac{P^W}{P^Z} \right)^{-1} \left(\frac{R_i}{1-R_i} \right)^{-1} L_i \quad (6)$$

For participants, their input demands are given by

$$\bar{z}_i = \left\{ \frac{1}{\delta} \left(B(1-\delta) \frac{P^W}{P^Z} \right) \left(\frac{R_i}{R_i - 1} \right)^{-1} + \frac{\delta-1}{\delta} \right\} \cdot (1-\lambda) \cdot L_i \quad (7)$$

and their optimal yield is

$$\bar{y}_i = \delta \left[(1-\delta)B \right] \left(\frac{P^W}{P^Z} \right)^{-1} \left(\frac{R_i}{1-R_i} \right)^{-1} (1-\lambda) L_i \quad (8)$$

Given the program parameters P and λ , 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 (3) and (4), and a determination of the participation decision. This, in turn, allows input demands and outputs to be calculated.

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

The Remainder of the Model

As indicated above, this treatment of the US wheat sector has been introduced into a multi-country general equilibrium structure of the global grain market, used by Trela et al. (1987) to analyze the effects of global policy interventions in grains. This model uses the same ad valorem equivalent approach which we criticize here, and our modification of the earlier treatment of the US is aimed at highlighting the pitfalls of ad valorem modelling that we discuss above. Also, proceeding in this way allows comparisons between the approach used here, and a more conventional "price wedge" approach to be made for comparable data.

Thirteen countries or blocs¹⁰ of countries are identified in this earlier model, with wheat and other goods as the only produced commodities. Demands in each region are based on utility maximizing behaviour with a single

national consumer assumed who receives all the income originating in the country. This consumer faces domestic consumer prices in making consumption decisions, but the country as a whole satisfies trade balance at world prices, i.e.:

$$P^W \cdot C_k + X_k^C = P^W g_k + X_k^P \quad k=1, \dots, 13 \quad (9)$$

where P^W is the world price of wheat denominated in terms of other goods (whose price is unity), C_k is consumption of wheat in country k , g_k is production of wheat in country k , and X_k^C and X_k^P are country k 's consumption and production of other goods.

Production in all regions (all regions other than the US in the present model) is specified through a constant elasticity of transformation (CET) function between wheat and other goods where δ_k is the share parameter

$$\bar{F}_k = \left[\delta_k g_k^{\rho_k} + (1-\delta_k) X_k^{\rho_k} \right]^{\frac{1}{\rho_k}} \quad k=1, \dots, 13 \quad (10)$$

in the CET function, and is the elasticity along the transformation surface. Distortions in the wheat sector in these countries are modelled in ad valorem equivalent form, typically as ad valorem subsidies which produce a difference between producer and consumer prices within the country.

In the present modified model, a CET function is used in the US to describe the economy's production possibilities for other goods (X_{US}^P) and non-land inputs into wheat production (ZUS).

$$\bar{F}_{US} = \left[\delta_{US} X_{US}^{P \rho_{US}} + (1-\delta_{US}) Z_{US}^{\rho_{US}} \right]^{\frac{1}{\rho_{US}}} \quad (11)$$

where δ_{US} is the share parameter the CET function, and $\sigma_{US} = \frac{1}{\rho_{US} - 1}$

is the elasticity along the transportation surface, as in equation (2). The separate treatment of price supports and set asides as modelled above also enters the model.

Equilibrium Solution of the Model

The equilibrium structure of this extended model involves three prices; those for wheat, other goods, and non-land inputs into wheat production in the US. There are three associated market excess demand functions. The first two prices affect behaviour in all regions captured in the model, including the US, the third price only affects behaviour in the US component of the model.

In regions other than the US, the relative price of wheat in terms of other goods, along with the ad valorem domestic subsidies or taxes allows production and consumption of these two goods to be calculated using the first order conditions for utility and profit maximizing behaviour. Knowing producer prices in the country (given by world prices gross of any distortions at producer level), a tangency to the production frontier can be found. The country will then trade along a world price line, such that a tangency of an indifference curve and a domestic price line is found on the world price line through the production point. Solving for production and consumption behaviour in this way implies the net trades for each region in wheat and other goods.

In the case of the US, information on the prices of non-land inputs into wheat and other goods allows outputs of these two goods in the US to be determined from the first order conditions from profit maximization subject to the CET production frontier. The prices of wheat and non-land inputs also

Table 1

Data on Production, Consumption, and Trade in Wheat, and Domestic
Prices Used in Calibrating the Model
(1981 data in value terms)

A. Consumption, Production and Trade Data. (All values are in \$ billions.)

Region	Production	Consumption	Net Exports
U.S.A.	10.9	4.0	6.9
Canada	3.4	0.6	2.8
Argentina	1.3	0.7	0.6
Brazil	0.4	0.4	0.0
Other America	0.7	3.6	-2.9
China	9.7	11.7	-2.0
Japan	0.1	1.0	-0.9
Other Asia	12.6	13.4	-0.8
EEC	10.7	8.3	2.4
Other Europe & Oceania	4.4	8.6	-4.2
Australia	2.4	0.6	1.8
U.S.S.R.	14.7	16.9	-2.2
Africa	1.5	2.9	-1.4
World	72.7	72.7	

¹ Production data is from FAO Production Yearbook 1985. (1979-81 averages); Trade data is from FAO World Trade Yearbook 1981.

B. 1981 Domestic Price Data (in US\$ per metric ton)

	Producer	Consumer
	Prices ¹	Prices ¹
U.S.A.	164.0 ²	164.0
Canada	182.2	168.8
Argentina	93.9 ³	150.8
Brazil	319.0	92.8
Other America	220.4	202.5
China	164.0 ⁴	164.0 ⁴
Japan	979.0	393.4
Other Asia	235.5	151.1
EEC	168.5 ⁵	168.5 ⁵
Other Europe & Oceania	164.0 ⁶	164.0 ⁶
Australia	152.0	154.0
U.S.S.R.	123.0	123.0 ⁷
<u>Africa</u>	<u>227.8⁸</u>	<u>227.8⁸</u>

¹ Unless otherwise noted, the source for this price data is Lattimore (1982).

² Producers price for non program participants.

³ From Cirio (1986).

⁴ No data (set to "world" price).

⁵ EC intervention price. Sources Agricultural Situation in the Community (1981) and Yearbook of Agricultural Statistics (1981), both published by Eurostat.

⁶ Data used for New Zealand.

⁷ Producers' price data used.

⁸ Average of data for Kenya, Egypt, Morocco, South Africa, and Nigeria.

allow for solution of program participation decisions for all the farm types in the model, using equations (3) - (8). This allows both the use of non-land inputs, and the returns to land for all farm types to be calculated. Knowing the value of production of other goods and non-land inputs, and the return to land for all farm types, allows aggregate income and hence US demands for other goods and wheat, to be determined.

Aggregating across the US and all the other countries or regions in the model yields the market demands for wheat and other goods. Summing production across all countries yields total supply, and hence excess demand for wheat and other goods. The third excess demand is given by the difference between the demand for non-land inputs into wheat summed across all farm types, and output of Z_{US} from the tangency to the CET production frontier in the US.

The model thus generates a system of three excess demands involving three prices. Equilibrium occurs in the model when a zero is found for all three excess demands. The model is solved using a modified Newton method, for which the experience has been that convergence is rapid.

IV. Data, Model Calibration, and Elasticities

We use 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. The global component of the model has been calibrated to the 1981 data set using the inverse function method outlined in Mansur and Whalley (1984). This involves solving for values of share and scale parameters in the CES and CET functions so as to produce data on quantities demanded and produced as solutions to optimising behaviour at 1981 equilibrium prices.

Prior to implementing these procedures, values of substitution elasticities in the CES and CET functions need to be specified. We use estimates reported by Valdes and Zeitz (1985) for supply and demand elasticity estimates for wheat by country, and values of the elasticities of substitution are chosen to reproduce these.

The main features of the microconsistent data used in this calibration procedure are displayed in Table 1. They show the large net export position of the US in wheat in 1981, along with the significant wheat export position of the EEC. Price data reveal the significant effects of domestic policy interventions by region, especially in Japan. US producer prices are those paid to non-participants, rather than target prices.

To use the inverse function calibration method to determine parameters for the wheat production functions for the US component of the model it would be necessary to know acreage, input use, yields, and the elasticity of substitution between inputs for farms of all types. There is no linked data of this form available.

We therefore iteratively search across combinations of the wheat production function parameters, δ , B , and the mean value of R_i until the following three conditions are met:

- (i) The US production of wheat from farm optimising behaviour equals the value of production in the microconsistent data set.
- (ii) Non-land inputs used in the production of wheat as a result of optimising behaviour equal the value of inputs appearing in the microconsistent data set.
- (iii) The endogenously determined participation rate equals the observed 1981 rate of 42 percent.

We thus determine values of these parameters such that optimising behaviour by farmers is consistent with the observed data.

We then assume that the substitution elasticities across farms, R_i are spread over an interval, with a stepsize somewhat at 0.065. This distribution of R_i leads to a mean supply elasticity of wheat of 0.78, in line with consensus estimates used elsewhere.¹¹ This 0.065 step-size can then be varied in subsequent sensitivity analysis. These differences in substitution parameters across farms allow an endogenous participation rate to be determined which matches the 1981 observed value of 42 percent.

Table 2 reports both some of the other data we use in implementing these procedures, along with the substitution elasticities by farm class and implied own price elasticities of wheat supply by farm type. The data on program characteristics are presented largely to provide an indication of the differences between market prices, loan rates and target prices and in a footnote we indicate how these have changed in recent years. The set-aside rate, λ , used in the model is the 1981 value of 15 percent.

An issue of some controversy in the agricultural economics literature¹² has been the degree of "slippage" in commodity programs, and it is worth indicating how this was handled in the data and the model. Slippage indicates the extent to which a 1 percent acreage reduction in the program due, say, to participation in set asides, leads to a smaller than 1 percent reduction in both planting and yields. Slippage reflects the response of farmers to a number of substitution margins in response to set aside requirements. These include more intensive use of remaining land, setting aside the least productive of the land they have available for cultivation, and planting all land and then subsequently plowing under the least productive

Table 2

Data on the U.S. Wheat Sector Used in Calibrating the ModelA. Production Data

1. Wheat Programme Acreage		90.6 Million Acres ¹
2. Value of non-land inputs into wheat production		\$6.84 Billion ²
3. 1981 participation rate		42%
4. Farm Types	Elasticity of Substitution Ri	Own Price Elasticities of Wheat Supply by Farm Type
0	0.31	0.45
1	0.38	0.60
2	0.44	0.78
3	0.50	1.02
4	0.57	1.32

B. 1981 Program Support Levels³
(Prices are \$US per bushel.)

Target price	3.81
Market price	3.66
Loan rate	3.20
Paid diversion	5%
Set-aside requirement	15%

¹ Glaser (1986) p. 85.² Estimate based on U.S.D.A. information for Illinois.³ Coyle et. al., p. 16.⁴ Comparable data for 1986 are \$4.38 for the target price, \$3.30 for the market price, and \$2.40 for the loan rate, showing the large increase in programme supports occurring through the 1980s.

once the realized yields on the various parcels of land is known. The "slippage" from farms altering their input use in response to land being idled as a result of set asides is captured in the model, but these other effects are not. To the extent that increased cultivation of non-idled land is the largest source of slippage, making no special modifications to the model to take account of these other factors seems to us a reasonable way to proceed.

V. Comparing Ad Valorem and Full Program Modelling of US Wheat Market Intervention

In this section, we report results from the model on the effects which would follow from elimination of both US price supports and set-aside requirements for wheat using 1981 data. We contrast the results from our model when programs are represented in "full form", that is incorporating the endogenously determined participation decision as set out in the preceding section, with those produced by a comparable model in which their effects are modelled in ad valorem equivalent form. The differences between both production and welfare effects of eliminating program supports and set asides are large, emphasizing the point we make in the introduction to our paper, that ad valorem equivalent modelling of the effects of these programs can be highly misleading. We also explore the sensitivity of model results to elasticity values and other parameters.

Because of the sharp escalation of program supports in recent years, we have chosen to dramatize our model results by using the estimates of ad valorem equivalent for wheat support programs represented as the producer subsidy equivalent (PSE), reported in recent USDA publication (1987) rather than the actual levels of program supports for 1981 in our microconsistent

equilibrium data set. The PSE for wheat is defined by the USDA as "the revenue required to compensate producers if existing government programs were eliminated", which the USDA estimates for wheat to be in the range of 0.25 to 0.49 (ibid. p. 29). This PSE estimate thus suggests that the value of US programs to producers is between one-quarter and one-half of the gross domestic value of production. This includes deficiency payments, paid diversion and the commodity loans program.

We have used the minimum of this USDA range in modelling the effects of US intervention in the wheat market, first treating these commodity programs as equivalent to an ad valorem producer subsidy. When modelled in this way, these programs have an unambiguously positive effect on production, even though our earlier discussion suggests the net effect of commodity programs is ambiguous. This is because of the offsetting effects of set-aside requirements, and production incentives associated with program benefits.

With the programs modelled explicitly, as in earlier sections, the results could hardly be more different. This is shown in Table 3. When modelled as ad valorem subsidies, eliminating the programs causes US output to fall and the world price to rise. When the policies are explicitly modelled to capture changing participation decisions and acreage set asides, the opposite result occurs. Our estimated PSE is low, and increasing it to the middle of the range suggested by the USDA's calculations would only serve to increase the disparity in results between the two approaches.

Under explicit program modelling, output rises when programs are abolished because the increase in production from the extra acreage planted more than offsets the fall in production due to the decrease in prices received by producers originally in the program. In the ad valorem subsidy

Table 3

Effects on Production and Welfare from Elimination of U.S.
Price Supports and Set Asides for Wheat

When U.S. Intervention is Modelled As:

	(1) <u>Producer Subsidy Equivalent</u>	(2) <u>Full Commodity Program with Price Supports and Set Asides</u>
% Wheat Production in U.S.	-10.3	+1.3%
% World Price	+9.1%	-1.11
% Rental Value of Land Used for Wheat Production	N/A	-1.6%
% Change in U.S. Welfare as a % of the Value of Wheat Production	6.5%	1.4%

% Change in Production in Other Countries:

Canada	2.4	-0.3
Argentina	1.8	-0.2
Brazil	1.8	-0.2
Other America	1.8	-0.2
China	0.0	0.0
Japan	0.0	0.0
Other Asia	2.0	-0.2
EEC	0.0	0.0
Other Europe & Oceania	1.8	-0.2
Australia	3.9	-0.5
USSR	0.0	0.0
Africa	0.0	0.0
World	-0.8	0.1

* Welfare is measured as the Hicksian EV in millions of \$US (1980) and calculated as a proportion of the original value of production at world prices.

case, the output of the US wheat sector must fall when the subsidy is eliminated so long as the world price does not rise by more than the subsidy.

Other implications follow from the results. When support programs are explicitly modelled, budget expenditures of over one quarter billion have a remarkably small impact on land rents. This is because the idled resources implied by acreage set-asides act as lump sum taxes on program participants. Budget expenditures of \$264 million are initially associated with annual land rents of \$4,281 million. Elimination of program supports reduces program costs to zero, but only reduces annualized returns to land by \$75 million, or less than 2 percent.

Also, the effects of program elimination are different across farms. Farms that were previously participating experience a loss of program benefits, plus a decrease in world price. Farms who were not initially participating only experience the effects of the lower world price. Land values thus fall by 3.3 percent for the most-likely-to-participate class of farms, but by only 1.1 percent for the least-likely-to-participate.

Furthermore, the elimination of set-asides and paid diversion generates a sizeable welfare gain for the US, and the world as a whole. The world welfare gain (\$245 million) corresponds almost precisely to the value of the land originally idled under the set-aside program (\$253 million). Results in Table 3 suggest that while adverse terms of trade effects from abolition of US programs do occur, they are not large enough to offset the welfare gains associated with eliminating the waste of domestic resources.

In all numerical modelling, the implied effects of policy changes depend on both the structure of and the underlying parameter values used in the model. In the present case, we can be reasonably sure that the qualitative

effects on output and welfare from removing program supports when modelled as ad valorem subsidy form will not be sensitive to model specification. However, the qualitative effects when programs are explicitly modelled do depend on the parameter specification, since the output response will depend on both the elasticities of substitution between land and other inputs, and the elasticity of transformation between agricultural inputs and non-agricultural goods.

Some sensitivity analyses of the results reported in Table 3 are presented in Table 4. Results under ad valorem equivalent treatment are not that sensitive to model respecification. All of the signs of changes in response to program elimination are preserved. Perhaps somewhat surprisingly, when programs are explicitly modelled results are also not qualitatively changed by using these alternative re-specifications of the model.

This seems to give more support to the hypothesis that, at least in the pre-1985 period, the set-aside features of commodity programs in the US more than offset production incentives associated with increases in target prices.

VI. Summary and Conclusions

This paper stresses the pitfalls involved in modelling domestic agricultural support programs in ad valorem equivalent form, illustrating how in the use of US commodity programs for wheat, payments to producers who participate in programs are linked to non-marginal reductions in total acreage planted. High support prices which might appear to subsidize production can thus also increase participation in support programs cutting acreage planted, and potentially reducing output. Ad valorem modelling will miss these effects.

Table 4

Sensitivity of Results on the Effects of US Programme Supports for Wheat to Model ParametersSensitivity of Results to Model Specification when US Intervention Modelled in Ad Valorem Equivalent Form

	Central Case	"High" Supply ¹ Elasticities	"Low" Supply ¹ Elasticities	"High" demand ¹ Elasticities	"Low" demand ¹ Elasticities
% Δ U.S. Production	-10.3	-17.8	-6.0	-11.7	-9.2
% Δ World Production	-0.8	-0.9	-0.6	-1.2	-0.5
% Δ World Price	+9.1	+10.5	+7.0	+6.9	+10.8
% Δ U.S. Welfare Relative to Wheat Production	6.5	7.7	5.0	5.4	7.3

¹ "High" and "Low" mean that the specified elasticities of substitution in production and demand are (respectively) doubled, and halved in all countries.

Sensitivity of Results to Elasticity Specification when US Programme Supports are Explicitly Modelled

	Central Case	Supply Elasticities in all regions other than the US		Demand Elasticities in all regions		Elasticity of Transformation between non-land inputs & other goods in the US		Elasticity of Substitution in farm production in the US	
		High ¹	Low ¹	High ¹	Low ¹	High ¹	Low ¹	High ¹	Low ¹
% Δ U.S. Production	1.3	1.4	1.2	1.5	1.2	1.0	1.6	1.2	1.4
% Δ World Production	0.1	0.1	0.1	0.2	0.1	0.1	0.1	0.1	0.1
% Δ World Price	-1.1	-0.8	-1.3	-0.8	-1.3	-0.9	-1.4	-1.0	-1.2
% Δ U.S. Welfare Relative to Wheat Production	1.4	1.6	1.2	1.6	1.2	1.6	1.2	1.5	1.3
% Δ Rental Value of Land	-1.6	-1.2	1.8	-1.2	-1.9	1.5	-1.7	-1.1	-2.1

¹ "High" and "Low" elasticity configurations involve all specified elasticities being set equal to twice and one-half (respectively) of the central case estimate used in all countries. In the case of the US elasticity of transformation, there is no corresponding elasticity in other regions in the model. Since the distribution of farms is specified by the mean elasticity of substitution between land and other inputs, and the associated range, these configurations can be summarized in terms of the implied supply elasticities for wheat.

	Wheat Supply Elasticities		
	Mean	Minimum	Maximum
Low	0.47	0.22	0.85
Central Case	0.78	0.45	1.32
High	1.14	0.70	1.87

A numerical general equilibrium model built and calibrated to 1981 data suggests that, when fully modelled, US commodity program can have a positive effect on producer incomes, and a negative effect on total production, which is opposite to the effects which would be portrayed by ad valorem equivalent models. The model also serves to highlight the (perhaps obvious) wastefulness of commodity programs which involve unemployment of productive resources (acreage set-asides) as a pre-condition for income support. This is reflected in the relatively small reduction in land rents brought about by abolition of commodity programs in the model simulations.

Similar features occur in commodity programs in other countries, such as the Japanese rice support program, and so the use of ad valorem equivalent measures of the effects of agricultural programs obviously needs to be more widely questioned. This same point also carries over into the current international trade negotiations in the Uruguay Round where much of the technical work is focused on the construction of ad valorem-like measures (producer subsidy equivalents, or PSEs) as negotiable instruments.

ENDNOTES

1. See, for example, Chisholm and Tyers (1985), Valdes and Zeitz (1980), and Froberg et al. (1987).
2. We concentrate on pre-1985 programs, because of changes in support programs in the 1985 Farm Bill. These weakened but, as we discuss below, by no means removed the features we stress here.
3. These include the 'acreage quotas' used by the Canadian Wheat Board to limit grain deliveries to wheat pools. One can argue that the major constraint on grain production is the transportation system, and these quotas merely ration access to shipment facilities. Price supports to dairy farmers in the EEC have, since 1984, been accompanied by quotas. Again ad valorem equivalent modelling of the price support component alone will be misleading. Also, rice producers in Japan must comply with acreage diversion requirements in order to qualify for high support prices paid by the government (see Yasuo (1987) and Naraomi and Takamitsu (1987)). Another complex situation is the differential exchange rate facing farm exporters in Argentina (see the description in Cirio (1987)).
4. See the exposition of applied general equilibrium modelling techniques in Shoven and Whalley (1988).
5. This is a government-owned and operated corporation established in 1933 to stabilize and support farm incomes and prices.
6. Farmers also receive diversion payments to cover part of the foregone earnings on idled land. These apply to required diversions and to voluntary (extra) acreage diverted to approved conservation uses. The sum of deficiency and diversion payments is capped at \$50,000 per farm under the wheat and feed grain programs combined, although this is rarely a binding constraint for wheat producers since until recently there were no restrictions on subdividing acreage covered by the programs.

7. In periods when price supports (and loan rates) have been high, such as in the late 1970s, a sharp growth in stockpiles of wheat and feed grains has occurred. Further policies beyond acreage reductions have then been used for stockpile management. One such programme was the Payment-In-Kind (PIK) programme introduced in 1983. Under this programme, farmers who agreed to reduce their acreage by between 10 and 30 percent more than the amount required to be eligible for loans, purchases, and payments were compensated by the government, in-kind, i.e. by payment of commodities out of its own commodity reserves.
8. Also, the more that yields vary across the land on any individual farm, the more attractive is the program, since the lowest yield land can be diverted from production.
9. Subject to limitations that aim to avoid gluts.
10. The assumption that only R_i (or equivalently σ_i) varies by farm class also generates a distribution of yields across farms.
11. To simplify the calculations we make with the model, we calculate solutions to farm optimization problems for five elasticity values, and interpolate over a range of elasticities of substitution between land and other inputs.
12. United States, China, Australia, Canada, Japan, USSR, Argentina, Other Asia, Africa, Brazil, EEC, Other America, Other Europe & Oceania.
13. Valdes and Zeitz estimate is 0.80.
14. See Garst and Miller (1985) for example.

References

- Chisholm, A.H. and R. Tyers. Food Security: Theory, Policy and Perspectives from the Pacific Rim. Amsterdam: North-Holland, 1982.
- Cirio, F. "Agricultural Trade in Argentina: Impacts on the Global Economy and Strategy for the Next GATT Negotiations". Mimeo, June 28, 1986 (on file).
- Coyle, B., Robert G. Chambers and Philip L. Paarlberg. "Measuring the Gains from Trade for US Farm Exports". USDA Economic Research Service (FAER-XXX) 1985.
- Dam, K.W. The GATT. Chicago: University of Chicago Press, 1970.
- de Goerter, H. and Karl Meilke. "The EECs Wheat Price Policies and International Trade in Differentiated Products". American Journal of Agricultural Economics. January 1987.
- Food and Agriculture Organization of the United Nations. FAO Commodity Review and Outlook 1980-81. Rome: FAO, 1981.
- Food and Agriculture Organization of the United Nations. Production Yearbook 1981. Rome: FAO, 1982.
- Food and Agriculture Organization of the United Nations. World Trade Yearbook 1981. Rome: FAO, 1982.
- Garst, Gail D. and Thomas A. Miller. "Impact of the Set-Aside Program on US Wheat Acreages", Agricultural Economics Research, Vol. 27, No. 2 (1983), 30-7.
- Gerrard, C. and G. Posehn. "Government Intervention in Food Grain Markets in Kenya". Saskatchewan: University of Saskatchewan, (mimeo), 1985.
- Glaser, Lawrence K. Provisions of the Food Security Act of 1985. Washington: USDA (Economic Research Service) 1986.
- Hufbauer, G.D. and J.S. Erb. Subsidies in International Trade, Washington, DC: Institute for International Economics, 1984.
- Lattimore, R.G. "World Grain Market Instability and Food Security: An Exporters Perspective". Chapter in A.H.
- Chisholm and R. Tyers, Food Security: Theory, Policy and Perspectives from the Pacific Rim, 1982.
- Naraomi, Imamura and Sawa Takamitsu. "Rice and the Politics of Protectionism", Japan Echo, Vol. XIV, No. 3 (1987), 57-61.

- Shoven, J.B. and J. Whalley, *Applying General Equilibrium, 1988*, to be published by Cambridge University Press.
- Trela, Irene, John Whalley and Randall Wigle. "International Trade in Grain: Domestic Policies and Trade Conflicts" in *Scandinavian Journal of Economics*, Vol. 89, No. 3 (1987), 271-83.
- USDA (Economic Research Service) *Policy Research Notes Issue 22*, Washington: Government Printing Office, November 1986.
- USDA (Economic Research Service) *Government Intervention in Agriculture: Measurement, Evaluation, and Implications for Trade Negotiations*, Washington: Government Printing Office, April 1987.
- Veeman, T. and Michele Veeman. *The Future of Grain: Canada's Prospectives for Grains, Oilseeds, and Related Industries*. Toronto: The Canadian Institute for Economic Policy, 1984.
- Yasuo, Takeuchi. "Rice Policy: The Outlook for Change", *Japan Echo*, Vol. XIV, No. 3 (1987), 55-6.