ENDOGENIZING GOVERNMENT BEHAVIOR: EMPIRICAL STUDY OF THE U.S. DAIRY PRICE SUPPORT PROGRAM

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Abstract: The dairy price support program has existed for more than 70 years and the 2002 Farm Bill extends the dairy price support program through the end of 2007. The choice of the support price is a political decision and affects the economics of the U.S. dairy industry. In this research, economic, political, domestic, and international variables that may influence U.S. policymakers' choice of the support price for manufactured dairy products (MDP--butter, cheese and nonfat dry milk) were identified through the development of two models--a behavioral model and a criterion function model. Empirical results of these two models ranked the importance of these variables and compared results.

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I. INTRODUCTION

The dairy price support program has existed for more than 70 years. The original objective of the program was to stabilize farm level milk prices. Once permanently enacted by Congress in 1949, additional goals included: (1) to assure an adequate supply of milk, (2) to reflect changes in production costs and (3) to assure a level of farm income to maintain productive capacity to meet future needs. Although the provisions of the 1996 Farm Bill called for termination of the dairy price support program in 1999, Congress extended the program into 2000 and 2001. The 2002 Farm Bill further extends the dairy price support program through 2007 (Westcott, Young and Price, 2002).

The choice of the dairy support price is a political decision made by elected officials in the political arena. Yet it affects the economics of the dairy industry. For example, past high support prices encouraged overproduction, resulting in costly surpluses. Models that include economic variables alone do not acknowledge this political setting. Thus, political economy theory must be considered in the formation of agricultural policy and in the development of economic models that incorporate this political choice. The literature on endogenizing government behavior seeks to quantitatively incorporate political decisions into economic models. These models analyze the policy result, such as the dairy support price, for the purpose of understanding agricultural policy choices.

Based on data from 1971 through 2001, empirical results presented in this paper contribute to previous political economy empirical findings by (1) endogenizing government behavior using both types of models--a criterion function and a behavioral model--via estimating policy equations and comparing results and (2) consolidating potential explanatory variables based on significant empirical results from the general political economy literature, not necessarily related to the dairy industry.

II. THEORETICAL MODELS

Rausser, Lichtenberg and Lattimore (1982) categorized empirical government behavior models into two groups: (1) analytical derivation followed by estimation of policy instruments from policy preference or criterion functions (criterion function models) and (2) direct estimation of policy instrument behavioral equations (behavioral models). In general, endogenizing government behavior models follow either a criterion function approach or a behavioral model approach.

Criterion function models, which analytically derive and then estimate policy instruments, include Rausser and Freebairn (1974), Zusman and Amiad (1977), Sarris and Freebairn (1983), Paarlberg (1983), Paarlberg and Abbott (1986). Behavioral models, which directly specify then estimate policy equations, include Dixit and Martin (1986). Models which appear to use both criterion function and behavioral approaches include de Gorter (1983).

With the exception of de Gorter (1983), prior political economy literature on the US dairy industry did not endogenize government behavior. Much of the political economy literature relevant to the US dairy industry pertained to the economic welfare impacts of regulatory policies, e.g., import quotas (Neff (1989), Novakovic and Thompson (1977), Salathe, Dobson and Peterson (1977)); milk marketing orders and classified pricing (Buxton

(1977 and 1979), Masson and Eisenstat (1980)); and price supports (Buxton and Hammond (1974) and Heien (1977)). LaFrance and de Gorter (1985) analyzed the economic welfare impacts associated with both milk marketing orders and price support regulations.

Two models of the US dairy industry attempt to quantitatively test the influence of economic, political, domestic and international variables on the US support price for manufactured dairy products (MDP; i.e., butter, powder and non-fat dry milk). These models differ in their theoretical approach. The criterion function model uses a policy preference function, or decision making rule, whereas the behavioral model assumes that the decision making rule is unknown. In the absence of a policy preference function, the behavioral model directly specifies a policy equation that is estimated. Direct specification of a policy equation allows for a large set of variables to be empirically tested for their influence on policy choice. Alternatively, the policy equation in the criterion function model is analytically solved via the first order necessary condition and estimated. The independent variables in this policy equation are dependent on the structure of policymakers' decision making rule. When the rule changes, so does the analytically derived policy equation. Results from both models endogenize government behavior by identifying variables that influence policymakers' choices. In addition, results of the criterion function model identify which special interest group --consumers, processors or taxpayers-- most influences policymakers' decisions.

A. Behavioral Model

The behavioral model consists of two components: (1) a commodity component describing the supply, demand, stocks, and government revenues and costs associated with the US dairy industry and (2) a policy component describing policymakers' choice of the support price for MDP. A general description of the model follows:

Commodity Component

(1) $\hat{S} = \hat{a}_0 + \hat{a}_1 P^{Spt} + \hat{a}_2 P^{Farm} + \hat{a}_3 P^{Input}$

(2) $P^{Retail} = P^{Spt} + M$

(3) $\hat{D} = \hat{b}_0 + \hat{b}_1 P^{Rtl} + \hat{b}_2 \text{INC} + \hat{b}_3 POP + \hat{b}_4 P^{M\arg arine}$

(4) SR = (Sales) + (Dntns)

(5) $\text{Stocks}_t = \text{Stocks}_{t-1} + SA_t - SR_t$

(6) $GR = (Sales)*(1.1*P^{Spt})$

(7) $GC = SA*P^{Spt} + Stocks*SC + Dntns*D$

Policy Component

(8) $P_t^{Spt} = f(P_{t-1}^{Spt}, Stocks, (GR - GC)^{US}, Y^{Farm}, X, SIG)$

Where:

S = Supply of MDP produced in the US.

P^{Spt}= Support price for MDP, set by policymakers; the output price realized by processors and the derived demand price paid by consumers as well as the purchase price paid by the government for surplus MDP and the "trigger price" for the sale of MDP from government stockpiles (The trigger price equals the 110 percent of the support price.).

P^{Farm} = Price paid by processors to dairy farmers; the input price.

P^{Inputs} = Price of other processing inputs.

P^{Rtl} = Retail price of MDP.

M = Marketing margin between processing and retail prices.

D = Derived demand for MDP by US consumers.

INC = US disposable personal income.

POP = US population.

$P^{Margarine}$ = Retail price of margarine (a substitute for butter).

SR=Stock removals from Commodity Credit Corporation (CCC) stockpiles, e.g., domestic and international outlets for sales and donations.

Sales = Sales of CCC MDP stocks, either domestic and/or international (export) sales.

Dntns = Donations from CCC MDP stockpiles, either domestic or international (Public Law 480-Title II and Section 416 of the Agricultural Act of 1949).

Stocks = Surplus MDP stored by the CCC equaling carryover stocks plus stock additions (SA) minus stock removals (SR).

SA = Additions to CCC stockpiles.

GR = Government revenue obtained from sales of MDP stocks either domestically or internationally (exports).

GC = Government costs of the dairy support program associated with purchasing domestic surpluses, storing surpluses in stockpiles, and distributing surpluses as donations.

SC = Storage costs associated with government storage of surplus manufactured dairy products.

DC = Distribution costs associated with distributing donations, both domestic and international donations are considered.

$(GR- GC)^{US}$ = This net government expenditures variable can be thought of as a general variable which includes both net US government expenditures associated with the federal budget as well as net government expenditures on the dairy program (GR - GC).

Y^{Farm} = Income received by US farmers.

X = International variables, e.g., value of US exports, trade balance, etc.

SIG = Special interest group variables, e.g., campaign contributions to politicians from dairy lobbying groups.

Processors' supplies of MDP are specified in equation (1). Equation (2) describes the marketing margin between processing and retail prices. Equation (3) specifies derived demand for MDP by US consumers. Stock removals from the Commodity Credit Corporation (CCC) stockpiles equal the sum of sales and donations as identified in equation (4). Domestic and international outlets are included for both sales and donations. Equation (5) is a market balancing equation, where current government stocks equal carryover stocks plus additions to stocks minus stock removals. Government revenues and expenditures on the dairy support program are specified in equations (6) and (7), respectively.

Equation (8) describes the policy component where the support price is a function of six general groups of variables based on economic and political economic theory: (A) institutional inertia; (B) stocks; (C) net government revenue; (D) domestic net farm income; (E) international variables, (F) special interest groups.

B. Criterion Function Model

The criterion function model also consists of two components: (1) a policy preference function describing US policymakers' decision making rule in choosing the price support level for MDP and (2) a commodity component similar to that used in the behavioral model. A general description of the model follows:

Policy Preference Function

(9) $\underset{\{P_t^{Spt}\}}{Max}$ PPF=Γ_1(CS) + Γ_2(PS) + Γ_3(GR - GC)

Commodity Component

(10) $\hat{S} = \hat{a}_0 + \hat{a}_1 P^{Spt}$

(11) $\hat{D} = \hat{b}_0 + \hat{b}_1 P^{Rtl}$

(4) SR = (Sales) + (Dntns)

(5) $Stks_t = Stks_{t-1} + SA_t - SR_t$

(6) $GR = (Sales)*(1.1*P^{Spt})$

(7) $GC = SA*P^{Spt} + Stocks*SC + Dntns*D$

Where the same variable definitions hold as identified in the behavioral model.

Equation (9) describes the policymakers' preference function which consists of four economic agents, each with its own objective: (A) consumers, who maximize consumers' surplus (CS), (B) processors, who maximize producers' (processors') surplus (PS), (C) taxpayers, who minimize net government expenditures on the dairy support program (GR-GC), and finally (D) policymakers, who maximize a policy preference function (PPF), which is a weighted sum of all other agents' objectives. The weights (Γ_i, i=1,2 and 3) measure the political influence of each interest group as perceived by members of Congress, where the political weight associated with taxpayers is set equal to one ($\Gamma_3 = 1$), i.e., the numeraire.

Equations (10), (11), and (4) through (7) composed the commodity component of the criterion function model. The equations (4) through (7) are identical to those in the behavioral model. The difference occurs in the equations describing supply and demand. Now, both the supply equation (10) and the demand equation (11) are functions of the support price solely. The reason behind this stems from the mathematical process used to recover the political weights, (Γ_i, i=1,2). The political influence weights are recovered from equations which relate the parameter estimates of the policy equation to the known parameter estimates of the supply and demand equations, as well as the unknown political weights. Note that only two political weights are unknown. An overidentified system of equations occurs when the estimated policy equation consists of more than two independent variables, resulting in non-unique solutions for the political influence weights. In order to obtain a just identified system of equations, the supply and demand equations must be functions solely of the intercept and the support price variable. (See Marchant 1997 and 1993 for a detailed explanation.) For estimation purposes these equations will be estimated in their expanded form, as specified in the behavioral model (equations (1) and (3)), to obtain unbiased and consistent parameter estimates. Adjusted intercept (setting other variables at average levels and add the products of the averages and their slopes to the original intercept) and support price slope parameter estimates will then be used in the criterion function model.

The estimated policy equation of the criterion function model is analytically derived (Marchant 1993). Verbally, the policy preference function is transformed into an unconstrained optimization problem by substituting the commodity component constraints into the objective function. The optimal support price is analytically obtained from the first order necessary condition and equals the following:

$$(12)\quad P_t^{Spt} = \left[\frac{-\Gamma_1\hat{\beta}_0\hat{\beta}_1 - \Gamma_2\hat{\alpha}_0\hat{\alpha}_1}{\Gamma_1(\hat{\beta}_1)^2 + \Gamma_2(\hat{\alpha}_1)^2}\right] + \left[\frac{1}{\Gamma_1(\hat{b}_1)^2 + \Gamma_2(\hat{a}_1)^2}\right][\text{SA-1.1*Sales}]$$

In more general terms, equation (12) can be written as:

$$(13)\quad P_t^{Spt} = \lambda_1 + \lambda_2\ [\text{SA-(1.1*sales)}]$$

where $\lambda_1 = \left[\frac{-\Gamma_1\hat{\beta}_0\hat{\beta}_1 - \Gamma_2\hat{\alpha}_0\hat{\alpha}_1}{\Gamma_1(\hat{\beta}_1)^2 + \Gamma_2(\hat{\alpha}_1)^2}\right]$, $\lambda_2 = \left[\frac{1}{\Gamma_1(\hat{\beta}_1)^2 + \Gamma_2(\hat{\alpha}_1)^2}\right]$

Equation (12) specifies the policy equation of the criterion function model, comparable to the policy equation (8) in the behavioral model. Policymakers' choice of the optimal support price for MDP in the criterion function model is dependent on (A) estimates of the political weights associated with each economic agent (Γ_i, i=1,2), (B) parameter estimates from the supply and demand functions (α_j and β_j, j=0,1), and (C) exogenous variables related to the net change in stocks, [SA - (1.1*Sales)]. Equation (12) is estimated to obtain parameter estimates λ_k (k=1,2). Once all parameters are estimated, (α_j, β_j and λ_k; j=0,1 k=1,2), the political influence weights, (Γ_k, k=1, 2) can be analytically recovered from equations (14) and (15) (Marchant 1993). This solution, describing the political influence weights for each special interest group, in matrix notation is the following:

$$(14)\ \begin{bmatrix} \hat{\Gamma}_1 \\ \hat{\Gamma}_2 \end{bmatrix} = \begin{bmatrix} (\hat{l}_1(\hat{b}_1)^2 + (\hat{b}_0\hat{b}_1)) & (\hat{l}_1(\hat{a}_1)^2 + \hat{a}_0\hat{a}_1) \\ (\hat{l}_2(\hat{b}_1)^2) & (\hat{l}_2(\hat{a}_1)^2) \end{bmatrix}^{-1} \begin{bmatrix} 0 \\ 1 \end{bmatrix}$$

Thus, empirical results of the criterion function model will (A) indicate whether the net change in stocks variable influences policymakers' choice of the support price for MDP based on estimation of the policy equation (12) and (B) identify which special interest group most influences policymakers' decisions based on calculation of political influence weights, equation (16), using supply, demand, and policy parameter estimates. Stigler (1971) postulated that producer (in this case processor) interests prevail over consumer interests.

III. EMPIRICAL ESTIMATION AND INTERPRETATION

A. Behavioral Model

Three equations were estimated[1] in the behavioral model: supply, equation (1); demand, equation (3); and policy, equation (8). The estimation results for supply and demand were presented below:

(15) $\hat{S}$ = 37.0462 + 2.6442 P

S.E.:	(5.5504)	(0.2437)
t-value	6.68	10.85

R^2 = 0.9308, F[1, 30] = 403.65, DW = 2.1350

(16) $\hat{D}$ = 52.7460 - 0.7611 P + 0.0083 INC + 0.1889 CPI

S.E.:	(2.2111)	(0.3190)	(0.0013)	(0.0888)
t-value:	23.86	-2.39	6.32	2.13

1 Data sources include USDA-ERS, and the President's Council of Economic Advisors.

R^2 = .9909, F[3, 28] = 1011.75, DW = 1.8818

Equation (1) and (3) were estimated by using Prais-Winsten method (linear regression with correction of both autocorrelation and heteroscedasticity). Equation (15) and (16) showed the best estimation results. The signs were correct, and the t-values indicated that all the variables were significant in these two equations.

For policy, estimation of equation (8) used both nominal and real prices, respectively, with the Prais-Winsten method (linear regression with correction of autocorrelation and heteroscedasticity). Estimations were performed for the years 1971 through 2001. Listed below are our empirical results:

$$(17)\quad \hat{\mathrm{P}}_{\mathrm{t}}^{\mathrm{Spt}} = 2.1519 + 0.9441\, P_{t-1}^{Spt} - 0.0230\,\mathrm{Y}_{\mathrm{t-1}}^{\mathrm{Farm}} - 0.6741\left(\frac{\mathrm{X}^{\mathrm{MDP}}}{\mathrm{X}^{\mathrm{Ag}}}\right)_{t-1} - 0.3099\, GC_{t-1}^{MDP}$$

S.E.	(0.5020)	(0.0539)	(0.0077)	(0.2124)	(0.1644)
t-value	4.29	17.50	-2.99	-3.17	-1.89

R^2 = 0.9761, F[4, 26] = 265.54, DW = 1.7789

Equation (8) was estimated at an aggregate level using nominal prices. All previous definitions hold. The estimation results indicated the existence of an overall relationship between policymakers' choice of the support price and (A) support price in the previous year, (B) lagged net farm income, (C) the lagged ratio of MDP exports to total agricultural exports and (D) Lagged government expenditure on MDP. Note the strong explanatory power of the lagged dependent variable, the support price in the previous year. In fact, its partial correlation coefficient was 0.9441 compared to -0.0230 for the lagged net farm income, -0.6741 for the lagged ratio of MDP exports to total agricultural exports and -0.3099 for the lagged government expenditure on MDP.

Equation (8) was also estimated at an aggregate level using real terms. The estimation was just performed by OLS method; no heteroscedasticity or autocorrelation were detected. The results are presented below.

$$(18)\ \hat{P}_t^{Spt} = -0.4906 + 1.0791\,P_{t-1}^{Spt} - 0.0053\,Stk_{t-1} - 0.5925\,GC_{t-1}^{MDP}$$

S.E. (0.3163) (0.0327) (0.0131) (0.1800)

t-value -1.55 33.03 -0.40 -3.29

$R^2 = 0.9783$, $F[3,27] = 405.03$, $DW = 1.9310$

The estimation results indicated the existence of an overall relationship between policymakers' choice of the support price and (A) support price in the previous year, (B) lagged CCC stocks, (C) the lagged government expenditure on MDP. However, the lagged stocks were not significant despite the correct sign. In real terms, the lagged support price and lagged government expenditure on MDP have stronger explanatory power than that of nominal prices. The partial derivatives of support price with respect to the lagged support price and lagged government expenditure on MDP were 1.0709 and –0.5925 respectively.

One interesting result from this estimation is that the Stock was not important for the policymakers now. It's different with the results from the literature, where the stock did have an important influence on policymakers. The reasons can be explained by Figure 1.

From Figure 1 we can see that after 1980, the support prices were almost constant, while the stocks changed greatly. That's why the stocks didn't have much influence on the support price. Another interesting result is that the stocks moved in the opposite direction with world price. The MDP exports played a very important role here. When world price was high, the exports would reduce the purchase by CCC.

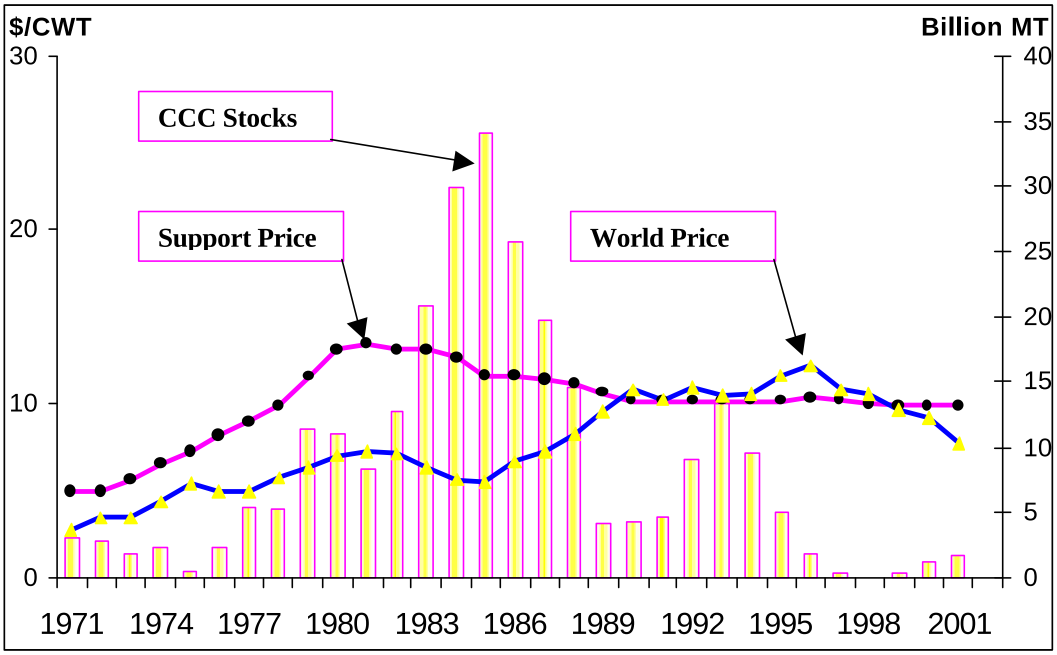

Figure 1: Relationship between CCC stocks and prices

B. Criterion Function Model

As shown in equation (12), the analytically derived policy equation in the criterion function model equals the first order necessary condition (FONC). This equation was estimated. Its parameter estimates, $\{\lambda_1, \lambda_2\}$, are functions of the known supply {á$_0$, á$_1$} and demand $\{\beta_0, \beta_1)$ parameter estimates and of the unknown political influence weights, $\{\Gamma_1, \Gamma_2\}$. Presented below is a discussion of the empirical results of (A) the estimated policy equation and (B) the calculated political influence weights of each interest group.

The general form of the analytically obtained FONC of equation (13) is

(19) $P^{Spt} = f(SA - 1.1 * Sales)$

where P^{Spt} = The processors' support price, (SA - 1.1∗Sales) = Net change in government stocks of MDP, aggregated on a milk equivalent basis and equaling stock additions (SA) minus total sales (domestic and international).

One expects the support price to be negatively related to the variable (SA - 1.1∗Sales).

Estimations results appear below:

$$(20)\ \Delta\hat{P}^{Spt} = 1.1583 - 0.0254\,(SA - 1.1*Sales) - 0.0577\,Time$$

S.E.: (0.4762) (0.0154) (0.0258)

t-value: 2.43 -1.65 -2.24

R^2 = 0.405624, F[2,20] = 7.85, DW = 1.6761

Equation (20) was estimated using nominal prices. Estimation results had the correct signs and were significant after correction of autocorrelation.

Political Weights of the Policy Preference Function

As shown in equation (14) in the Theoretical Models section, political weights for each special interest group were calculated using the demand, supply, and policy parameter estimates. Results were calculated using the results from equation (20).

$$(21)\ \hat{\Gamma}_1 = -6.64746,\ \hat{\Gamma}_2 = -5.08532,\ \Gamma_3 = 1.0$$

given that:

$$\hat{a}_0 = 37.04622,\ \hat{a}_1 = 2.644203$$

$$\hat{b}_0 = 101.4151,\ \hat{b}_1 = -0.7611$$

$$\hat{l}_1 = 0.379403,\ \hat{l}_2 = -0.02538$$

These empirical results indicated that taxpayers have the most influence on policymakers' decisions when stock changes and the support price changes move in opposite directions. In this case, government cost minimizing taxpayers was politically effective, and profit maximizing processors were not. As stockpiles increase, policymakers will decrease the support price level, which discourages overproduction and reduces additions to CCC stocks. Thus, government costs, financed by taxpayers, are reduced, as are processors' profits.

IV. COMPARISON OF TWO MODELS

Empirical results for the behavioral model were good in terms of statistical significance and properties. Significant explanatory variables which appeared to influence policymakers' choice of the support price level for MDP can be categorized into the following general groups: (1) political variables, the lagged support price and the lagged net farm income, as a proxy variable representing the domestic goal of increasing farm income; (2) government costs, as measured by the government expenditures on the dairy program, (3) International variables, the lagged ratio of MDP export to total agricultural export.

Based on economic and political economy theories, all of these variables were expected, apriori, to influence policymakers' decisions. Thus, the empirical results of the behavioral model make sense, are supported by other empirical results, and lend credibility to the questioning of the empirical results of the criterion function model.

Empirical results of the criterion function model specify (A) the influence of a variable measuring the net additions to government stocks on policymakers' choice of the support price for MDP and (B) the relative political influence of each special interest group--consumers, processors and taxpayers. To determine the relative political influence of each interest group, political weights were calculated. Results from equation (20) indicated that taxpayers had the largest political weight and appeared to have the most influence on policymakers' decisions. Political weights for processors and consumers were negative, indicating a negative influence on policymakers' choices, and processors appeared to have more political clout than consumers.

What conclusions can be drawn from the empirical results of the criterion function and behavioral models? In both models, the government cost minimizing interests of taxpayers dominated. In the behavioral model, government cost variables, such as the government expenditures on the dairy program appeared to influence policymakers' decisions. In the criterion function model, taxpayers' political influence weight dominated relative to that of processors and consumers. International variables, such as the MDP export shares of agricultural goods also has some influence on policymakers' decisions. Political variables, e.g., inertia and farm income, did appear to influence policymakers' decisions. The data on campaign contributions consisted of too few observations to determine their influence.

In comparing estimated policy equations of the two models, the criterion function policy equation is simplistic, due to imposition of theoretical restrictions, discussed above. In order to obtain this analytically derived policy equation, much was sacrificed. Restrictions were imposed on the number of independent variables in the supply, demand, and policy equations. Consequently, empirical results of the criterion function policy equation refer to the influence of only one variable--the net change in government stocks--on policymakers' decisions. In contrast, the behavioral model allowed for a larger set of independent variables to be tested for their influence on policymakers' determinations of the support price for MDP. Empirical results of the behavioral model yielded estimates that were statistically significant and supported existing empirical findings.

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