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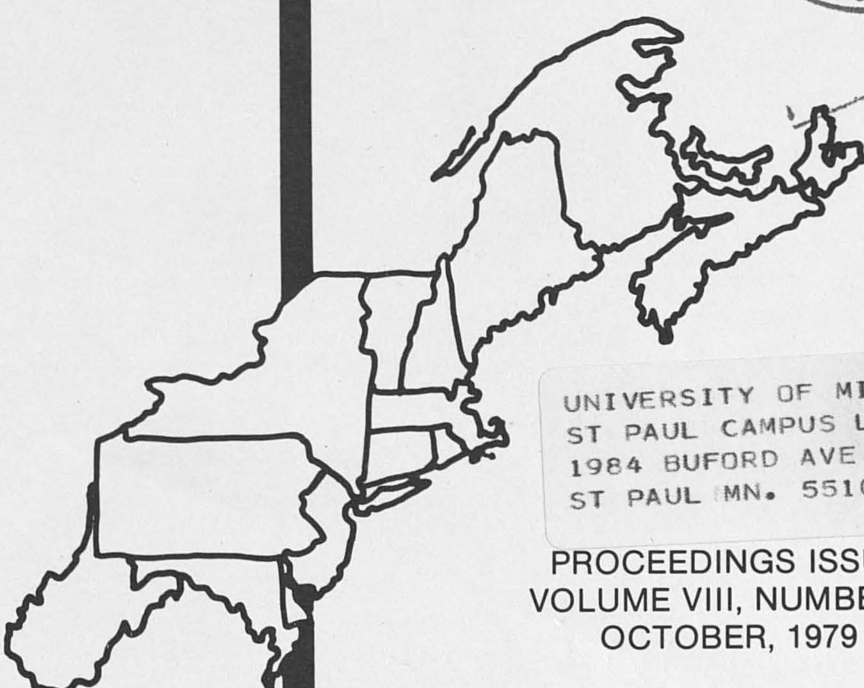

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PRICE EQUILIBRIUM OR PRICE DISEQUILIBRIUM IN THE CORN SECTOR

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Agricultural policy makers are aided in the decision making process by analytical models. This implies that national agricultural policy is dependent on the correctness of the model's structure and specification. Traditionally, econometric models of the crop sector have been estimated in a price equilibrium framework. Heien (1977) summarizes this as a system where supply and demand interacts to determine price. This conceptualization places a heavy burden on the stock equation; ending commercial stock equations often perform very poorly, and therefore, reduced form estimates, particularly for price, tend to reflect this corresponding error.

Several reasons are given for poor equation performance, including (1) entry of data in the balance sheet as a residual which picks up measurement error throughout the system, (2) varying incentives for holding stocks, plus mistaken inventory decisions, and (3) theoretical specification for the range of motives for holding stocks is very weak. As an alternative approach, Heien suggests a disequilibrium model generated in an excess demand market. This modification is closely aligned to literature on the Phillips curve and the Eckstein and Fromm Price equation. This model results in a price dependent equation where stocks are estimated as a residual from the market clearing identity.

The objective of this paper is to compare these two alternative model structures as they relate to agricultural crops, and the implications of the two structures as they relate to policy analysis. The corn sector is used as an example. The corn sector was chosen since it represents about 70 percent of the feed grain industry, and the majority of commercial corn reserves are held on the farm. For this case, the flexible accelerator model is assumed an appropriate specification of commercial grain reserves and, therefore, provides a reasonable test for the correctness of a price equilibrium or price disequilibrium statement of market activity in an annual framework.

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Price-Disequilibrium

Disequilibrium implies that total quantity demanded does not equal total quantity supplied. Hence, price responds to the imbalance in the short-run. Eckstein and Fromm indicate that markets characterized by (1) highly centralized companies, (2) high costs involved with frequent price changes, (3) batch production that requires additional maintenance control to allocate over time, (4) variation in design in response to back orders, and (5) high inventory costs are examples of those in which the continuous market clearing pricing mechanism is inefficient.[1]

If market pressures result in an excess demand situation, the suppliers reduce their inventories below specified level, buyers place orders, some perspective buyers exit the market, and some suppliers may increase price. This in turn stimulates short-run production, reduces demand, and decreases the supply-demand imbalance. In the event that supply exceeds demand, inventories are restocked, orders filled, market participants regained, and prices fall. Declining prices decrease short-run production and increases quantity demanded which again diminishes the supply-demand balance.

Eckstein and Fromm derive a change in price equation which depends on changes in inventories, unfilled order, and lost orders all as a proportion of production. Heien modified the price disequilibrium equation for agricultural crop commodities - the change in price is assumed to depend on the rate of excess supply. For the corn sector, this implies that:

$$PC_t = f(ESC_t ESC_{t-1}, PROD_t, PC_{t-1})$$ [2]

where PC is corn Price, ESC is ending stocks, PROD is production, and t designates the crop year.[3]

Price Equilibrium

Price equilibrium models are given the majority of attention in econometric models of the U.S. crop and livestock industries.[4] These models are built around a supply and demand identity where the solution in any one time period determines a market clearing price and equilibrium quantities. The framework is basically recursive with simultaneous solutions for consumption, price, and inventory adjustment. The recursive component normally enters through a supply or production equation based on lagged prices. This system can be expressed as:

(2) $$Q_{1t} = f_1(P_t, X_{1t}, \ldots, X_{kt})$$

(3) $$Q_{2t} = f_2(P_t, X_{it}, \ldots X_{kt}),$$

(4) $$Q_{3t} = f_3(P_{t-j}, X_{1t}, \ldots X_{kt}),$$

(5) $$Q_{3t}+Q_{2t-1} = Q_{1t}+Q_{2t}$$ where:

Q_{1t} = total consumption less ending stocks,

Q_{2t} = total ending stocks,

Q_{3t} = total production,

P_t = product price,

X_{it} = appropriate exogenous variables required to complete the specification, i=1, ..., k.

A common characteristic of the equilibrium model for the grain industry is the ending stock equation. Since grains are storable, the level of ending stocks play an important role in utilization from one crop year to the next. The modified flexible accelerator model developed by Lovell has received considerable attention as an appropriate specification for estimating levels of desired ending commercial stocks. The thrust of this formulation is centered around the motivation for inventory accumulation - speculative, transaction, and precautionary demand.

The sequence of research leading to the flexible accelerator model is presented in considerable detail by Labys. He points out that this estimation technique is often used where manufacturers or processors act as suppliers, which is normally the case for crop commodities such as grains. For this reason most econometric models dealing with the soybean, wheat, feed grain, and other crop industries generally appeal to the accelerator principle as a guiding structure for empirical estimation.

The modified flexible accelerator model for ending stocks is given as:

$$Q_{2t} = f_X(P_t, P_t^*, Z_{3t}, Q_{2t-1}, X_{1t}, \ldots, X_{kt}),$$

where P_t^* = Expected future price of the commodity.

In the following section both models are presented. It is assumed the specification is correct. Estimated structural parameters are given that reflect the U.S. corn industry in an annual econometric framework. The discussion centers on the price equilibrium model, with an estimated ending stock equation based on the accelerator principle, and the disequilibrium model suggested by Heien (1977), where a price adjustment equation is estimated thus eliminating the structural equation for ending commercial stocks.

The Models: Empirical Estimation

Empirical estimation and summary statistics for the price equilibrium model (PEM) and the price disequilibrium model (PDM) for corn utilization are found in Table 1. Each model contains the same six endogenous variables; feed demand (CORDF), food demand (CORDH), commercial exports (CORMC), total exports (CORMX), commercial carryover (CORHCC), and farm price (CORPF) and are estimated in an annual framework. Each model is closed and contains similar but not identical predetermined variables.

The PEM is represented by equations 1-5 and 6a, and the PDM is represented by equations 1-5 and 6b. Each equation was estimated by ordinary least squares using time series data over the periods specified in Table 1.

Corn is viewed as an input to livestock production. Therefore, equation 1 is a derived demand equation. Quantity demanded as feed depends on corn price (CORPF), livestock price index (LIVIF1), soybean meal price (SOMPF), grain consuming animal units (GCAU), and two intercept shifters in 1973 and 1974 (D7374 and D74). Results indicate that the "price freeze" years significantly altered the structure of the feed industry in 1973 and 1974.

Table 1

Corn Models

1. FEED DEMAND (Million bushels) 1949-75

$$CORDF_t = 325.89 - 951.609\left(\frac{CORPF}{LIVIF1}\right)_t + 197.111\left(\frac{SOMPF}{LIVIF1}\right)_t + 28.234GCAU_t$$

$$+ 989.244D7374_t - 429.771D74_t$$

(t)	.825	-5.41	4.40	9.83	5.84	-2.15
Elas		-.358	.214	1.02	.024	-.005

$\bar{R}^2 = .947$ SE = 139.525 D.W. = 1.33

2. FOOD DEMAND (million bushels) 1948-75

$$CORDH_t = 210.391 - 22.5637CORPF_t + .344575CEN1_t$$

(t)	22.63	-2.80	.01847
Elas		-.1011	.430

$\bar{R}^2 = .947$ SE = 16.1538 D.W. = .6097

3. COMMERCIAL EXPORTS (million bushels) 1962-75

$$CORMC_t = 1211.475 - 507.3\left(\frac{CORPF}{SOYPF}\right)_t - 392.936DUM720_t + .139CORMEUSSR_t$$

(t)	3.55	-1.12	-4.14	2.99
Elas		-.155	-.193	.002

$$-10.1\left(\frac{CORPA}{SOYSDR}\right)_t + 1105.67HOGCHIS_t$$

-1.68	6.37	
Elas-.217	.731	

$\bar{R}^2 = .98$

SE = 59.7

D.W. = 3.08

4. TOTAL EXPORTS (million bushels)

$$CORMX_t = CORMC_t + POLICYX_t$$

5. $$CORSP_t + CORHCC_{t-1} + CORHH_{t-1} + CORMI_t = CORDF_t + CORDH_t + CORMX_t +$$

$$CORHCC_t + CORHH_t + CORDS_t$$

6 a. COMMERCIAL CARRYOVER (million bushels) 1948-75

$$CORHCC_t = 664.762 - 331.034CORPF_t + .188897CORSP_t - .06875CORSPGR1_t -$$

$$.17318CORHH_t$$

(t)	5.64	-7.27	9.52	-1.79	-3.12
Elas		-.807	1.27	-.477	-.142

$\bar{R}^2 = .757$ SEE = 99.2316 D.W. - 1.87

Table 1 (con't)

6b. PRICE BEHAVIORAL EQUATION (dollars per bushel) 1948-75

$CORPF_t = 1.27768 + .47705CORPF_{t-1} + .0233023TREND - .000313794CORHH_t - .00125756CORHCC_t$

(t)	4.63	4.51	4.32	-2.73	-5.28
Elas		.472	6.74	-.105	-.518

$\bar{R}^2 = .84$ SE = .202 D.W. = 1.4199

The demand for corn as a food is given in equation 2. Quantity demanded depends on corn price and consumer expenditures on nondurables (CEN1), which substitutes for income.

Equation 3 depicts the excess demand for U.S. commercial corn in the world market. Both economic and operational variables are included in the specification. Exports are a function of corn price (CORPF), soybean price (SOYPF), imports by the USSR (CORMEUSSR), the EEC threshold price (COPRA), the soybean price deflated by the SDR (SOYSDR), a hog and chicken production index aggregated for the EEC, United Kingdom and Japan (HOGCHIS), and an intercept shifter for 1972 (DUM720) reflecting an upward shift in the demand structure.[5]

The fourth equation is an identity. Total exports are the sum of commercial exports plus government sponsored or policy exports (POLICYX).

Equation 5 is the market clearing equation. Production (CORSP) Plus beginning commercial stocks, beginning government stocks ($CORHH_{t-1}$) plus corn imports (CORMI) equals feed demand plus food demand plus total exports plus commercial carryout plus government carryout plus seed use (CORDS). This equation ensures price equilibrium for the PEM and determines commercial carryover for the PDM.

Commercial carryover is specified in equation 6a. It is based on the modified flexible accelerator theory. However, beginning stocks proved insignificant in the estimated equation and future corn production is used as a proxy for future price. Commercial carryover is a function of corn price, production, future production (CORSPGR1), and government carryover.

The price behavioral equation, 6b, for the PDM is Heien's empirical specification. The signs of the coefficients are identical to Heien's, but the magnitudes differ because of scaling and different sample periods. Price depends on the lagged price, time trend (TREND), government carryout, and commercial carryout. Beginning stocks were insignificant in the estimated equation and trend is a proxy for production.[6] Equations 6a and 6b were estimated over the same time period in an attempt to maintain consistency in model comparison.

Each model was solved for the current endogenous variables using the Gauss-Seidel technique (Heien, et. al.) Comparisons over the 1964-75 historical period and 1976-78 forecast period were made.

Evaluation of the Results

The simultaneous performance of the models (PEM and PDM) are compared over the historical period by using (1) the mean absolute percent error of the endogenous variables and (2) a linear regression of actual endogenous variables against the corresponding reduced form estimates (test for bias). Three years were saved outside the period of fit to create a prediction interval test. This allows examination of model performance where actual exogenous variables are known, but actual endogenous information has not been incorporated in the estimated coefficients. Historical and prediction interval tests were applied where the complete model solution takes all exogenous and lagged endogenous variables as given (Case 1), and a second solution set that utilizes estimated lagged endogenous variables (Case 2).

In comparison of the models the focal point will be on price and stock behavior in the reduced form system. The PEM has an estimated ending commercial stock equation. Thus, structural coefficients are based on a minimized sums of squares normalized on commercial stocks. This formulation favors larger error on price if the majority of stocks are undesired, implying a PDM system. Likewise, in the PDM model the price adjustment equation results in a minimized sum of squares normalized on price. If stocks are actually desired (PEM), then this model should reflect larger relative errors in the stock equation.

Panels a and d of Figure 1 show the aggregate demands for corn as a feed, food, total export, and seed usage in the PEM and PDM respectively. Since the two models are the same with respect to the demand components cited above, panels a and d are identical. Panel b depicts the stock demand for the PEM: the direct price elasticity is -.81. Panel e represents the same demand for the PDM; the implied direct price elasticity is -1.93. The differences in the stock demands indicate that the PEM is less elastic than the PDM, as shown in the total demand panels c(PEM) and f(PDM). Then, an exogenous shift in supply from S to S' in each model, results in larger price and quantity adjustments for food, feed, and exports demand in the PEM relative to the PDM, as shown in Figure 1. However, the quantity adjustment for stocks induced by the supply shift is greater for the PDM than for the PEM.

If one model is a better representation of true structure, then a clear pattern should be established in either case of price and stocks. Since each model assumes a different structure, the underlying total direct price elasticities were estimated -.37 for the PEM and -.51 for the PDM implying that total price responsiveness is 38 percent greater in the PDM system. Both cases indicate a price inelastic industry, but different impacts are generated as shown in Table 2. If policy exports are increased 100 million bushels, price increases six cents per bushel in the PEM and four cents in the PDM. This results in substantial differences in impacts on commercial stocks, down 22 and 41 million bushels in the PEM and PDM, respectively. Feed use also shows significantly different impacts. Similar patterns are apparent for exogenous changes in production and accumulation of government stocks. All these impacts are of crucial importance in the current environment. Participants in farm programs are guaranteed a floor price of $2 per bushel for corn. In the event that the free market price (as the result of a bumper crop) is below the $2 minimum, say $1.60 per bushel, the PEM suggests that approximately 667 million bushels will have to be taken over by the government whereas the PDM implies that 1,000 million bushels will have to be taken over in order to maintain the floor price of $2 per bushel.

Mean absolute percentage errors in Table 3 and "F" statistics in Table 4 indicate that the PEM is a more reliable predictor over the historical period for the major categories, feed, commercial stocks, and price. Table 4 reflects the joint null hypothesis test that the intercept is zero and the slope term is one for the linear regression of actual endogenous versus corresponding reduced form estimates. The hypothesis of unbiased forecasts is rejected for PDM commercial stock equation performance for the Case 1 solution and the price estimates in the Case 2 solution. Thus, historical performance tends to favor the specification of the PEM,

Figure 1—Price and Quantity Adjustments in the PEM and PDM

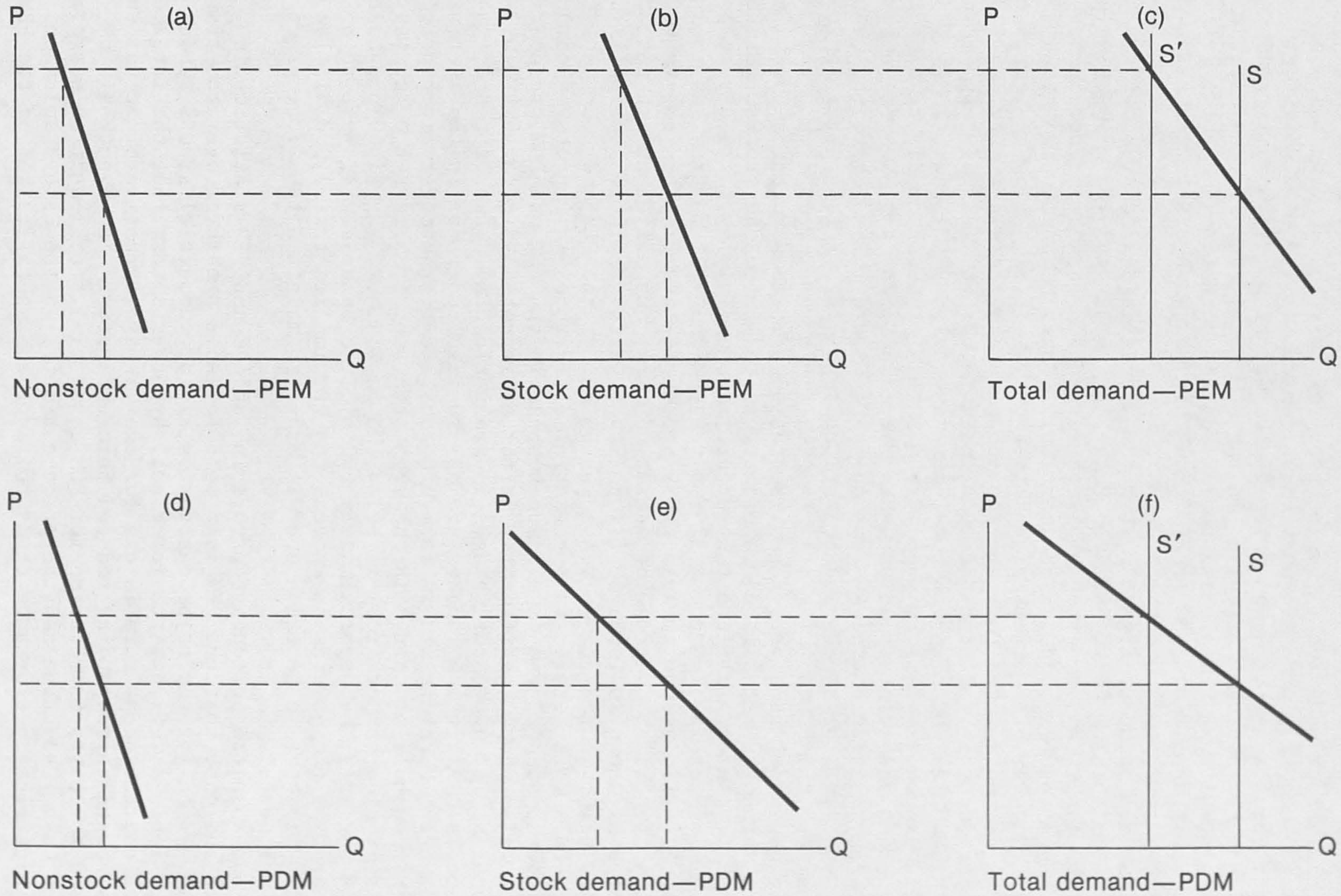

Table 2

First round impact multipliers

Endogenous variable	100 million bushels increase in:					
	Production		Government stocks		Policy exports	
	PEM	PDM	PEM	PDM	PEM	PDM
CORDF	51.570	47.980	-51.908	-36.772	-62.405	-48.767
CORDH	1.221	1.162	-1.275	-.891	-1.491	-1.182
CORMC	10.220	9.731	-10.668	-7.458	-12.490	-9.981
CORMX	10.220	9.731	-10.668	-7.458	87.510	90.109
CORHCC	36.763	41.354	-36.092	-53.769	-21.978	-40.899
CORPF	-.055	-.052	.066	.052	.056	.038

Table 3

Mean absolute percent error: Historical period (1964-75)[a]

Item	Case 1		Case 2	
	PEM	PDM	PEM	PDM
CORDF	1.793	2.486	2.203	2.638
CORDH	4.038	3.720	4.002	3.677
CORMC	3.683	3.121	3.680	3.209
CORMX	3.412	2.882	3.426	2.978
CORHCC	12.238	17.542	11.289	19.921
CORPF	5.146	5.380	5.416	6.057

[a]Mean absolute percent error (MAPE) is defined as:

$$\text{MAPE}=\left[\frac{\sum_{t-1964}^{1975} \frac{|P_t - A_t|}{A_t}}{12}\right]*100$$

where A_t is the actual value and P_t is the predicted value.

Table 4

F statistics over the historical period (1964-75):
Critical value 4.10

Item	Case 1		Case 2	
	PEM	PDM	PEM	PDM
CORDF	.581	1.760	.210	1.760
CORDH	2.555	2.946	2.691	2.622
CORMC	.468	.527	.415	.549
CORMX	.457	.368	.392	.475
CORHCC	.336	2.490	.242	9.407*
CORPF	2.215	4.887*	3.910	2.053

*Significant at the five percent level.

Table 5

Mean absolute percent error: Forecast period (1976-78)[a]

Item	Case 1		Case 2	
	PEM	PDM	PEM	PDM
CORDF	3.560	3.677	2.729	2.503
CORDH	5.022	5.069	4.461	4.669
CORMC	1.976	2.132	2.755	2.415
CORMX	1.653	1.785	2.242	2.00
CORHCC	15.361	22.030	21.063	22.451
CORPF	1.848	5.064	5.984	3.459

[a]See table 3 for definition.

but this is not necessarily true for the prediction interval period (Table 5). If actual lagged values are used over the prediction interval (1976-78), the PEM demonstrates superior performance in all cases with significantly smaller errors on price and commercial stocks. But, the more stringent test of model performance where generated lagged values are utilized (Case 2), the PDM has smaller errors for feed use, commercial exports, and price. The enactment of the farmer-owned reserve may account for the ambiguous result over the forecast period.

Conclusion

The fact that the PEM demonstrated superior performance over the historical period for price and commercial stock estimates tends to indicate that a large portion of toal ending commercial stocks fall under the desired category. However, closer price estimates by the PDM over the prediction interval for the Case 2 solution suggest that Heien's notion of undesired stocks should not be ignored. This implies that if commercial stocks cannot be separated into different categories (desired versus undesired), then a blend specification for ending commercial stocks will be necessary that contains both price equilibrium and price disequilibrium theories.

Obviously these results are contingent on correct equation specification. However, empirical results do conform to previous related research over the historical period of fit. The recent policy development of the farmer-owned reserves with economic incentives to withhold grains from the market until trigger level prices are reached has not been included in the estimated structural parameters. Additional observations are required before validation of the equilibrium specification can be maintained. Therefore, model performance over the historical period is likely a better indicator of structure with regard to the price equilibrium or price disequilibrium framework.

FOOTNOTES

[1]Characteristics of commodities where a continuous market clearing pricing mechanism is efficient are: (1) Minimal costs for changing prices, (2) many buyers and sellers in communication, and (3) large losses due to unsuccessful transactions.

[2]Heien states that the price level function equation is valid since only the current years price and carryout levels are unknown at the beginning of the crop year.

[3]It is interesting to note that Eckstein and Fromm imply that agricultural commodities would be better modeled in the price equilibrium framework and manufactured goods in the disequilibrium framework.

[4]See Houck, et. al., Meinken, Matthews, et.al, and Baumes

[5]See Bredahl, et.al.

[6] This is the Heien specification.

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