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Modelling distortionary aspects of the US wheat program and policy reform

B. Stephen Labson
Australian Bureau of Agricultural and Resource Economics
GPO Box 1563, Canberra 2601

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Evaluation of US agricultural policy reform is complicated by the interaction of price support programs and production constraints. Researchers have typically presumed that price support policies as observed in the US wheat program increase the producer incentive at the margin; however, little work has been done to determine whether such a presumption is warranted by the data. In this paper the structural model of price support based on production constraints is developed and its predictions compared with the data. From the structural model, a simulation model is constructed to evaluate the effect of US agricultural policy reform on US wheat production, exports and price. Simulation results demonstrate that the elimination of price support and production controls increases acreage planted to wheat, as a portion of acreage which was previously set aside is returned to production. The net increase in production leads to a corresponding decrease in market price. The price effects are shown to be potentially large, given the inelastic nature of excess demand facing the United States.

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Introduction

The Uruguay Round of the GATT has called for trade liberalisation in the form of limitation of agricultural policies which have a distorting affect on world trade. The GATT mandate has induced a great deal of research regarding the quantitative effects of agricultural policy reform. Because the United States is a major exporter of grains, the distortionary impact of its farm policy is of great importance in world trade of grains. However, evaluation of US agricultural policy reform is complicated by the interaction of various policy instruments. For example, producers who participate in the US wheat program receive price support, but they are often required to 'set aside' acreage from production. Furthermore, the quantity of production eligible for price support is based on past production, and is thus itself subject to constraint.

Researchers (for example, Tyers and Anderson 1986; Roningen, Sullivan and Waino 1987) have typically presumed that, at the margin, US agricultural policy promotes production due to the price support mechanisms employed. Operationally, in their models US price support is treated as an unconstrained *ad valorem* producer subsidy. Hertel, Thompson, and Tsigas (1989); and Robinson, Adelman, and Kilkenny (1989) explicitly take account of the effect of the set-aside requirement, but they too presume that the level of price support offered to farmers is a reasonable approximation of the price incentive facing all US farmers. Their results suggest that US farm policy promotes grain production, as compared to an undistorted market, even when set-aside is considered.

Whalley and Wigle (1988, 1990), and Rutherford, Whalley, and Wiggle (1991), have argued that models of policy reform that measure the effect of US price support without taking into account the voluntary nature of the US farm program can be misleading in their predictions. Since only producers who participate in the program and comply with production constraints receive price support, it is inappropriate to presume that all US farmers face the same producer incentive price. Kilkenny and Robinson (1991) have taken account of the different production incentives faced by program participants and non-participants. However, they have not addressed the fact that price support within the US farm program is typically based on past planting decisions. The importance of this feature is that price support conditional on production constraint may not increase production at the margin.

Econometric models of agricultural policy reform (for example, Westhoff, Stephens, Helmar, Buhr and Meyers 1990; Just, Rausser and Zilberman 1991) typically produce results which imply that the price support mechanism, as observed in the US wheat program, is production decreasing. This perverse result is obtained because the increase in price support increases the level of acreage entered into the program, which further increases total acreage set aside when production constraints are in effect. While most of the behavioural relations used in these models are estimated and are subject to standard specification tests, the sampling properties and empirical validity of the many market identities are often less well understood. Although standard measures of model validation are usually examined, the sampling properties of such measures are not well defined.

Thus, while a great deal of work has been done concerning the effect of US agricultural policy reform under certain presumptions as to the nature of the distortionary effects of US price support measures on production and market clearing price, little work has been done to determine whether the models used adequately reflect the true distortionary effects. The purpose in this paper is to extend the existing work in several directions. First, a structural model of production is presented, incorporating price support based on production constraints. Using this structural model, comparative static exercises are conducted which offer predictions which can be compared with observed data in order to ascertain the empirical validity of the structural model. Furthermore, on the basis of the structural model it is possible to identify and estimate key structural parameters necessary for this policy evaluation. Most importantly, it is possible to identify and estimate the free market supply function for US production using data observed in the distorted market. Using this information, a policy simulation model which is compatible with the data is constructed in order to better understand the effects of US agricultural policy reform.

This framework is here applied to the US wheat sector. In the first section, areas of the US wheat program that are relevant to this study are described. Next, a partial equilibrium model is introduced which captures many of the distortionary aspects of the US wheat program, and whose predictive accuracy is tested by reference to historical data. In the third section an econometric policy simulation model which solves for quantities and prices is presented. The simulation model is then used to quantify the effects of US agricultural policy reform.

The policy set

The set of policy instruments currently employed in the US wheat program is essentially that established by the Agricultural and Consumer Protection Act of 1973 (one of the series of 'farm bills' in which US agricultural policy is formulated at intervals of four or five years).

The major instruments used are target price, acreage controls and loan rate. While these policy instruments have remained intact since 1973, their settings are subject to change by Congress and the Secretary of Agriculture. Participation in the program is voluntary, and changes from year to year. A brief summary of the characteristics of the major policy instruments follows. For a more detailed explanation of the policy set, see Gardner (1987, 1989).

Deficiency payments

Producers who participate in the wheat program are eligible for deficiency payments. The unit value of the deficiency payment is the difference between the legislated 'target' price and either the market price or the loan rate (see below), whichever is the higher. Producers receive this deficiency payment for a predetermined 'program yield' times a given proportion of their 'base acreage'. Acreage planted by participating producers is often (but not always) constrained not to exceed their base acreage minus a uniform percentage which is to be set aside (the diversion rate — see 'Acreage reduction', below). Base acreage is a five year moving average of acreage 'considered planted', which consists of acreage planted, set aside as above, and diverted in other ways referred to below. The program yield has been fixed since 1985. Prior to 1985, program yield was based on a rolling average of past yields. By fixing program yield, much of the distortionary effect of price support has been removed from the production decision regarding variable inputs, since the yield on which farmers receive price support no longer increases with their realised yield. Over the past decade, deficiency payments have ranged from less than 5 per cent of market price to over 50 per cent.

Acreage reduction

Subject to the discretion of the Secretary of Agriculture, yearly diversion rates are established which limit the amount of a participating producer's base acreage eligible for payments, through the Acreage Reduction Program (ARP). A uniform rate is set which is the percentage of the producer's base acreage that must be set aside for the crop year. During the 1980s, the diversion requirement rose to as much as 30 per cent of base acreage.

The loan rate

The Commodity Credit Corporation (CCC) is required by law to accept wheat as collateral from program participants in exchange for a loan repayable in nine months. The amount of the loan is equal to the number of bushels placed as collateral times the legislated 'loan rate'. Within the nine month loan period, producers can pay back the loan plus interest and sell at the market price if they wish. The terms of the loan are 'non-recourse' — that is, if the producer wishes to default on the loan, the grain held as collateral serves as payment in full. In general, the loan rate serves as a price floor, in that the CCC stands willing to purchase whatever amount is necessary to support the price at the loan rate. The loan rate has often provided an effective price floor for wheat; however, it is important to note that, since 1988, the loan rate has been well under the market price received by US farmers.

The Farmer-Owned Reserve

The Farmer-Owned Reserve (FOR) is a long term storage program. A loan rate is established which may differ from that above, but which likewise provides a price floor, and loans are made against wheat stored. In addition, the government pays the farmer a storage payment. Originally, the terms of the FOR required that wheat be held for a minimum of three years, but the 1990 farm bill has relaxed this constraint and farmers may release FOR stocks at their discretion.

Additional voluntary diversion programs

Several other program instruments have been used to divert more acreage from production than the minimum required diversion mentioned above. Voluntary diversion has taken place under payment-in-kind (PIK) programs, whereby farmers are paid in grain from CCC stocks, in amounts approximately equal to their forgone production. This program instrument has been used sparingly, however, for in the several years that it has been used the effect on the market has been significant. In 1983 over 18 million acres were set aside under the PIK program.

Since 1986, producers have been offered additional incentives to divert acreage. Producers receive deficiency payments on 92 per cent of any acreage diverted from production over and above the minimum diversion required under the ARP. When the program was instituted in 1986, the maximum amount of diversion eligible for payments under this program was 50 per cent of the farmer's base acreage. Currently, farmers may divert 100 per cent of their base acreage and remain eligible for payment on the acreage diverted in excess of the ARP constraint. This paid diversion program is hence called the '0–92' program, since producers can plant 0 per cent of their base acreage while receiving deficiency payments on 92 per cent of eligible acreage.

The Food Security Act of 1985 authorised the Conservation Reserve Program (CRP), with the intention of removing 40–45 million acres of fragile crop land from production for a ten year period (Young and Jagger 1989). Payments by the government are based on individual bids by the producers. Over 10 million acres of wheat base acreage have been entered into this long term diversion program since its inception.

The 1990 farm bill includes new provisions which are intended to allow for more flexibility in adjusting to market signals. Tsolakis, Love and Helmar (1991) report the results of a simulation experiment on a policy similar to the flexibility provisions of the 1990 farm bill. The results indicate that such flexibility provisions will change wheat production by less than 2 per cent. In view of this result, the relatively minor implications that the flexibility measures may have on the wheat sector will not be considered here.

Selected statistics concerning the US wheat program are given in table 1.

Table 1: Selected US wheat program statistics, 1974–1989

Year a	Target price	Farm price	Loan rate	Base acreage b	Enrolled acreage	Acreage reduction c
	$/bushel	$/bushel	$/bushel	million acres	% of base	%
1974	2.05	4.09	1.37	55.0	100	0
1975	2.05	3.56	1.37	53.5	100	0
1976	2.29	2.73	2.25	61.6	100	0
1977	2.90	2.33	2.25	62.2	100	0
1978	3.40	2.97	2.35	58.8	63	20
1979	3.40	3.80	2.50	70.1	51	20
1980	3.63	3.99	3.00	75.0	100	0
1981	3.81	3.69	3.20	84.5	100	0
1982	4.05	3.45	3.55	90.6	48	15
1983	4.30	3.51	3.65	90.2	78	20
1984	4.38	3.39	3.30	94.0	61	30
1985	4.38	3.08	3.30	93.9	73	30
1986	4.38	2.42	2.40	91.6	84	25
1987	4.38	2.57	2.28	87.6	87	27.5
1988	4.23	3.72	2.21	84.8	85	27.5
1989	4.10	3.72	2.06	82.3	78	10

a Crop year. b Including that of non-participants. c Requirements of Acreage Reduction Program and the similar, but minor, Cash Land Diversion Program.
Source: US Department of Agriculture (1991).

A partial equilibrium analysis of the US wheat program and acreage response

Under the current US wheat program, as explained above, acreage eligible for program benefits for any given year is predetermined, since base acreage is determined by past acreage 'considered planted'. In a static analysis, therefore, total acreage planted to a program crop can be expressed as the sum of constrained acreage planted by program participants and acreage planted outside the program. This simple identity provides the starting point for the model used here to evaluate the effect of program instruments on total acreage planted to a program crop. This structure is similar to the crop supply model presented by Just, Rausser, and Zilberman (1992). Total acreage planted is defined as:

(1) $$AP \equiv (1-\alpha_\pi)Q_m + \alpha_\pi \overline{Q}$$

where α_π is the proportion of base acreage entered into the program $(0 \le \alpha_\pi \le 1)$, $\overline{Q}$ is the constrained acreage, which is the base acreage (BAC) times one minus the diversion rate, $\overline{Q} = (1-AD)\ BAC$,

and $$Q_m = \arg\max F(P_m), \frac{\partial Q_m}{\partial P_m} \ge 0$$

which denotes that Q_m is the acreage, Q, such that some function $F(\,)$ is maximised: that is to say, the acreage which would have been planted at market output price P_m in the absence of a distortionary farm program. Furthermore, Q_m is increasing in market output price P_m. Similarly,

$$\alpha_\pi = \arg\max G(\pi), \frac{\partial \alpha_\pi}{\partial \pi} \ge 0,$$

where π is addition to net returns per acre obtained by participating in the wheat program.

Since participation in the US wheat program is voluntary, it is necessary to explain the participation decision in order to understand the effect of the program on total US production. The participation rate α_π is presumed to be an increasing function of p.

Excess profit per acre from program participation, π, is defined as the value of deficiency payments minus forgone returns due to the diversion requirement, plus additional diversion payments.

(2) $$\pi = \bar{y}[(P_T - P_m)(1 - AD) - (P_m - VC)AD + ADP]$$

where $\bar{y}$ is a conversion factor used to convert price per bushel into price per acre, P_T is the target price per bushel, VC is a measure of variable costs per bushel, AD is the proportion of base acreage a farmer must divert in order to participate in the program, and ADP is any applicable additional diversion payments. For this partial equilibrium analysis, the yield of non-participants is also taken as fixed. This simplifying assumption does not change the qualitative results of the analysis, and is relaxed later in the quantitative analysis, where a distinction is made between expected yields and program yields.

For simplicity of presentation, market price is exogenous in this section. In the simulation exercise, price is determined within the model. Also note that the loan rate has not been accounted for. The omission of the loan rate has no effect on the results for situations in which P_m is greater than the loan rate and less than the target price.[1]

Dependence of acreage planted on target price and diversion requirement

The model provides predictions about observable relations which can be compared with historical data in order to ascertain its validity. First, differentiate the acreage identity of equation (1) with respect to the target price.

(3) $$\frac{dAP}{dP_T} = (\bar{Q} - Q_m)\frac{\partial \alpha}{\partial \pi}\frac{\partial \pi}{\partial P_T}$$

This expression is zero or negative provided that Q_m is greater than $\bar{Q}$. This is the case, in equilibrium, if Q_m is taken to be the base acreage — that is, if the latter is the acreage that in the past was planted at market price — and if the diversion rate is positive. Under these assumptions, the model unambiguously predicts that an increase in the target price decreases acreage planted, or at least leaves it unchanged. An increase in the target price makes program participation more attractive, which leads to an increase in set-aside acreage. (The feedback effects on the market price, and thus on production, are not accounted for in this part of the analysis, but they are explicitly accounted for in the simulation exercise. For the wheat market, such feedback effects are shown to be minor.)

1 These results may not generalise to a stochastic environment. The loan rate truncates the distribution of expected price, and a change in the loan rate will therefore change expected price, even when the expected price is above the loan rate. A stochastic model has been developed by J.T. LaFrance and V.H. Smith (Department of Agricultural Economics, Montana State University, personal communication, 1990). This limitation is not likely to have much importance for the study at hand, since the loan rate is well below market price.

The effect of the diversion requirement on the acreage planted can be evaluated by differentiating the acreage identity with respect to the diversion requirement.

(4) $$\frac{dAP}{dAD}=\alpha_{\pi}\frac{\partial\overline{Q}}{\partial AD}+(\overline{Q}-Q_{m})\frac{\partial\alpha}{\partial\pi}\frac{\partial\pi}{\partial AD}$$

The first term in equation (4) is the direct effect of a change in the diversion rate. It is negative, and is the proportion of base acreage entered into the program times the base acreage itself. Thus, it is simply the acreage entered into the program.

The second term in equation (4) is the indirect effect of a change in the diversion rate. As the diversion rate increases, so does the opportunity cost of participation, and thus participation decreases. As participation decreases acreage planted increases, since less land is subject to the diversion requirement. This indirect positive effect partially offsets the negative direct effect. The sign of expression (4) cannot be ascertained a priori. However, when estimates of the underlying parameters (obtained for the policy simulations reported later) are inserted, the predicted net influence of diversion rate on acreage planted proves to be negative, though with less than a one-to-one correspondence: that is, a 1 percentage point increase in diversion rate will reduce acreage planted by less than 1 per cent of the base acreage. The increased opportunity cost of program participation and resulting decrease in acreage under acreage constraint tempers the direct effect of the change in the diversion rate.

A reduced form test of the structural model

In order to test the empirical validity of the market identity represented in equation (1), a reduced form test was constructed (see table 2) by regressing the policy instruments on total acreage planted to wheat in the United States over the period 1974–89 (the period over which the present policy instruments have been in use). The target price was deflated by the

Table 2: Reduced form test of the structural model

Dependent variable	Constant	Target price	Diversion rate	Market price	$\overline{R}^2$	DW
AP a	110.89	-8.153	-25.115		.56	1.48
		(-1.882)	(-1.782)			
AP a	101.44	-7.339	-21.490	1.388	.59	1.52
		(-1.736)	(-1.537)	(1.311)		

a Corrected for first order serial correlation. Figures in parentheses are t values.

US producer price index (PPI). A simple linear function was used, with area planted measured in million acres and target price in constant US dollars per bushel. In order to determine whether the results were robust against omitted variables, the reduced form test was then repeated adding expected price as a regressor, using as proxy for expected price at planting time the average of the high and low Chicago Board of Trade futures price of wheat quoted in October for September delivery, deflated by the PPI.

In this reduced form test an identification problem may arise, since in the structural model the influences of the target price and diversion requirement depend on a number of exogenous variables. (In the policy simulation section, the underlying parameters will be specified in order to ameliorate this identification problem.) The test will therefore give only an idea of an average effect of the target price and diversion requirement on acreage planted over the sample period. Since the point of this reduced form test is to ascertain the empirical validity of the model, the results are nevertheless helpful.

First, according to the model, and under the assumptions adopted, the coefficient on the target price will never be positive. For the sample period under consideration, the target price is found to have a negative effect on acreage planted. In both tests, the coefficient on the target price is significantly less than zero, as judged by the one tail test, which is the appropriate test for the hypothesis in question.

Second, as has been mentioned, when estimates of the structural parameters are inserted into the model, an increase in the diversion rate is predicted to have a negative influence on acreage planted; however, the relation should be less than one-to-one. From the estimated reduced form coefficient on the diversion rate of –21.5 it would follow that a 30 per cent diversion requirement results in less than a 10 per cent acreage reduction. This result must be interpreted with care, as the coefficient is dependent on exogenous system variables and, as argued earlier, can only be interpreted as some sort of average over the sample period.

Dynamic effects of the wheat program

de Gorter and Fisher (1989), using a deterministic, dynamic model, have argued that producers may vary their production decisions in order to gain future benefits related to the farm program. They assume that farmers maximise a stream of profits. If farm subsidies are proportional to acreage constraints based on a moving average of past acreage planted, farmers have an incentive to increase acreage planted. A rise in the target price, by increasing this incentive, might lead to an increase in acreage.

To capture such possible dynamic influences, the same tests as reported in table 2 were first run with a lagged dependent variable. The coefficient on target price (table 3) is again negative, as in the static model.[2]

This test procedure is subject to an obvious identification problem. Furthermore, it is well known that the geometrically distributed lag structure used here may be overly restrictive, particularly when there are several explanatory variables (see, for example, Theil 1971). For these reasons, a bivariate test was also performed which imposes less a priori restrictions on the underlying dynamics of the system. The target price was regressed on acreage planted at various lag lengths. Following the Akaike final prediction error criterion, a five year lag length was chosen. In view of the limited degrees of freedom, the bivariate test was run with a smoothed second order polynomial distribution of the lag weights, as well as without restriction on the lag distribution. The results are reported in table 4.

No attempt has been made to identify the dynamic system. Nevertheless, it is of interest that the reduced form evidence supports the qualitative predictions of the static model, rather than the results that might be expected from the de Gorter and Fisher dynamic model. Following the logic of Friedman (1953), it need not be inferred that US wheat farmers have been living in a static environment. The test results do, however, offer support for the predictive validity of the static model as an approximation to the system under observation. In any case, the deterministic model offered by de Gorter and Fisher is itself only an approximation to the stochastic environment which producers must cope with, and it is not obvious that the results of that model generalise to the stochastic environment. It seems

Table 3: Reduced form test with the inclusion of a lagged dependent variable

Dependent variable	Constant	Target price	Diversion rate	Market price	Lagged acreage	$\bar{R}^2$	DW
AP	70.232	–9.265	–15.725		0.613	.64	1.70
		(–2.514)	(–1.589)		(4.358)		
AP	66.28	–9.02	–28.085	–1.444	0.760	.64	2.04
		(–2.389)	(–1.941)	(–1.311)	(3.919)		

Figures in parentheses are t values.

2 The negative coefficient on market price is contrary to the prediction of the static model. This result is probably due to the endogenous nature of price, and the identification problem. The use of a suitable instrumental variable would be appropriate, but since the coefficient of interest, namely the coefficient on the target price, appears to be robust to various specifications, this problem has not been pursued further.

Table 4: **Bivariate test of dynamic response to the target price**

Dependent variable	Constant	Sum of coefficients	$\bar{R}^2$	DW
AP	368.68	–78.874 a (–6.773)	.945	2.07
AP	261.53	–56.942 b (–2.57)	.758	2.12

a Unrestricted lag distribution. b Second order polynomial lag distribution. Figures in parentheses are t values.

reasonable, therefore, to compare the models on their empirical merits. The results as shown in tables 3 and 4 offer no evidence to support the hypothesis of a positive dynamic relation between the target price and acreage planted.

A policy simulation model of the US wheat market

In order to evaluate the effect of policy reform on US wheat production, exports, and price. an econometric policy simulation model of the US wheat sector is used which is based on the static model of US supply presented in the preceding section of this paper. To solve for equilibrium price, an annual, two-region trade model was constructed that explains participation in the US wheat program, acreage planted by program participants and non-participants, yield, US food demand and feed demand, US market storage, government storage, and export demand. The estimated behavioural equations are reported in the appendix. The complete model comprises these behavioural equations, equations (1) and (2) and a number of accounting identities.

Production

Production response is separated into acreage response and yield response. Since participation in the wheat program is voluntary, acreage response must be further disaggregated into participants' acreage response and non-participants' acreage response. Participation is determined within the system. This framework follows directly from equations (1) and (2). Notice that in order to solve for total acreage planted the acreage planted by non-participating producers, $(1-\alpha)\ Q_m$, must be identified. The acreage which would have been planted in a free market, Q_m, cannot be directly observed; however, acreage planted by non-participants (*AN*) is approximated by a function of the observable expected market price, variable costs of production, the relative price of substitute crops, and the acreage entered into the program. To see why this is a reasonable approximation, note that equation 1 can be rearranged as follows:

(1a) $$AP - \alpha_\pi \overline{Q} \equiv Q_m - \alpha_\pi Q_m.$$

Since $AP - \alpha_\pi \overline{Q}$ is total acreage planted minus acreage planted by program participants, it is the acreage planted by non-participants (AN). Furthermore, when — as has been assumed above — base acreage is the acreage which at one time was planted at market price, Q_m is identical to base acreage in equilibrium. If, further, acreage planted in a distortion-free environment is specified as a linear function of market price, P_m , the price relative to substitutes in production, SP, and variable costs of production, VC:

(5) $$Q_m = \alpha + bP_m - cSP - dVC.$$

Substituting equation (5) into (la), it is seen that the underlying parameters can be identified and estimated from observable data. The relation to be estimated is:

(6) $$AN = \alpha + bFP - cSFP - dVC - eAC$$

where futures prices (see appendix) are used as proxies for expected prices, and program acreage considered planted (AC) is used as a proxy for α_π times Q_m. The latter appears to be a reasonable proxy, since the estimated coefficient on this variable is not significantly different from the predicted value of one. Most importantly, the free market supply curve can be identified, allowing estimation of the acreage that would be planted under policy reform. In that case, AC becomes zero and AN becomes the total acreage.

Total production is simply total acreage planted times yield per acre. Yield per acre (Y), is presumed to be determined by expected market price, as proxied by the futures price (FP); variable costs of production (VC); acreage set aside (AS), which enters to capture the effect of 'slippage', following the work of Love and Foster (1990); and time (t), to capture exogenous technical change.

(7) $$Y = f\{FP, VC, AS, t\}$$

Demand

Following common practice in the literature, the exchange rate, the real interest rate, and income are specified as e..ogenous shifters of export demand, food demand, feed demand, and market-held storage.

US feed demand (*FS*) is determined by own price (*WP*), the relative price of wheat to corn (SP), income (*GNP*), and lagged feed demand (*LFS*). Income is used here to represent the meat demand from which feed demand is derived (since a fuller representation is not necessary at the level of aggregation of the present project). Lagged feed demand may capture dynamic adjustment in the livestock sector. Own price and income have been deflated by the consumer price index.

(8) $$FS = f\{WP, GNP, SP, LFS\}$$

US food wheat demand (*F*) is determined by own price (*WP*) and income (*GNP*), which have been deflated by the consumer price index. The relative price of other food grains is not included, since little substitutability was found among wheat and similar grains in food demand. Lagged food demand (*LF*) was entered solely on the basis of its statistical fit. (Since food demand has remained close to trend over the sample period, it is unlikely that the lack of identification of this lag term will be of much consequence.)

(9) $$F = f\{WP, GNP, LF\}$$

A single-equation representation of export demand (*ED*) is used. Large trade models such as those described by Baily (1989) and Devadoss, Helmar, and Meyers (1990) typically disaggregate the world market into regional submodels. Operationally, these models basically identify various intercepts; however, in the absence of a priori knowledge of how these intercepts will change following policy reform, the added identification is superfluous. Since the policy reform concerned is unilateral, the coefficient on price should capture much of the response in the world wheat market. Following Chambers and Just (1981), separate effects of exchange rates and prices are allowed for. Export demand is thus specified as being a function of the US wheat price (*WP*), the Federal Reserve Board trade-weighted exchange rate (*EX*), world income (*WGP*) and lagged export demand (*LED*). Own price and income have been deflated, and the exchange rate is in nominal terms.

(10) $$ED = f\{WP, EX, WGP, LED\}$$

The Export Enhancement Program (EEP) is not considered to have a *direct* effect on export demand. As Gardner (1989) explains, so long as the countries targeted for EEP subsidies obtain any of their wheat imports at the market price, it is the market price that acts at the margin to determine import quantity. The EEP will however have an important *indirect* effect. The transfer of wheat from CCC storage to the market, in the form of in-kind payments, increases availability and thus lowers equilibrium price. When private storage co-exists with public storage, measurement of this effect is difficult, since the market may have anticipated this outflow and adjusted privately held stocks accordingly. This price depressing effect of EEP storage transfers and adjustment of private storage is modelled explicitly in the storage equations.

Storage has typically been an important means of government intervention in the wheat market since the early 1950s. In the simulations, inflow to government storage is solved for by first solving for equilibrium price and then, if this initial equilibrium price is less than the predetermined loan rate, allowing stocks to flow into government control until equilibrium price is equal to the loan rate. Government release is assumed to be exogenous. Since the purpose in this study is to evaluate policy, not to forecast it, a behavioural release equation is unnecessary.

When private, rational speculative storage exists, private storers will hold stocks such that current price equals the discounted expected value of the commodity in the next period (as long as stocks are positive). Thus, market storage (*KM*) is determined by the endogenous current price of wheat and expected future price, along with the exogenous real interest rate (*R*). Since the government does not generally destroy its reserves of grains, any government acquisition will eventually be returned to the market. The market (private storers) must therefore also form an expectation on the means and timing of government storage disposal. Future net government release (*DKG*) serves as an instrument representing expectations as to both government release and price, and ties together government and market storage in an explicit form.

(11) $$KM = f\{WP, R, DKG\}$$

The policy simulation

In order to quantify the effect of eliminating US price support and production controls, a reasonable *ex ante* approximation of the 1991 crop year market equilibrium under the *status quo* is first computed. The target price, loan rate and diversion requirement are set at their announced levels for the 1991 crop year, and the lagged variables and exogenous demand shifters are set at their 1990 observed values. Government stock release is also set at the level observed in 1990. As described above, government acquisition of stocks is determined within the model.

Holding all predetermined and exogenous variables constant, price support and production controls are then removed (including the 0–92 program) and the market equilibrium is recomputed using the free market supply acreage curve as identified in equation (6).[3] Acreage entered into the long term Conservation Reserve Program is presumed to be held out of production in both the status quo and policy reform simulations. The resulting percentage changes in US acreage planted, yield, production, exports, and price are reported in table 5. Both short run and long run effects are reported. The short run effect is that in the first year of policy reform. The long run results are obtained by simulating successive years, using the lagged terms, until convergence is reached.

Table 5: Effects of elimination of price support and production control in the US wheat market a

	Acreage planted	Yield	Production	Exports	Price
	%	%	%	%	%
Initial diversion rate 15 per cent					
Short run	14.8	–4.1	9.9	4.4	–33.1
Long run	13.2	–3.8	8.9	10.2	–19.0
Initial diversion rate 5 per cent					
Short run	8.3	–2.5	5.5	2.5	–22.3
Long run	8.1	–2.5	5.4	6.2	–12.8
Initial diversion rate 25 per cent					
Short run	19.8	–5.3	13.5	5.8	–39.4
Long run	15.7	–4.3	10.7	12.2	–21.7

a Elimination of deficiency payments, Acreage Reduction Program, and 0–92 program.

Since the diversion rate varies from year to year, the arbitrary setting of the diversion rate at its 1991 value of 15 per cent may be overly restrictive. The same set of simulation experiments has therefore been run with two other initial values of the diversion requirement, in order to evaluate the sensitivity of the results to this parameter. The simulation results are also shown in table 5.

The elimination of price support and production controls is shown to increase acreage planted and production, with a corresponding decrease in price. With the actual initial

3 The relative price of wheat to corn is held constant in the policy reform simulations, because corn is also a program crop and would be likely to be influenced in much the same way as wheat if price support and production controls were eliminated.

diversion rate of 15 per cent, production increases by 14.8 per cent in the short run as acreage which was previously set aside under the ARP and 0–92 program is brought back into production. Price falls by over 33 per cent in the short run, largely due to the inelastic nature of domestic and export demand.[4] US acreage response to price is also inelastic, and though there is some downward effect on acreage due to the price fall, it is less than the acreage brought back into production. The endogenous effect of price on yield, however, tempers the price depressing effect of policy reform: less variable inputs are used, and hence total production increases less than acreage. In the long run, as demand adjusts to the new equilibrium, the price fall diminishes to 19 per cent.

As would be expected, the initial setting of the diversion requirement has a direct effect on the magnitude of adjustment to policy reform. It is important to note, however, that elimination of price support based on the relatively low diversion rate of 5 per cent decreases price in the short run by 22.3 per cent. It should be noted also that the 0–92 program has been assumed to be eliminated as well. In 1991, this program took 5.2 million acres out of production. Though continuation of this program would appear inconsistent with elimination of price support, a reform simulation was also run holding this 5.2 million acres out of production, again based on a 5 per cent diversion requirement. The effect was still to increase US production and decrease price.

It is not claimed here that all aspects of US farm policy as historically observed increase price. For example, the huge government stock releases of the mid and late 1980s, adding hundreds of millions of bushels of wheat to the market, may have had a severe negative impact on price. The important point, however, is that in policy evaluation the salient aspects of the system under study must be explicitly identified and accounted for.

Conclusion

In this paper a structural model has been presented which explicitly takes into account the effects of the price supports and production controls applied under US agricultural policy. Comparative static exercises predict that elimination of price support in the United States will lead to an increase in US production and a corresponding decrease in price. A reduced form test of the comparative static results provides evidence of the empirical validity of the structural model used.

4 The parameter estimates with regard to domestic and export demand are consistent with the literature (for example, Chambers and Just 1981). Furthermore, the qualitative results of this study are robust to alternative domestic and export demand elasticities.

Information gained from the model was then used to identify and estimate the underlying parameters so that a policy simulation model could be constructed that is robust to the range of intervention settings considered in this study. With this policy simulation model the effects of possible US policy reform were quantitatively assessed. The results demonstrate that the US farm program cannot be modelled under the presumption that price support increases production at the margin when that price support is based on a constrained level of production. Furthermore, it is shown that elimination of the existing policy instruments affecting production within the US wheat program would lead to a decrease in price.

APPENDIX
Estimation of policy simulation model

Production

The production block has been estimated over the sample period of 1974–89, which is the period since the inception of the target price as a policy instrument. The block was estimated as a system using the Seemingly Unrelated Regression estimator to account for correlation among the error terms across equations.

Variables

PR = program participation rate;
PP = real net profit from participation;
DD = indicator variable for zero mandatory diversion;
Y = yield per planted acre;
FP = real futures price of wheat (October quote for September delivery);
VC = real variable costs;
AS = acreage set aside (mandatory and voluntary programs);
t = time;
AN = acreage planted by non-participants;
AC = program acreage considered planted;
SFP = relative futures price (futures price of wheat divided by futures price of corn).

Program participation rate

$$PR = 0.633 + \underset{\substack{(6.837)\\ [0.05]}}{0.00659\,PP} + \underset{(12.857)}{0.411\,DD}$$

t-ratio ( ); elasticity [ ]; $R^2 = 0.93$; DW = 2.25

Yield per planted acre

$$Y = -23.9 + \underset{\substack{(0.838)\\ [0.11]}}{0.699\,FP} - \underset{\substack{(0.609)\\ [-0.20]}}{0.103\,VC} + \underset{\substack{(0.426)\\ [0.02]}}{0.039\,AS} + \underset{(0.181)}{0.083\,t}$$

t-ratio ( ); elasticity [ ]; $R^2 = 0.41$; DW = 2.16.

Acreage planted by non-participants

$$AN = 94.6 + 0.493\,FP - 0.491\,VC - 0.975\,AC + 10.824\,SFP$$

	FP	VC	AC	SFP
T-ratio	(0.361)	(1.866)	(14.01)	(1.055)
Elasticity	[0.10]	[–1.20]	[–2.70]	[0.63]

T-ratio ( ); elasticity [ ]; $R^2 = 0.92$; DW = 1.50.

Demand

The demand block has been estimated over the sample period 1963–89 using the three-stage least squares estimator.

Variables

F = US wheat used for food;
LF = lagged *F*;
WP = real price of wheat (price received by farmers, annual average weighted by marketings);
GNP = real US gross national product;
FS = US wheat used for feed and seed;
LFS = lagged *FS*;
SP = July price of wheat divided by July price of corn;
ED = export demand;
LED = lagged *ED*;
EX = rest of world currency per dollar (Federal Reserve Board trade-weighted exchange rate);
WGP = world GNP (OECD GNP, as proxy)
KM = market-held carry over at end of crop year;
R = real rate of return on six month Treasury bills (*ex post*);
DKG = net change in government held stocks in period t+1.

Food

$$F = 96.4 + 0.664\,LF - 2.612\,WP + 0.041\,GNP$$

	LF	WP	GNP
t-ratio	(4.044)	(1.107)	(2.345)
Elasticity	[0.65]	[–0.02]	[0.16]

t-ratio ( ); elasticity [ ]; $R^2 = 0.97$; DW = 1.85.

Feed

$$FS = 394.3 + 0.515\,LFS - 19.220\,WP + 0.024\,GNP - 212.47\,SP$$

(3.444)	(1.739)	(0.798)	(2.407)
[0.51]	[–0.34]	[0.28]	[–1.04]

t-ratio ( ); elasticity [ ]; $R^2 = 0.71$; DW = 1.81.

Export demand

$$ED = 1701.8 + 0.625\,LED - 48.094\,WP - 9.781\,EX + 0.002\,WGP$$

(3.153)	(1.057)	(2.662)	(0.039)
[0.61]	[–0.19]	[–1.00]	[0.01]

t-ratio ( ); elasticity [ ]; $R^2 = 0.73$; DW = 2.11.

Market stocks

$$KM = 1058.1 - 103.3\,WP - 60.38\,R + 0.558\,DKG$$

(3.300)	(3.592)	(5.563)
[–0.88]	[–0.17]	[–0.04]

t-ratio ( ); elasticity [ ]; $R^2 = 0.49$; DW = 1.62.

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