On the Search of Appropriate Price Determination Specifications in Structural Models

by

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A comprehensive set of criteria for evaluation of price determination specifications is proposed. A generalized theoretical relationship is developed to facilitate the search of appropriate structural models. Price elasticities, price flexibilities, and demand shares of the model are used to test the price response behavior of simultaneous structural models. A wheat model is used for empirical comparison of three popular inverse demand (price-dependent) structural model specifications: domestic demand model, export demand model, and stock demand model. Results indicate that price-dependent domestic demand and price-dependent export demand are inappropriate, while the price-dependent stock demand model generates credible results.

Introduction

Price determination is the heart of structural econometric models for farm commodity sector analysis. Failure to develop an adequate linkage between theory of price and structural model specification has not only created an econometric "black hole", but has also crippled the application of models in forecasting, impact simulation, and policy analysis. To capture complex farm commodity price relationships in econometric model has long been a difficult task to economists. Such difficulty stems from the inherent nature of economic data which are mainly drawn from non-experimental sources to reflect the intricate nature of price determination behavior. It is well recognized that econometric model building is not an endeavor at the construction of a unique, all embracing theory (Jang), but rather a search process of selecting the appropriate specification from a variety of competing models.

In the search for appropriate price specifications, economic theory, statistical properties, predictive performance, and simulation capability are all important criteria. Previous researchers devoted most of their attentions, however, to the statistical aspects of structural models: identification of supply-demand structure (Working), derivation of simultaneous equations estimators (Haavelmo), tests of price and quantity endogeniety relationship (Thurman), evaluation of predictive accuracy of commodity prices (Just and Rausser). However, the ultimate performance of the model in real-world applications lies upon its' price response behavior and simulation capability.

As models often generate substantially different prices and price impacts a critical question is the choice of appropriate specifications. This study explores a comprehensive set of criteria in evaluating structural model price specifications and proposes a generalized theoretical framework for empirical investigation of the influence of price flexibilities, price elasticities and demand shares on prices. Testing procedures and statistics are developed to analyze price impacts of single equation model against alternative structural model specifications.

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For empirical analysis three popular inverse demand specifications are used: price-dependent stock demand, price-dependent domestic demand, and price-dependent export demand. The estimated structural models under alternative normalization rules are subjected to a simulation experiment using the Gauss-Seidel method to relate price outcome to estimated price flexibility, price elasticities, and demand share in each model. Then, some propositions are drawn from these interrelationships as a source of a priori information to facilitate the search of appropriate price specifications.

Model Evaluation Criteria

In empirical work structural models generally viewed as a set of equations strung together through common variables. The theoretical interpretation of each equation is often neglected as far as the complete model generated 'desirable' results. However as Fisher noted each equation in the model should have an existence independent of the model within which they are imbedded. He further states "...every equation of he model represents the behavior of decision makers who set the value of a particular endogenous variable in response to the stimuli provided by their perceptions of the values of other variables."

The single and most important model evaluation criterion is thus the theoretical validity of price determination specification within a structural model setting, i.e. all supply and demand functions and the market clearance identity must be consistent with the theoretical expectation of price movement. In simulation experiments in particular, theoretical interpretation of each equation in the model has a special significance. Simulation experiments are conducted by shocking an exogenous variable to examine its' effects on the endogenous variables. When the shock is introduced at one point it is transmitted across the model through a traceable path. Therefore it is useful to trace the cause-effect relationship in each equation affected by the shock.

Another critical standard for model evaluation is the simultaneous relationships of the model. When we focus our attention on the price behavior of a structural model, a top consideration is its intra-model price response behavior under condition of a shock (eg. a supply shock caused by an increase or decrease in yield). The exogenous shock is expected to be transmitted into all demand functions and market clearance identity in a simultaneous manner. Price elasticities and flexibilities are the key determinants of the final price outcome. Therefore, practical model evaluation criteria should emphasize on the connection among price elasticities and flexibilities to behavioral aspects of the model, in particular, to the process of price determination in structural model.

In evaluating the price determination behavior, only the price-dependent (inverse demand) structural models are used for simulation study in this paper. The crux of price-dependent models is to normalize a specific demand function in a quantity-dependent model to express it as an inverse demand function. Thus, a specific quantity-dependent model can be represented by many alternative price-dependent (inverse demand) models depending on the demand function to be normalized. With each normalization rule used, a different model is produced with a unique combination of a price flexibility and price elasticities.

The ability of the model to generate realistic solutions is extremely important to the model users for real-world forecasting and policy analysis. Reasonable price range developed by commodity expert should be utilized as the standard for preliminary evaluation. For inverse demand structural models, price response depends not only on the theoretical foundation of the normalization process, but also on the particular combination of price elasticities and price flexibility in the model. Empirical application of price-dependent models can be greatly facilitated by an investigation of how the internal structure of the model influence the price determination process. Lack of such comprehensive investigation has often led to "experimentation" with different normalization rules in search of a "suitable" model.

This study also proposes a theoretical framework for statistical testing of differences in price impacts of alternative model specifications. It provides an empirical basis for comparing alternative price dependent models.

Alternative Inverse Demand Specifications

In inverse demand models, price is explicitly determined by the specific demand function which is normalized on price, i.e., a price-dependent demand function. Thus a structural model can be represented in alternative price-dependent forms depending on which demand function is normalized on price. The basic form of a price-dependent structural model can be expressed as

(1) $P = f(Q_i; X_i)$

(2) $Q_j = g_j(P; X_j)$

(3) $Q_s = Q_s(\Pi(P); X_s)$

(4) $Q_i = Q_s + X_k - (\Sigma_j Q_j)$

where Q_s equals quantity supplied, Q_i equals inverse demand and Q_j are other demand components. X_i, X_j and X_s refer to relevant exogenous variables. Profits are denoted by $\Pi(P)$ as a function of price, and exogenous components in the market clearance identity, such as beginning stocks, imports, etc., are denoted by X_k.

This study examines the appropriateness of three commonly used inverse demand specifications: (1) inverse stock demand model, (2) inverse domestic demand model, and (3) inverse export demand model. A seven-equation simultaneous system of supply, demand, and market clearance identity is presented in Table 1

Table 1. Alternative Inverse Demand Structural Model Specifications[1]

	P-dependent Domestic Demand	P-dependent Export Demand	P-dependent Stock Demand
Inventory Demand	$Q_h=Q_h(P;Z_h)$	$Q_h=Q_h(P;Z_h)$	$P=P(Q_h;Z_h)$
Domestic Demand	$P=P(Q_o;Z_o)$	$Q_o=Q_o(P;Z_o)$	$Q_o=Q_o(P;Z_o)$
Export Demand	$Q_x=Q_x(P;Z_x)$	$P=P(Q_x;Z_x)$	$Q_x=Q_x(P;Z_x)$
Feed Demand	$Q_e=Q_e(P;Z_e)$	$Q_e=Q_e(P;Z_e)$	$Q_e=Q_e(P;Z_e)$
Seed Demand	$Q_d=Q_d(P;Z_d)$	$Q_d=Q_d(P;Z_d)$	$Q_d=Q_d(P;Z_d)$
Supply	$Q_s=Q_s(\Pi;Z_s)$	$Q_s=Q_s(\Pi;Z_s)$	$Q_s=Q_s(\Pi;Z_s)$
Market Clearing Identity	$Q_o=Q_s+Q_{h-1}$ $-(Q_e+Q_d+Q_x+Q_h)$	$Q_x=Q_s+Q_{h-1}$ $-(Q_e+Q_d+Q_x+Q_h)$	$Q_h=Q_s+Q_{h-1}$ $-(Q_e+Q_d+Q_x+Q_h)$

1. Q_s refers to quantity supplied, and Q with subscripts o,e,d,x and h refers to demands for domestic consumption, feed, seed, export, and inventory stocks, respectively. P and Π refers to farm price of wheat and profits from wheat, respectively. Z to the vector of relevant exogenous variables identified by the subscripts described above, and $Q_t=Q_o+Q_x+Q_d+Q_e$.

to describe these alternative price-dependent structural models. The only differences across models are the price determination equation and the market clearance identity. To satisfy the model solution requirement, the left-hand-side variable of the identity is the same quantity demand variable of the inverse demand function.

Theory of Price Response

Alternative inverse demand specifications are evaluated by their price response behavior under the condition of an exogenous shock (e.g., a supply shock). The model undergoes price and quantity changes to achive a new market equilibrium. If the initial market clearance condition is

(5) $$Q_i = Q_s + X_k - (\Sigma_j Q_j)$$

then, after a supply shock of ΔQ_s, the resultant quantity changes should satisfy the following condition,

(6) $$\Delta Q_i + \Sigma_j \Delta Q_j = \Delta Q_s$$

where ΔQ_i is the change in the quantity of the inverse demand i,
ΔQ_s is the exogenous supply shock, and
ΔQ_j is the change in quantity of other demand component j.

In the inverse demand function, the price (single equation) impact is

(7) $$\Delta P = \beta_i \Delta Q_i \text{ and}$$

(8) $$\Delta Q - \frac{\Delta P}{\beta_i}$$

where ΔP is the single-equation price impact, and β_i ($= \partial P/\partial Q_i$) is the structural coefficient of quantity demand in the inverse demand function.

From equation (2), a quantity change in other demand component j can be given as

(9) $$\Delta Q_j = \beta_j \Delta P$$

where β_j ($= \partial Q_j/\partial P$) is the structural coefficient of price of the j^{th} demand function. Summing (9) over j yields

(10) $$\Sigma_j \Delta Q_j = \Delta P \Sigma_j \beta_j \quad .$$

Substituting (8) and (10) for ΔQ_i and $\Sigma_j \Delta Q_j$ in (6) we get

(11) $$\Delta \frac{P}{\beta_i} + \Delta P \sum_j \beta_j - \Delta Q_s .$$

From (11) ΔP can be written as

(12) $$\Delta P - \frac{\Delta Q_s}{\frac{1}{\beta_i} + \sum_j \beta_j}$$

where $i \neq j$; $j = 1, \ldots, n$; and n is the number of quantity-dependent demand functions in the model.

Equation (12) shows the structural model price impact as a function of the structural coefficients of the demand functions in the model. Substituting these structural coefficients by price elasticities (ξ_j) and price flexibilities (η_i), equation (12) can be rewritten as

$$\Delta P = \frac{\Delta Q_s}{K\left(\frac{w_i}{\eta_i} + \sum_j \xi_j w_j\right)} \tag{13}$$

where w_i and w_j are demand shares, $w_i = Q_i/Q$ for inverse demand, $w_j = Q_j/Q$ for other demands, and $K = Q/P$.

Equation (13) reveals important behavioral aspects of inverse demand structural models in generating price impacts of exogenous shocks. The denominator of (13) has two components. The first term in the denominator represents the single equation price impact of the structural model. The second term in the denominator represents the feedback effect generated by other demand functions. In the absence of the second term of the denominator, equation (13) reduces to equation (7). Equation (7) represents the price impact of inverse demand function if Q_i is shocked by an amount equal to ΔQ_s.

Thus the structural model price impact can be partitioned into: (1) a single-equation price impact which is determined by the inverse of the price flexibility weighted by the demand share of the inverse demand, and (2) a feedback effect generated by the price elasticities of other demand functions weighted by their respective demand shares.

When the price elasticities of other demands approach zero, the feedback effect disappears and the structural model solution approaches the single-equation solution. When the price flexibility of the inverse demand approaches zero, the first term in the denominator becomes large. In this case the single-equation price impact dominates the feedback effect. Under this circumstance, the single-equation price impact and the structural model price impact may not be much different. On the other hand, a large price flexibility, large price elasticities or their combinations may cause the structural model price impact to be significantly different from the single equation price impact.

Denoting single-equation price impact in equation 7 as $(\Delta P_{(i)})$, its variance is

$$\mathrm{var}(\Delta P_{(i)}) = (\Delta Q_s)^2\, \mathrm{var}(\beta_i) \tag{14}$$

where $\Delta Q_i = \Delta Q_s$ = a constant in the single equation case.

From equation (12) variance of the structural model price impact ΔP is

$$\mathrm{var}(\Delta P_{(i)}) = \mathrm{var}\left[\frac{\Delta Q_s}{\left[\left(\frac{1}{\beta_i} + \sum_j \beta_j\right)\right]}\right]. \tag{15}$$

The variance term given in (15) can be derived by using an approximation formula (Wallace and Silver).

Now, it is possible to statistically test whether the single equation price impact is significantly different from the final price impact. The hypothesis of interest is

$$H_0 = \Delta P_{(i)} - \Delta P = 0$$
$$H_a = \Delta P_{(i)} - \Delta P > 0 .$$

The test statistic is

$$(16) \qquad t = \frac{\Delta P_{(i)} - \Delta P}{\sqrt{[\ var(\Delta P_{(i)}) + var(\Delta P)}} \sim N(0,1)$$

where $var(\Delta P_{(i)})$ and $var(\Delta P)$ are given by (14) and (15), respectively. Reject the null hypothesis H_0 if $t > t_{n-2,\,\alpha}$, where α is the level of significance.

Some Propositions

The theoretical foundation developed in the above section provides a basis for some propositions on the price determination behavior of inverse demand structural models. These propositions are useful to describe some important behavioral characteristics of P-dependent structural models.

Single Equation vs Structural Model

A major advantage of using a structural simultaneous model over a single equation model is the ability of the simultaneous system to capture intra-model relationships among different demand equations through the market clearance. In a single equation model there is only a single equation price impact. In a structural model the price impact consists of both a single equation price impact and a feedback effect from changes in other demands. However, when the price flexibility of the particular inverse demand function is small, or when the feedback component in the denominator is large, the difference between the single equation price impact and the structural model impact may not be significant. Therefore, the search for appropriate structural models may first be determined by the preference of the selected structural model over its corresponding single equation model.

<u>Proposition One</u>.

> For a given structural model, the combination of a large single equation price impact, i.e., small w_i/η_i, and/or a small feedback component, i.e., small $\Sigma_j\ (\xi_j\ w_j)$ may result in a final price impact which is not significantly different from the single equation price impact. This implies that in such models the price impact may not be significantly different from the single equation solution. On the other hand a small price impact and large price elasticities or other combinations may cause different price impacts between single equation and the structural model.

Acceptable Price Range

Once those structural models are chosen which generate significantly different price impacts as compared to their corresponding single equation solutions, the next step is to select the one which generates price impacts within an "acceptable" price range. In general it is possible to perceive a reasonable price range in response to an exogenous shock. Such a range may be obtained by using the expert knowledge of commodity analysts and policy researchers, or by any other means. For example, a reasonable price range is defined as $\Delta R = (\Delta P_{max} - \Delta P_{min})$, where ΔP_{max} and ΔP_{min} are the maximum and minimum values of price impacts, respectively.

In P-dependent structural models the feedback effect offsets the single equation price impact. The single equation price impact, however, sets the upper bound of the price impact of structural model. Therefore, if single equation price impact, $\Delta P_{(i)}$ is equal or less than the minimum of the acceptable range, ΔP_{min},

$$\Delta P_{(i)} \leq \Delta P_{min} \tag{17}$$

then the suitability of the inverse demand specification is suspect. Based on this relationship the following second proposition is formulated.

<u>Proposition Two</u>.

> The single equation price impact of a supply shock imposes an upper bound on the price impact of the corresponding structural model to the same supply shock. If the upper bound falls below the lower limit of acceptable price range, then the price impact of the model solution cannot fall within the acceptable price range.

In essence, propositions one and two can help formulate some practical guidelines for screening alternative inverse demand structural models. It is conceivable that more than one model may qualify as valid specifications, i.e., price impacts of more than one model may fall within the acceptable range. In this case the decision on the appropriate specification(s) can be determined by testing the price impacts of alternative P-dependent models.

Differences in Inverse-demand Specifications

Alternative P-dependent models have different combinations of a inverse demand function and a set of Q-dependent demand functions. Therefore, if we consider two price dependent models, equation (12) can be expressed for inverse demand model i and j respectively as

$$\Delta P^i = \frac{\Delta Q_s}{\left(\frac{1}{\beta_i} + \beta_j + \sum_k \beta_k\right)} \tag{18}$$

for inverse demand i, and

$$\Delta P^j = \frac{\Delta Q_s}{\left(\frac{1}{\beta_j} + \beta_i + \sum_k \beta_k\right)}. \tag{19}$$

for inverse demand j.

If ΔP^i and ΔP^j are equal, then

(20) $$\frac{\Delta Q_s}{\left(\frac{1}{\beta_i}+\beta_j+\sum_k \beta_k\right)} = \frac{\Delta Q_s}{\left(\frac{1}{\beta_j}+\beta_i+\sum_k \beta_k\right)}.$$

Equation (20) can be simplified as

(21) $$\frac{\beta_i}{1+\beta_i\beta_j} = \frac{\beta_j}{1+\beta_j\beta_i}.$$

From equation (21) it is clear that if the structural coefficients o quantity in the inverse demand functions i and j are not significantly differen the price impacts of a constant supply shock are also not significantl different. Therefore, to compare price impacts of two P-dependent specifications the proposed hypothesis is

H_0: $\Delta P^i = \Delta P^j$
H_a: $\Delta P^i \neq \Delta P^j$.

The test statistic is

(22) $$t = \frac{\beta_i-\beta_j}{\sqrt{\operatorname{var}\beta_i+\operatorname{var}\beta_j+2\operatorname{cov}\beta_i\beta_j}}.$$

Reject H_0 if

(23) $$t > t_{\frac{\alpha}{2},\, n_1+n_2-2}.$$

Based on the test developed for comparison of alternative P-dependent models, w formulate the final proposition for selection of appropriate structural mode specifications:

<u>Proposition Three</u>.

> If two inverse demand structural models exist with inverse demand i and inverse demand j as the price determination specifications, they generate price impacts which are not significantly different in response to a constant supply shock if the structural coefficient of quantity of inverse demand i, β_i is not significantly different from the structural coefficient of quantity of the inverse demand j, β_j.

The propositions presented in this section provide the basis for th empirical evaluation of alternative P-dependent structural models as to thei suitability as price determination specifications in structural models.

Empirical Results

Estimated Model

The theoretical formulations of three alternative inverse demand model given in Table 1 are used for empirical estimation. For each specification, complete sectoral model of wheat was developed. The simulation analysis wa conducted by endogenizing 21 variables, including all endogenous variables in th price determination block. As each equation in the model has an existenc independent of the model within which it is embedded, the resulting submodel can be considered as a complete model for the purpose of the simulation experiment (Fisher). In all models wheat price is determined through a unique price-dependent demand function. The models were estimated using annual data from 1973 to 1983. The estimated models are presented in Table 2.

Table 2. Estimated Alternative Q-dependent and P-dependent Specifications

Supply and Demand Equations

Inventory Demand $Q_h = -801.40\,P - 577.88\,(Q_h / Q_t)^e - 2631.32$
(3.79) (0.78) (4.0)
R. Sq = 0.94 D.W. = 1.34

Domestic Demand $Q_o = -14.63\,P + 0.45\,I - 280.00$
(1.33) (6.12) (3.18)
R. Sq. = 0.94 D.W. = 1.36

Export Demand $Q_x = -103.92\,P + 0.76\,Q_{x,-1} + 267.19\,X + 1.75\,P^w + 92.06$
(1.25) (6.95) (0.54) (1.59) (0.24)
R. Sq. = 0.80 D.W. = 2.14

Seed Demand $Q_d = 3.53\,P + 1.33\,A - 12.17$
(1.47) (3.56) (0.71)
R. Sq. = 0.51 D.W. = 1.5

Supply $Q_s = Y \times A$

Price Equation and Market Clearance Identity*

P-dependent P-explicit Stock Demand Model

Price $P = -0.00068\,Q_h - 1.16\,(Q_h / Q_t)^e - 3.16$
(3.87) (4.08) (21.93)
R. Sq. = 0.92 D.W. = 1.79

Market Clearance $Q_h = Q_{h-1} + Q_s - Q_o - Q_d - Q_x$

P-dependent P-explicit Domestic Demand Model

Price $P = -0.0113\,Q_o + 0.0029\,I + 0.915\,D - 5.935$
(3.82) (1.74) (7.07) (8.34)
R. Sq. = 0.95 D.W. = 2.45

Market Clearance $Q_o = Q_{h-1} + Q_s - Q_d - Q_x - Q_h$

P-dependent P-explicit Export Demand Model

Price $P = -0.0005\,Q_x - 4.05\,X + 10.82\,P^w + 8.01$
(1.15) (1.23) (3.23) (2.49)
R. Sq.=0.68 D.W. = 1.68

Market Clearance $Q_x = Q_{h-1} + Q_s - Q_d - Q_o - Q_h$

t - statistic is given in parenthesis. D.W. is the Durbin-Watson Statistic. P = farm wheat price (deflated), $(Q_h / Q_t)^e$ = expected stock/demand ratio, total demand $Q_t = (Q_o + Q_e + Q_d + Q_x)$, I = disposable income (deflated), $Q_{x,-1}$ = lagged exports, X = exchange rate, P^w = world wheat price, A = acreage, Y = yield per acre, and D is 1 if period is 1973-1975, and 0 otherwise. Price in Q-dependent models are implicit equations derived from the corresponding estimated demand functions given above. Price in P-dependent model is directly estimated.

Estimated price elasticities and price flexibilities are within the range of earlier modeling work. Statistical properties of all the demand functions in the model show a good fit, with high R^2 and expected signs across different specifications. Most of the estimated coefficients are significant at the 95% level.

Preliminary Search

Comparison of price impacts of three alternative specifications with their corresponding single equation models indicate that the P-dependent export demand model does not generate price impacts which are significantly different from the single equation model. Therefore, on the basis of proposition one, there appear to be little advantage in the export demand structural model over the single equation model given the current estimated structural coefficients. This lack of feedback in the simultaneous system may be due to insufficient supply/demand interaction or inappropriate estimated parameters. However, as estimated price elasticities and flexibilities can differ substantially, it is possible a different set of estimated structural coefficients may render significantly different price impacts. Due to this reason all three models are further subjected to test by proposition two.

Acceptable Price Range

Based upon expert opinion on a reasonable price range of a supply shock[1], the single equation price impacts were evaluated against the lower limit of the acceptable price range. All three models have single equation price impacts which are greater than the lower limit (Table 3).

Table 3. The Relationship of Price Elasticities, Price Flexibilities, and Demand Shares to Price Impacts.

	P-dependent Domestic Demand	P-dependent Export Demand	P-dependent Stock Demand
w_i (Demand share)	0.24	0.46	0.23
$\acute{\eta}_i$ (Price flexibility)	-4.56	-0.42	-0.50
$w_i/\acute{\eta}$ (Single equation effect)	-0.05	-1.09	-0.46
$\Sigma_j(\xi_j w_j)$ (Feedback effect)	-0.30	-0.21	-0.30
$w_i/\acute{\eta}+\Sigma_j(\xi_j w_j)$ (Total effect)	-0.34	-1.30	-0.76
$\Delta P_{(i)}$ (Single equation impact)	-8.07	-0.36	-0.62
	(0.62)	(0.04)	(0.09)
ΔP (Structural model impact)	-1.4	-0.29[a]	-0.47[a]
	(0.60)	(0.04)	(0.09)
$\Delta P_{(i)} - \Delta P$ (Difference)	-6.67 *	-0.07	-0.15 *

Standard errors of estimates are given in parentheses.
a/ structural model price impacts are not significantly different.
* indicate single equation and structural model price impact differences which are significant at 95% level.

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[1] A survey of expert opinions based on informal conversations with extension economists and commodity analysts indicated a 210 million bushels increase of wheat production would lead to a 30-50 cents decrease in wheat price.

Thus the possibility exist all or some of them may have price impacts within the acceptable price range. Since they are greater than the lower limit, the structural model price impacts may be considered falling within the reasonable range.

Price impacts were further evaluated against the upper limit of the acceptable price range. The results suggest that only the P-dependent stock demand model is within the acceptable price range while P-dependent export demand price impact is at the margin of the lower limit. As conditions stated in proposition two is crucial for the acceptability of the inverse demand specification at this point P-dependent domestic demand can be eliminated from further consideration. Only P-dependent stock demand and P-dependent export demand need be given further consideration.

Inverse stock demand model and inverse export demand models need be further tested using proposition three. Comparison of structural coefficients of quantities the inverse demand functions indicate that they are not significantly different at 95% level. Therefore, according to the condition specified in proposition three, their price impacts are also not significantly different at 95% level. As it appears that both models qualify as valid specifications further elimination requires resorting to other aspects of model specification.

Cause-Effect Consideration

In a general equilibrium setting in inverse demand functions, a supply shock (i.e., a supply increase) would result in lower prices and higher quantities. However, in structural models, when an inverse demand function is used for price determination, the effect of a supply shock in the process of price determination can be traced. Increase in yield per acre first increases total supply. Total supply is an argument on the right-hand side of the market clearance identity. To satisfy market clearance, the quantity on the left-hand side of the identity should increase by the same amount as the supply shock.

The quantity on the left-hand-side in the market clearance identity is always the quantity demand of the inverse demand function. Increased quantity demand thus results in a price decrease due to the negative coefficient of quantity of the inverse demand function. The final outcome is that the exogenous supply shock is transmitted into the price-dependent demand function. Therefore, for a P-dependent demand function to be theoretically valid within a structural model setting, such a quantity movement along the inverse demand function should be consistent with the theoretical expectation of price movements.

Every demand function represents the behavior of the decision maker who sets the value of a particular demand component (endogenous variable) in response to stimuli provided by their perceptions of the values of other exogenous variables (Fisher). In the inverse demand function the response variable is price while the stimulus is the quantity. For domestic consumption demand and export demand this relationship may not constitute an acceptable cause-effect relationship.

In P-dependent stock demand, the supply shock transmission to the inverse demand function is the same as in inverse domestic and export demands. Here the increase in supply increases the level of stock and decreases price. However, unlike the case of inverse domestic and inverse export demand specifications, in this case the cause-effect is logically meaningful.

From a theoretical viewpoint, increased supply accumulates inventory stocks. To clear the market, demand for other uses needs to increase. To increase demand for domestic use, export, feed, etc., the price level goes down, and the market clearance is achieved. Thus, increased stocks induce a price decrease. On the basis of theoretical merit, the P-dependent stock demand appears to yield a meaningful cause-effect relationship in the process of price determination in structural models.

Generally, if the price impacts are significantly different, the decision on the selection of appropriate models depends on the researcher's subjective judgment on the relative merits of price impacts. Prior experience, expert opinion, and performance of other models can be utilized to reduce the subjectivity of the decision.

The criteria developed in this paper suggest that, of the three P-dependent model specifications tested, the price-quantity relationship for P-dependent domestic demand and P-dependent export demand shows the correct associations, however, their cause-effect relationships do not appear to be in a theoretically consistent manner.

Implications and Conclusions

The inferences drawn from this study have important implications for modeling farm commodity markets in general, and agricultural price analysis in particular. The study illustrates how structural coefficients, and hence price elasticities and price flexibilities of demand functions, affect the farm price behavior in structural models.

In econometric model building there are only a few methodological guidelines for model construction. The decision on the selection of appropriate inverse demand specification is often guided by a researcher's experience or by the performance of previous models. The value of such information is quite limited for evaluation of the significant variation of estimated structural coefficients, price elasticities and flexibilities across models. As price outcomes are directly linked to their internal statistics, a useful a priori knowledge on the model specification can be obtained. Important guidelines can thus be suggested to determine price response behavior of structural models.

The importance of the propositions formulated in this study lies in their ability to anticipate price outcome of alternative models. To illustrate the implications of these propositions, we use previous modeling work as examples. Meilke and Young found extremely unstable price behavior in the Q-dependent model for soybean meal price. When the demand function was normalized on price, desirable price effects were observed. The structural coefficient of quantity in the inverse demand function of soybean meal was -30.90, which is significantly less than the inverse of 0.00305. Thus the normalized specification should generate a much smaller price impact, and hence a more stable solution outcome than that of the Q-dependent model.

The study by Adams and Behrman shed some light on the performance of alternative inverse demand specifications. In their study they used a P-dependent stock demand function for eight world agricultural commodities. This relationship did not work well for tea prices. This outcome could have been easily anticipated, as the estimated price flexibility of stock demand was relatively higher for tea compared to other commodities. As we state in proposition two, the higher the price flexibility, the higher the price impacts; i.e., for a quantity change, the price impact is larger. Thus, it is not surprising that the inverse stock demand underestimated tea prices. A priori comparison of price flexibilities of various model is useful to anticipate the price response behavior.

This study provides a comprehensive evaluation of three popular P-dependent specifications in terms of their price response behavior. In the selection of appropriate inverse demand specifications a testing procedure was proposed to perform a preliminary search. Their cause-effect relationships and the theoretical expectation of price response behavior were employed for further investigation. The proposed approach should help eliminate the need for subjective judgement and empirical 'experimentation' in the search of appropriate specifications. This is particularly useful for modeling agricultural commodities where elasticities and flexibilities are often given in ranges rather than as point estimates. Sensitivity analysis could be use as validity checks for such estimates, as price impacts are more readily observable than price elasticities and flexibilities.

Further, it is conceivable that domestic demand and export demand may constitute significant demand components for many commodities. In this research we concluded that inverse domestic and inverse export demands do not provide appropriate cause-effect relationships between price and quantity. Thus, more research is necessary to determine theoretically valid inverse demand models.

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