ESTIMATING THE EFFECTS OF VOLUME, PRICES, AND COSTS ON MARKETING MARGINS OF SELECTED FRESH VEGETABLES THROUGH MIXED ESTIMATION

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Prior information derived from previous research, commodity specialists, market institutions, and introspection was used to estimate margin equations for selected fresh vegetables through the mixed estimation technique. Use of this information increased the precision of parameter estimates. Behavioral implications of the statistical results are examined.

Keywords:

Prior information
Mixed estimation
Margin behavior

INTRODUCTION

When constructing econometric models, the researcher often has *a priori* notions concerning the signs and magnitudes of a number of parameters. These notions (prior information) originate from previous research, economic theory, commodity specialists, knowledge, characteristics of institutions within the system under investigation, and/or introspection. Persons engaged in applied research implicitly admit having prior information whenever they reject a model because it does not fit their expectations.

The mixed estimation technique originated by Theil and Goldberger (*12*) combines pure, sample information with uncertain prior information for derivation of parameter estimates.[1] Stochastic linear restrictions on a linear model's parameters represent the uncertain prior information. The disturbance terms associated with the linear restrictions are generally assumed to follow a normal distribution, although, in principle, the disturbances could be assumed to follow other continuous distributions. Essentially, the mixed estimate is an application of generalized least squares to a data set in which sample data and prior constraints are combined. Extensions have been made by Theil (*11*), Nagar and Kakwani (*8*, *9*), Kakwani (*4*), Swamy and Mehta (*10*), Yancy and others (*13*, *14*), Mittelhammer (*6*), and others.

A substantial number of properties, descriptive statistics, and tests of hypotheses concerning mixed estimators have been established. These include the percentage of the posterior precision of the mixed estimates that is due to prior information, a statistical test to determine if the prior information is compatible with the sample information, and tests to determine if the mixed estimator has smaller mean square error (that is, the expected squared distance of parameter estimates from true population parameter values) than estimates based on sample information alone (*6*, *14*).

A set of marketing margin relations was estimated for seven fresh vegetables (cabbage, carrots, celery, cucumbers, green peppers, lettuce, and tomatoes) (7). Prior estimates of the effects of volume, prices, and costs on the marketing margins were available from various sources, including consultations with commodity specialists and introspection by the authors (*2*, *3*, *5*). The mixed estimation technique provided estimates of the parameters that were judged mean square error superior to pure sample-based estimates.

The objectives of this article are twofold: (1) to illustrate the mixed estimation technique and (2) to provide estimates of the margin-forming behavior of produce markets.

THE MODEL

The margin behavior relations of the seven fresh vegetables were a subset of a complete model of domestic demand for the vegetables (7). The relations were specified in general functional form as:

$$M_{VEGi} = M_{VEGi}\left(P^f_{VEGi},\ Q^d_{VEGi}, IWPI, U_{VEGi}\right) \quad (1)$$

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[1] Italicized numbers in parentheses refer to items in References at the end of this article.

where

M_{VEGi} = Dollar margin associated with vegetable i per pound retail weight

P^f_{VEGi} = Dollar farm value of vegetable i per pound retail weight equivalent

Q^d_{VEGi} = Quantity of fresh vegetable i demanded by domestic consumer, in million pounds retail weight

IWPI = Industrial wholesale price index, 1967 = 1.000

U_{VEGi} = Disturbance term, assumed to be normally distributed

In the first three definitions, for lettuce, margin and farm values are measured in dollars per head, and quantity is measured in million head.

For simplicity and because no prior considerations suggested a nonlinear relationship, we set the specific functional form of the margin relations in linear terms, and we had 22 annual observations on data from 1954 to 1975.

The specification of the margin relations was motivated by the work of Buse and Brandow (*2*). The relations express the margin of a particular vegetable per retail unit as a function of the farm value of the vegetable, the total quantity of it demanded by consumers, and a proxy (IWPI) for other marketing costs.[2]

Manchester shows that 79 percent of the wholesale produce firms participating in his study used, in establishing margins, either a constant percentage of acquisition or selling price or a constant per unit markup above costs (*5*). An additional 18 percent of the firms indicated that supply and demand forces established prices or that these firms charged according to what the market would bear. Buse and Brandow maintain that "a large amount of evidence supports the conclusion that changes in farm-retail price spread over a period of time are determined primarily by changes in costs of all factors employed in processing and distributing operations" (*2*). Including the farm price and an intercept term in a linear equation provides measures of percentage markups and per unit markups. George and King used a specification algebraically similar to the margin equation; they expressed farm price as a linear function of retail price (*3*).

The quantity variable accounts for the marketing firms' reactions to changes in the level of quantity demanded. Changes in the margin will occur if marketing firms attempt to charge what the market will bear and adjust the level of margin in response to the strength of demand, or if the firms experience economies of size.

The IWPI is a proxy for all costs other than for raw product acquisition. Buse and Brandow indicate that the IWPI serves as a useful proxy for costs of factors employed in processing and distributing (*2*).

THE PRIOR INFORMATION

We formed prior estimates of the ranges for the mean margin elasticities with respect to farm prices, volume, and IWPI. We based these estimates on discussion with commodity specialists and colleagues, characteristics of institutions in produce markets, past research, and introspection.

The research by George and King (*3*) and Buse and Brandow (*2*) provided information that helped us form prior estimates of the likely range of elasticities of the margins for farm prices. The following mean level elasticities were obtained from the results of George and King:

$$E_{M,PCAR} = 0.15$$

$$E_{M,PLET} = 0.51$$

$$E_{M,PTOM} = 0.88 \qquad (2)$$

Buse and Brandow calculated the following mean level elasticities of the margins for retail prices for a pre-1957 period:

$$E_{M,PCAB} = 0.56$$

$$E_{M,PLET} = 0.58 \qquad (3)$$

Assuming the elasticities of price transmission are less than one, the estimates in (3) are upper bounds to the elasticities of the margins for farm prices.[3]

Given the previous estimates and the argument that elasticities among commodities with similar characteristics should be similar, the prior range of values for the mean level elasticities of the margins for farm prices was:

$$E_{M,Pf} \in [-0.25, 0.75] \text{ with probability } 0.95 \qquad (4)$$

For estimation, a prior point estimate of $\hat{E}_{M,Pf} = 0.25$, assumed to be generated by a normally distributed process with variance equal to 0.0625, was used to represent the prior information (*4*).

Buse and Brandow reported a positive relationship between margin and volume for cabbage and a negative, but statistically insignificant, relationship for lettuce. The mean level elasticities were calculated to be 0.36 for cabbage and −0.42 for lettuce.

[2] The farm value of a vegetable per pound refers to the price paid to the farmer for an amount of raw product sold at retail. For example, 1.18 pounds of fresh tomatoes at the farm are equivalent to 1 pound at retail. The difference between quantities at the farm and at retail is due to waste, shrinkage, and spoilage as the commodity passes through the market system. In this article, the term "farm price" will refer to the value of a vegetable per pound of retail weight equivalent.

[3] As would be indicated by the results of George and King (*3*, p. 62).

We anticipate that volume and margin will be positively related as, in times of slack demand, margins are expected to be lower than in times when demand is strong. This view is supported by Manchester's finding that many produce handlers report charging what the market will bear, or according to supply and demand (*5*). Our prior estimate of the range for the mean level elasticities of the margins for volume was:

$$E_{M,Q} \in [0, 2] \text{ with probability } 0.95 \tag{5}$$

The prior information (5) was represented as a normally distributed prior point estimate $\hat{E}_{M,Q} = 1$ with variance equal to 0.25.

Finally, Buse and Brandow, using the average market basket farm-retail price spread index as a proxy for costs in marketing, obtained the following elasticities:

$$E_{CAB,COST} = 1.09$$

$$E_{LET,COST} = 0.62 \tag{6}$$

They stated that using the IWPI in place of the market basket index made little change in the results, although they did not present them. As the market basket index is directly determined by the margin setting behavior of marketers while the wholesale price index is not, we believed that the IWPI would serve as a better proxy for the costs of marketing inputs.

The prior estimate of the interval for the mean level elasticities of the marketing cost margins was:

$$E_{M,IWPI} \in [0, 1.5] \text{ with probability } 0.95 \tag{7}$$

The prior information (7) was represented as a normally distributed prior point estimate $\hat{E}_{M,IWPI} = 0.75$ with variance equal to 0.140625. The covariances among the three prior constraints were assumed to be zero for each margin relation. The implication is that errors in the prior estimates of one coefficient do not affect prior estimates of the other coefficients in the equation. This assumption is plausible because prior estimates on an equation's coefficients were selected independently of one another.

RESULTS

Statistical

The margin equations were estimated with two-stage least squares mixed estimation.[4] The parameter estimates, share of prior information in the posterior precision, the χ^2 test of compatibility between sample and prior information (χ^2_3), and the simple correlation between the actual and predicted value of the margin appear in table 1.[5] Except for cucumbers, the prior estimates provided less than 20 percent of the information present in the posterior precision of the mixed estimates. Therefore, much of the information used to calculate the mixed estimates came from the sample.

The χ^2 test of compatibility indicates that, except for cabbage, the sample and prior information are judged compatible at the 0.05 level of Type I error. Acceptance of compatibility implies acceptance of strong mean square error superiority; that is, every linear combination of the mixed parameter estimates is smaller in mean square error than a corresponding linear combination of the pure estimates. For cabbage, compatibility is accepted at the 0.025 level of Type I error. Through a test of strong mean square error superiority based on the noncentral χ^2 distribution (see *6*), the mixed estimate of the cabbage relation is strong mean square error superior to pure estimates of the parameters at the 0.05 level of Type I error.

The lowest simple correlation between actual and predicted values of the margin was 0.885. Six of the seven margin relations exhibited simple correlations of 0.944 or better.

To provide a comparison between pure estimates (based on sample information only) and mixed estimates (based on sample and prior information), we present a table of prior, pure, and mixed mean level elasticity estimates (table 2). Two standard deviation (95-percent confidence level) intervals are also provided.

Although occasionally the pure and mixed estimates are not especially close to each other, most are the same general order in magnitude and all interval estimates overlap substantially. The point estimates of three of the 21 elasticities differed in sign between the prior and pure estimates. For these three elasticities, the mixed point estimates agreed in sign with the prior estimates in two cases and with the pure estimate in one case. A number of entries in table 2 illustrate that because of the covariance structures of the two-stage least squares estimate, the mixed point estimates need not lie inbetween the prior and pure estimates.

The variances of the mixed estimates were less than the variance of the pure estimates in every case. Consequently, the mixed estimation intervals averaged 21 percent shorter than the pure estimation intervals. In a few cases, the reductions in length were over 50 percent. However, it is evident upon examining tables 1 and 2 that, although generally the mixed estimates represented a relative improvement over pure estimates, in several cases confidence in individual point estimates remained rather low.

[4] For a discussion of the first stage of the two-stage analysis, see Mittelhammer (*7*). The first stage included predetermined variables that appeared in equations other than the margin relations.

[5] The simple correlations are computed using actual values for right-hand-side endogenous variables.

Table 1—2SLS-ME results for margin relations

Dependent variable	Independent variables: Constant	P^f_{VEG}	Q_{VEG}	IWPI	Share of prior information in precision	χ^2_3	r
M_{CAB}	1.617 (.57/.284)	1.011 (5.88/<.001)	.00050 (.28/.390)	2.032 (1.95/.026)	0.196	9.079	0.944
M_{CAR}	−3.119 (−1.22/.111)	−.117 (−.80/.212)	.00601 (2.43/.008)	7.547 (6.00/<.001)	.109	2.160	.948
M_{CEL}	−12.569 (−5.27/<.001)	.630 (3.38/<.001)	.01189 (5.25/<.001)	5.813 (4.98/<.001)	.101	.878	.973
M_{CUC}	−2.825 (−.47/.319)	.296 (.84/.201)	.01447 (1.09/.138)	8.005 (2.51/.006)	.418	4.537	.885
M_{GP}	−7.177 (−1.29/.099)	.561 (2.69/.004)	.03299 (1.87/.031)	9.578 (2.67/.004)	.182	2.342	.944
M_{LET}	−25.463 (−1.60/.055)	.481 (2.08/.019)	.01554 (11.23/<.001)	4.166 (1.97/.024)	.144	7.055	.985
M_{TOM}	−9.299 (−1.77/.038)	.592 (3.26/<.001)	.00876 (3.00/.001)	7.298 (2.30/.011)	.139	2.397	.967

Note: Except for P^f_{VEG}, all parameter estimates have been scaled by multiplying times 100; P^f_{VEG} and Q_{VEG} refer to the farm value and quantity demanded of the vegetable to which the dependent variable refers.

The asymptotic *t*-value and one-sided probability value are presented below each coefficient as asymptotic *t*-value/probability value. The probability values are based on the normal distribution.

Behavioral

The relationships between the margins of the seven vegetables and the farm value were positive in all cases except carrots, where the farm value is inversely related to the margin. For carrots, we have considerable doubt concerning the validity of the sign or magnitude of the coefficient due to the large variance of the estimate. Excluding carrots, the margin relations indicate that a 1-percent increase in the farm value of a vegetable will result in a first-round increase in the margin of from 0.158 percent (cucumbers) to 0.427 percent (cabbage). It is a first-round increase because the interaction effect on volume has not been considered.

Converting the elasticities of the margin to elasticities of price transmission (the percentage change in the retail price given a 1-percent change in the farm price) results in:

$$E_{P_{cab},P^f_{cab}} = 0.597 \qquad E_{P_{car},P^f_{car}} = 0.271$$

$$E_{P_{cel},P^f_{cel}} = .490 \qquad E_{P_{cuc},P^f_{cuc}} = .451$$

$$E_{P_{gp},P^f_{gp}} = .576 \qquad E_{P_{let},P^f_{let}} = .556$$

$$E_{P_{tom},P^f_{tom}} = .581 \tag{8}$$

Except for carrots, the magnitudes of the elasticities of price transmission are consistent. For the other six vegetables, a 1-percent change in farm value would result in a first-round change in retail price ranging from 0.451 percent to 0.597 percent.

The elasticities of the margins for quantities are all positive (table 2). Thus, the first-round change in margins and retail prices due to changes in farm values will be dampened when an interaction with negatively sloped demand curves is allowed.[6] Marketing margins for the salad vegetables will increase when quantity demanded increases and decrease when quantity demanded falls. Unlike the reaction to farm price changes, the elasticities of the margins for quantities demanded differ substantially in magnitudes, from a low of 0.105 for cabbage to a high of 2.024 for lettuce.

The elasticity of the marketing cost margin is uniformly positive and ranges from a low of 0.267 for cabbage to 0.670 for carrots (table 2). As with farm value, these elasticities represent first-round effects that occur before quantity demanded is allowed to change. Given the positive values of $E_{m,q}$, the upward effect on the margins for an increase in the cost index will be dampened by

[6] Estimates of retail demand curves for the seven salad vegetables can be found in (7).

the effects of the increased retail price on volumes sold.

To provide an overall view of the effects of farm price and quantity on the margins, we graphed retail and farm level demand relationships for lettuce (chart). The vertical difference between the two demand schedules is equal to the margin:

$$M_{LET} = a + b_1 Q_{LET} + b_2 P^f{}_{LET}$$

$$= \frac{1}{1 + b_2} \left(a + b_1 Q_{LET} + b_2 P^r{}_{LET}\right)$$

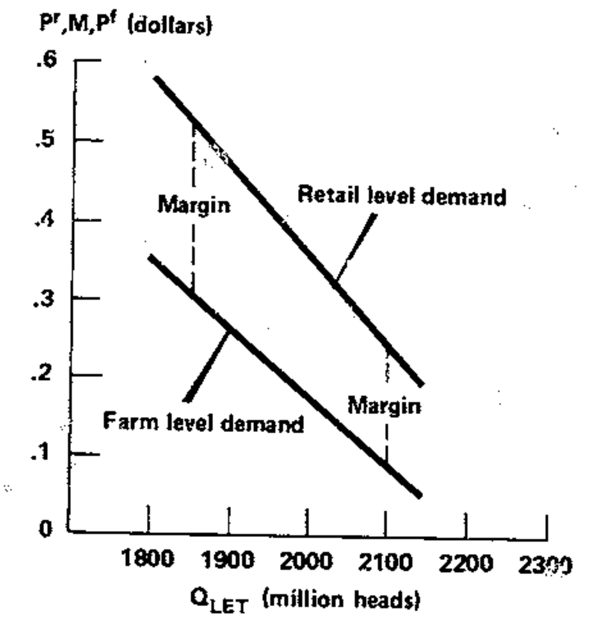
since $P^f{}_{LET} = P^r{}_{LET} - M_{LET}$. The demand curves are drawn at the mean levels of the other arguments of the functions.

The net effect of farm price and quantity is to decrease the margin as quantity increases and price decreases. As a result, the farm level demand schedule is flatter than at the retail level. The results are similar for the other vegetables excluding carrots. For carrots, the retail level demand schedule is flatter than the farm level demand.

Table 2—Comparison of prior, pure 2SLS, and mixed 2SLS estimates of mean level elasticities of the margins for farm values, quantities demanded, and cost index using two standard deviation confidence intervals

Elasticity	Prior	Pure 2SLS	Mixed 2SLS
$M_{CAB}, P^f{}_{CAB}$	0.25 ± 0.5	0.448 ± 0.162	0.427 ± 0.145
M_{CAB}, Q_{CAB}	1. ± 1.	−.935 ± 1.159	−.105 ± .752
$M_{CAB}, IWPI$	.75 ± .75	.288 ± .320	.267 ± .273
$M_{CAR}, P^f{}_{CAR}$	.25 ± .5	−.060 ± .141	−.052 ± .130
M_{CAR}, Q_{CAR}	1. ± 1.	.552 ± .633	.645 ± .530
$M_{CAR}, IWPI$	.75 ± .75	.706 ± .242	.670 ± .223
$M_{CEL}, P^f{}_{CEL}$	.25 ± .5	.280 ± .173	.271 ± .160
M_{CEL}, Q_{CEL}	1. ± 1.	1.359 ± .552	1.261 ± .480
$M_{CEL}, IWPI$	.75 ± .75	.468 ± .220	.504 ± .202
$M_{CUC}, P^f{}_{CUC}$	.25 ± .5	.471 ± .881	.158 ± .376
M_{CUC}, Q_{CUC}	1. ± 1.	−1.078 ± 1.816	.430 ± .791
$M_{CUC}, IWPI$	.75 ± .75	.627 ± .743	.486 ± .387
$M_{GP}, P^f{}_{GP}$	.25 ± .5	.421 ± .295	.328 ± .244
M_{GP}, Q_{GP}	1. ± 1.	.345 ± .770	.548 ± .589
$M_{GP}, IWPI$	.75 ± .75	.381 ± .354	.398 ± .298
$M_{LET}, P^f{}_{LET}$	.25 ± .5	.273 ± .352	.289 ± .278
M_{LET}, Q_{LET}	1. ± 1.	2.216 ± .414	2.024 ± .360
$M_{LET}, IWPI$	.75 ± .75	.143 ± .318	.273 ± .278
$M_{TOM}, P^f{}_{TOM}$	.25 ± .5	.445 ± .257	.341 ± .209
M_{TOM}, Q_{TOM}	1. ± 1.	.573 ± .576	.723 ± .486
$M_{TOM}, IWPI$	.75 ± .75	.200 ± .339	.328 ± .285

Lettuce Margin Behavior, Mean Level of Data



To examine the effects of changing farm level prices on retail price and margins after quantity demanded is allowed to interact, we combined the margin relations in table 1 with retail demand equations estimated elsewhere (7) to derive a partial reduced form. Mean level elasticities were computed and partial elasticities are also summarized (table 3).

The magnitudes of the partial elasticities are larger than the elasticities in which quantity demanded has been allowed to change in response to price stimuli. One reason is that the price-quantity demand relationships for the vegetables are negatively sloped (7). A farm level price increase leads to an increase in retail price and a decrease in quantity demanded. The decrease in quantity demanded leads to a decrease in the margin, one that is lower than the partial effect of a farm price change would indicate.

Except for carrots, marketers' final reaction to a higher level of farm value is to raise the level of the margins. Such a response could be expected as, if margins were not increased, marketers' revenues would decrease, given negatively sloped demand curves.

Table 3—Mean level elasticities

A 1-percent change in—	Percentage change in—			
	Retail price		Margin	
	With Q interaction	*Partial*	*With Q interaction*	*Partial*
P^f_{cab}	0.586	0.597	0.411	0.427
P^f_{car}	.227	.271	−.113	−.052
P^f_{cel}	.406	.490	.115	.271
P^f_{cuc}	.419	.451	.079	.158
P^f_{gp}	.538	.576	.267	.328
P^f_{let}	.480	.556	.182	.289
P^f_{tom}	.469	.581	.165	.341

CONCLUSIONS

Our objectives were to apply and evaluate the mixed estimation technique, and to specify the margin-forming behavior of produce markets.

The prior information used in the model was probabilistic, and its degree of uncertainty was included. Prior information was compatible with sample information, for all but one vegetable, at the 0.05 level of significance. For the exception, the mean square error test showed the mixed estimation estimates were superior to the pure estimates. For six of the seven vegetables, the prior information was responsible for less than 20 percent of the posterior precision of the estimates.

Regarding behavioral implications of the model, aggregate farm-retail price spreads for cabbage, celery, cucumbers, green peppers, lettuce, and tomatoes increased when farm price increased. The inverse relationship occurred for carrots, probably because of estimation error.

Aggregate margins increase when quantity demanded increases and they decrease when retail demand weakens. The behavior reflects a tendency of many marketers to charge what the market will bear and/or to attempt to equate demand forces with supply. Aggregate margins increased when marketing cost (proxied by the industrial wholesale price index) increased.

In our application, the mixed estimator resulted in parameter estimates that were relatively more precise than those derived from sample information alone. The extent to which it will improve the estimates in applications is problem specific. However, in modeling situations where respectable research has been previously accomplished and/or specialists familiar with the structure of the system under study are available, it would appear desirable to use prior information in parameter estimation. Statistical tests exist to indicate conflicts between the sample information and prior notions. Another test determines whether the precision of parameter estimates will be increased concomitant with decreases in the mean square errors of estimators. The U.S. Department of Agriculture is a prime example of an institution in which substantial amounts of commodity specialist expertise can be used to bolster the historical sample information base, and improve the estimation of commodity models.

In Earlier Issues

The beginner need not let the language and notation of the mature mathematical statistician deter him. The vocabulary and symbolism must be learned sometime by a prospective statistician and it may as well be at the start of his career.

Walter A. Hendricks
Vol. III, No. 1, Jan. 1951, p. 37

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In Earlier Issues

Collective action is now dominant in America and in all other important national economies throughout the world. Its principal forms in America are corporations, labor unions, and political parties. If economic analysis is to be directed to real problems of policy instead of merely to the solution of logical problems of mathematics, it cannot escape the analysis of collective action and the choice of alternatives available under collective action. In a period characterized by control economics, the most serious blindness is the illusion that it is possible to return to the individualism of the eighteenth century. The laissez-faire boys generally have already become pessimists who see America headed straight down the road to serfdom. The extreme Keynesians are already extreme optimists who seek only the authority to regulate the money switch.

Bushrod W. Allin
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