The Demand for Farm Output

James Dunn and Dale Heien

This paper treats the demand for farm output as part of an interrelated factor demand system. The farm level outputs are meat, poultry, dairy, fruits and vegetables and other food. The processing and distribution inputs are labor, packaging, transportation and all other. Input demands are modelled using a restricted translog cost function which is conditional on capital stock in the processing sector. The results show that: each category of farm output demand is inelastic; capital stock is an important determinant of the demand for farm output; there is no substitution among various farm outputs and little substitution between outputs and other inputs; there is moderate substitution among the nonfarm inputs; and, increases in nonfarm input costs have significant negative effects on farm output demand.

Over the past decade, the food processing and distribution sector has experienced major changes in the relative prices paid for inputs. The major categories of these inputs include labor, transportation, packaging, and capital. The differential changes in these costs have posed substantial adjustment problems for firms in this industry. These adjustments have, in turn, affected the demand for farm output which is the other main input into this sector. Although quantitative studies of the effects of input costs on the derived demand for farm output have been done (Chambers, 1982; Wohlgenant, 1982), no study has been made of the aggregate food sector. Also, with the exception of the study by Chambers, none have considered the various processing and distribution costs as a set of interrelated factor demands. This study attempts to measure the degree of substitution between these inputs and to measure the final demand for farm output as a derived demand.

It is frequently assumed that the demand for farm output is synonomous with retail consumer demand for food. This study demonstrates the extent to which and manner in which farm output demand depends not only on consumer related variables such as prices and income but also processing variables such as wages and capital stock. Because of the concept of 'farm gate' it is especially important, for policy purposes, to isolate the demand for farm output as opposed to the demand for food from which it is derived.

In order to do this, a cost function approach which distinguishes between farm output and processing inputs is developed. The cost function, through the use of duality relations, permits the derivation of input demand and output pricing relationships. The estimates of these input demand functions are used to compute the elasticities of demand for each factor input with respect to all factor prices, capital stock, and output. The associated retail pricing equations are used to obtain a reduced form solution. This is accomplished by utilizing information on retail demand elasticities from a previous study and combining it with the estimates produced in this study. This reduced form shows farm output demand as a function of farm output prices, the prices of marketing inputs (e.g., labor, transport), consumer income, nonfood retail prices, and capital stock. The model is then solved for farm prices and the flexibility matrices are calculated.

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Theoretical Development

Assume that a firm in the food processing and distribution sector can be represented by the implicit multiproduct production function,

$$0 = f(X, L, Q, K) \tag{1}$$

where X is a vector of retail outputs (e.g., dairy products, bread), L is a vector of nonfarm variable inputs (e.g., labor, transportation), Q is a vector of farm outputs (e.g., milk, wheat), and K is a vector of quasi-fixed factors (capital). At any given point in time, the firm's capital stock is fixed, implying that (1) is a conditional production function. In the short-run, the firm will choose inputs to minimize variable cost,

$$c = W'L + F'Q \tag{2}$$

where W is a vector of nonfarm input prices and F is a vector of farm output prices. Maximization of (1) subject to (2) yields the short-run cost function,

$$c = c(W, F, X, K) \tag{3}$$

which gives the cost of producing the vector of outputs conditional on capital stock K, and input prices W and F. Although the determinants of K can be derived as a multiperiod maximization process, this study analyzes variable input demand conditional on that given capital stock.

Utilizing Shephard's Lemma,

$$\frac{\partial c}{\partial w_i} = l_i = c_{w_i}(W, F, X, K). \tag{4a}$$

and

$$\frac{\partial c}{\partial f_j} = q_j = c_{f_j}(W, F, X, K) \tag{4b}$$

the short-run factor demand equations can be derived.

Under competitive conditions, firms will engage in marginal cost pricing, or

$$\frac{\partial c}{\partial x_j} = p_j = c_{x_j}(W, F, X, K) \tag{5}$$

where p_j is the price of the *jth* retail output. The set of factor demand relations given by (4) are incomplete in the sense that they depend on output. To complete the model, consider the set of retail demand relations

$$x_j = x_j(P, y, z) \tag{6}$$

where P is a vector of retail food prices, y is income, and z is other retail (nonfood) prices. Inserting (5) and (6) into (4) gives

$$l_i = l_i(W, F, K, y, z) \tag{7a}$$

and

$$q_j = q_j(W, F, K, y, z). \tag{7b}$$

The above, (7), is a reduced form for input demand. This paper provides estimates of (7) for a number of farm outputs and other inputs and quantifies the relative importance of each of the determinants.

Econometric Specification and Estimation

For the study at hand, five retail outputs, five corresponding farm outputs and four processing and distribution inputs are used. The farm outputs are meat, dairy, poultry, fruits and vegetables, and other foods (cereal, bakery products). These data were obtained from farm marketings and average prices received by farmers contained in USDA (1983). The data on wages and manhours in the processing and distribution sector were obtained from U.S. Department of Labor (1982). The capital stock data apply to the food and kindred products sector as reported in U.S. Department of Commerce (1979). No capital stock estimates are available for wholesale or retail food enterprises. However, significant portions of that capital are rented and appear in the cost function as rent. The other inputs are packaging, transportation, and all other (utilities, advertising, taxes, and rent). Totals for these categories are available from USDA (1975). Data on the costs of individual inputs, packaging, transportation, and all others, were obtained for the various census years. For noncensus years, these data were interpolated. Data for the retail food prices and quantities were taken from USDA (1983).

Estimation of the cost function was accomplished via the factor share equations. A distinction between farm outputs and other inputs is made since their roles in the production process are substantially different. The specification used is the translog cost function

$$\begin{aligned}\ln c_t = &\sum_{j=1}^{5} \alpha_j \ln f_{jt} + \sum_{j=1}^{5}\sum_{k=1}^{5} \alpha_{jk} \ln f_{jt} \ln f_{kt} \\ &+ \sum_{i=1}^{4} \beta_i \ln w_{it} + \sum_{i=1}^{4}\sum_{l=1}^{4} \beta_{il} \ln w_{it} \ln w_{lt} \\ &+ \sum_{i=1}^{4}\sum_{j=1}^{5} \phi_{ij} \ln w_{it} \ln f_{jt} + \sum_{j=1}^{5} \gamma_j \ln x_{jt} \\ &+ \sum_{j=1}^{5}\sum_{k=1}^{5} \gamma_{jk} \ln x_{jt} \ln x_{kt} \\ &+ \sum_{i=1}^{4}\sum_{j=1}^{5} \epsilon_{ij} \ln w_{it} \ln x_{jt} \\ &+ \sum_{j=1}^{5}\sum_{k=1}^{5} \mu_{jk} \ln x_{jt} \ln f_{kt} + K_t \sum_{j=1}^{5} \rho_j \ln f_{jt} \\ &+ \ln K_t \sum_{j=1}^{5} \theta_j \ln x_{jt} + \ln K_t \sum_{i=1}^{5} \Gamma_i \ln w_{it} \qquad (8)\end{aligned}$$

where the f_j's are farm output prices, the w_i's are other input prices, and the x_j's are retail outputs. The share (demand) equations for the farm outputs are,

$$\begin{aligned}v_{jt} = \alpha_j &+ \sum_{k=1}^{5} \alpha_{jk} \ln f_{kt} + \sum_{i=1}^{4} \phi_{ij} \ln w_{it} \\ &+ \sum_{k=1}^{5} \mu_{kj} \ln x_{kt} + \rho_j \ln K_t \qquad (9)\end{aligned}$$

j = M, D, P, FV, and O,

where M is meat, D dairy, P poultry, FV fruits and vegetables, and O other food and $v_{jt} = f_{jt} q_{jt}/c_t$. For the other inputs,

$$\begin{aligned}v_{it} = \beta_i &+ \sum_{l=1}^{4} \beta_{il} \ln w_{lt} + \sum_{j=1}^{5} \phi_{ij} \ln f_{jt} \\ &+ \sum_{j=1}^{5} \epsilon_{ij} \ln x_{jt} + \Gamma_i \ln K_t \qquad (10)\end{aligned}$$

i = L, B, T, and A

where L is labor, B packaging, T transportation and A all other and $v_{it} = w_{it} l_{it}/c_t$. Equations (9) and (10) are the form in which the share equations were estimated.

In order to complete the estimation, the set of marginal cost pricing rules for each output must be included. Following (5) these are

$$\begin{aligned}d_{jt} = \gamma_j &+ \sum_{k=1}^{5} \gamma_{jk} \ln x_{kt} + \sum_{i=1}^{4} \epsilon_{ij} \ln w_{it} \\ &+ \sum_{k=1}^{5} \mu_{jk} \ln f_{kt} + \theta_j \ln K_t \qquad (11)\end{aligned}$$

j = M, D, P, FV, and O,

where $d_{jt} = p_{jt} x_{jt}/c_t$.

To ensure that the theoretical conditions of linear homogeneity in input prices and symmetry hold, the following restrictions

$$\sum_{j=1}^{5} \alpha_j + \sum_{i=1}^{4} \beta_i = 1.0 \qquad (12a)$$

$$\sum_{l=1}^{4} \beta_{il} + \sum_{j=1}^{5} \phi_{ij} = 0 \qquad (12b)$$

$$\sum_{i=1}^{4} \phi_{ij} + \sum_{k=1}^{5} \alpha_{jk} = 0 \qquad (12c)$$

$$\sum_{i=1}^{4} \epsilon_{ij} + \sum_{k=1}^{5} \mu_{jk} = 0 \qquad (12d)$$

$$\beta_{il} = \beta_{li}, \quad \alpha_{jk} = \alpha_{kj}, \quad \gamma_{jk} = \gamma_{kj} \qquad (12e)$$

were imposed in the estimation. For the farm outputs it is doubtful if much substitution exists. Meat cannot be substituted for milk in the production of cheese for example. For the translog cost function the Allen partial elasticity of substitution between farm outputs is

$$\sigma_{ij} = (\alpha_{ij} + v_i v_j)(v_i v_j)^{-1} \quad i \neq j. \qquad (13)$$

In order to test the restriction that $\sigma_{ij} = 0$ for i, j = M, D, P, FV and 0 ($i \neq j$), first the system given by (9)–(11) was estimated by nonlinear 3SLS. Next a restricted system where $\alpha_{ij} = -\bar{v}_i \bar{v}_j$ ($i \neq j$)i, j = M, D, P, FV and 0 was estimated. This latter system restricts all farm output Allen partial elasticities to be zero at the means. The appropriate test statistic (see Berndt and Savin [1977] and Moran [1980]) is

TABLE 1. Parameter Estimates for Restricted Translog Cost Function.

		Farm Output Prices					Processing Input Prices	
	Intercept	Meat	Dairy	Poultry	Other Farm	Fruits and Veg.	Labor	Packaging
Factor Share								
Meat	0.549	0.093	−.0101*	−0.0065*	−0.0071*	−0.0075*	0.0094	−0.0076
	(10.7)	(16.9)					(0.82)	(1.46)
Dairy	0.286		0.0444	−0.0034*	−0.0037*	−0.0039*	−0.0122	−0.0068
	(13.3)		(20.0)				(2.30)	(2.19)
Poultry	0.086			0.0487	−0.0024*	−0.0025*	−0.0002	−0.0139
	(4.6)			(37.5)			(0.05)	(5.34)
Other Farm	−0.023				0.0459	−0.0027*	−0.0254	−0.0054
	(5.6)				(13.5)		(2.67)	(1.69)
Fruits and Veg.	0.062					0.0292	−0.0203	−0.0071
						(7.32)	(2.51)	(1.48)
Labor	0.409						0.0119	−0.0132
							(0.36)	(1.15)
Packaging	0.015							0.0310
								(3.44)
Transport	0.312							
Other Nonfarm**	−0.487							
Output Share					Symmetric			
Meat	0.7033							
Dairy	0.6779							
Poultry	0.4059							
Other Food	−0.6282							
Fruits and Veg.	−0.1439							

The figures below the coefficients in parentheses are the t-ratios.
* These coefficients are constrained so that $\alpha_{ij} = -\bar{v}_i \bar{v}_j$. This restriction is discussed in the text.
** Indicates deleted equation.

$$s = n \ln \left| \frac{\det|\mathrm{Var}(e_R)|}{\det|\mathrm{Var}(e)|} \right| \tag{14}$$

where $\mathrm{Var}(e_R)$ is the variance-covariance matrix of the residuals from the restricted model, $\mathrm{Var}(e)$ is the analogous matrix for the unrestricted model and n is the sample size. The test statistic, s, is distributed as a χ^2 with R degrees of freedom where R is the number of restrictions. For this application the test statistic was 15.54 while the χ^2 value for 10 degrees of freedom and $\alpha = .05$ is 18.31. Therefore, we cannot conclude that the restrictions are not true. Since some ambiguity exists as to which test is appropriate for this problem we also computed the Wald test and the La-Grange multiplier tests which produced the same results as the χ^2 test. Also, similar tests were made on a specification including time in each equation as a measure of technical change. The results showed that time was not a significant variable. This finding is consistent with results by Heien (1983) which showed no productivity change in this industry over a similar period. The estimates of the restricted system along with their t-ratios, $\bar{R}^{-2}$'s, and Durbin-Watson statistics are given in Table 1.

TABLE 1. Extended.

Processing Input Prices		Retail Output Quantities					Quasi Fixed Input		
Transport	Other Nonfarm	Meat	Dairy	Poultry	Other Food	Fruits and Veg.	Capital	R^2	DW
−0.032	−0.032	0.0899	−0.0253	−0.0078	−0.0529	−0.0037	−0.1463	0.934	2.27
(7.52)	(2.58)	(7.68)	(2.69)	(2.17)	(2.71)	(0.35)	(7.82)		
−0.0061	−0.0017	−0.0150	−0.0436	−0.0022	−0.0129	−0.0132	−0.0497	0.979	1.20
(2.65)	(0.30)	(3.19)	(7.27)	(0.79)	(1.26)	(2.13)	(9.03)		
−0.0028	−0.0170	−0.0157	−0.0222	0.0474	−0.0016	−0.0074	−0.1463	0.992	1.18
(1.40)	(4.05)	(4.03)	(5.04)	(23.7)	(0.19)	(1.48)	(1.22)		
−0.0038	0.0045	−0.0190	−0.0080	−0.0051	0.0459	−0.0178	0.0771	0.774	1.88
(1.12)	(0.42)	(3.39)	(1.60)	(2.83)	(4.23)	(3.42)	(7.70)		
−0.0076	0.0224	−0.0094	−0.0211	−0.0032	−0.0165	0.0502	0.0014	0.690	1.81
(0.63)	(0.16)	(0.79)	(0.34)	(2.18)	(0.16)	(0.32)	(0.15)		
0.0353	0.0148	0.0858	0.0186	0.0061	−0.0522	−0.0589	−0.0420	0.295	0.64
(2.74)	(0.40)	(3.35)	(1.00)	(0.73)	(1.37)	(2.58)	(1.17)		
−0.0051	0.0281	−0.0314	−0.0145	−0.0312	0.0736	0.0031	0.0084	0.812	2.15
(0.91)	(2.87)	(2.38)	(1.34)	(5.89)	(3.05)	(0.23)	(0.66)		
0.165	0.0052	−0.0683	0.0063	0.0071	0.0308	0.0247	−0.0623	0.642	0.59
(2.39)	(0.30)	(6.51)	(0.80)	(1.92)	(1.66)	(2.65)	(4.51)		
	−0.0277	−0.0169	0.0231	−0.0110	−0.0181	0.0230	0.2073		
	(0.45)	(0.77)	(1.54)	(1.80)	(0.49)	(1.35)	(5.31)		
		0.1677	−0.0128	0.0098	−0.1525	−0.0086	−0.1144	0.907	1.38
		(4.89)	(0.56)	(0.97)	(3.10)	(0.33)	(4.25)		
			0.1794	0.0067	−0.1001	−0.0633	−0.1275	0.898	1.49
			(6.72)	(0.06)	(2.14)	(2.67)	(6.01)		
				0.1054	−0.0603	−0.0537	−0.0633	0.989	1.48
				(14.84)	(3.28)	(4.79)	(6.46)		
					0.2710	0.0435	0.2199	0.680	1.62
					(2.29)	(0.90)	(4.40)		
						0.0827	0.0749	0.297	1.44
						(2.38)	(2.97)		

It is now possible to compute price and output elasticities e_{ij} from the formula,

$$e_{ij} = c \cdot c_{ij} \cdot v_j / c_i c_j. \tag{15}$$

The elasticities are given in Table 2. These estimates show that retail output is the main determinant of farm level demand. Table 3 presents the elasticities of output prices from (11). All elasticities are computed at the means of the shares.

Complete Model Solution with Extraneous Information

In this section, elasticity estimates from the above structural equations and from an earlier study are combined to obtain a reduced form expression for the demand for farm output. In order to simplify the presentation, the ensuing analysis is conducted in constant elasticity (double log) form. Using the elasticities from Table 2, the demand for farm outputs (Q) can be written in the double log form as

$$\ln Q = \Omega_1 \ln F + \Omega_2 \ln W + \Omega_3 \ln X + \Omega_4 \ln K \tag{16}$$

where ln Q is a vector of logarithms of each element of Q. The marginal cost pricing rules {equation (11)} in constant elasticity form are

$$\ln P = \Pi_1 \ln F + \Pi_2 \ln W + \Pi_3 \ln X + \Pi_4 \ln K \tag{17}$$

TABLE 2. Matrix of Elasticities for Farm Outputs and Other Inputs
(13) $\ln Q = \Omega_1 \ln F + \Omega_2 \ln W + \Omega_3 \ln X + \Omega_4 \ln K$.

	Farm Prices					Other Input Prices					Retail Quantities				
Quantities	Meat	Dairy	Poultry	Other Food	Fruits and Veg.	Labor	Packaging	Transport	Other	Capital	Meat	Dairy	Poultry	Other Food	Fruits and Veg.
Meat	−0.19	0	0	0	0	0.37	0.03	−0.17	0.03	0.44	0.94	−0.01	0.03	−0.12	0.20
Dairy	0	−0.31	0	0	0	0.13	−0.01	−0.03	0.22	1.02	0.08	0.78	0.05	0.08	0.04
Poultry	0	0	0.09	0	0	0.30	−0.22	−0.00	−0.17	1.19	−0.05	−0.31	1.10	0.23	0.07
Other Food	0	0	0	−0.05	0	−0.20	−0.03	−0.02	0.29	0.43	−0.08	−0.02	−0.02	1.24	−0.13
Fruits and Veg.	0	0	0	0	−0.40	−0.08	−0.05	−0.08	0.61	0.84	0.11	−0.22	0.02	−0.05	1.16
Labor	0.17	0.03	0.05	−0.03	−0.01	−0.66	0.04	0.17	0.25	0.15	0.57	0.23	0.10	0.09	0.03
Packaging	0.04	−0.01	−0.13	−0.02	−0.04	0.14	−0.53	−0.01	0.55	−1.06	−0.10	−0.01	−0.31	1.18	0.26
Transportation	−0.41	−0.03	−0.00	−0.01	−0.08	0.92	−0.01	−0.66	0.29	−0.57	−0.90	0.28	0.21	0.80	0.66
Other Nonfarm	−0.02	0.08	0.04	0.07	0.17	0.38	0.22	0.08	−0.94	1.58	0.21	0.29	0.03	0.17	0.34

TABLE 3. Matrix of Elasticities for Marginal Cost Pricing
(14) $\ln P = \Pi_1 \ln F + \Pi_2 \ln W + \Pi_3 \ln X$.

	Farm Prices					Other Input Prices					Retail Quantities				
Retail Prices	Meat	Dairy	Poultry	Other Food	Fruits and Veg.	Labor	Packaging	Transport	Other	Capital	Meat	Dairy	Poultry	Other Food	Fruits and Veg.
Meat	0.45	0.20	−0.01	−0.01	0.02	0.60	−0.03	−0.18	0.14	0.63	−0.13	0.13	0.12	−0.26	0.20
Dairy	−0.01	0.32	−0.08	0.00	−0.07	0.41	−0.00	0.09	0.33	0.41	0.22	0.21	0.09	−0.32	−0.14
Poultry	0.05	0.05	0.61	−0.01	0.02	0.37	−0.29	0.14	0.07	0.45	0.40	0.18	0.33	−0.45	−0.41
Other Food	−0.06	0.02	0.04	0.24	−0.01	0.10	0.36	0.18	0.13	0.50	−0.29	−0.21	−0.15	0.30	0.39
Fruits and Veg.	0.12	0.01	0.01	−0.03	0.28	0.04	0.09	0.17	0.30	0.58	0.25	−0.11	−0.15	0.45	−0.41

where, again, ln P is a vector of logarithms of retail prices (P). To close this system, consider the traditional double log retail demand model,

$$\ln X = \Phi_1 \ln P + \Phi_2 \ln z + \Phi_3 \ln y. \quad (18)$$

The above system, (14)–(16), can be solved for ln Q,

$$\begin{aligned} \ln Q = {} & (\Omega_1 + \Omega_3 \Gamma \Phi_1 \Pi_1) \ln F \\ & + (\Omega_2 + \Omega_3 \Gamma \Phi_1 \Pi_2) \ln W \\ & + (\Omega_4 + \Omega_3 \Gamma \Phi_1 \Pi_4) \ln K \\ & + \Omega_3 \Gamma \Phi_2 \ln z + \Omega_3 \Gamma \Phi_3 \ln y \end{aligned} \quad (19)$$

where

$$\Gamma = (I - \Phi_1 \Pi_3)^{-1}. \quad (20)$$

The above expression, (19), is the reduced form demand for farm output.

To empirically implement the model given above, the elasticities from Tables 2 and 3 were used for (16) and (17). The matrices for the retail demand equations, (18), were obtained by aggregating the elasticity matrix found in Heien (1982). These three sets of relationships were used to solve for the farm level demands given by (19), which are found in Table 4. Previous studies such as Brandow (1961) and George and King (1971) have found farm own price elasticities to be considerably smaller than corresponding retail own price elasticities. The results here confirm those findings.

The effect of other processing costs on farm level demand is moderate. The impact of nonfood retail prices is important. For meat, poultry, and other food, increases in nonfood prices depress farm level demand, i.e., the income effect dominates. For dairy and fruits and vegetables the reverse is true, indicating substitution prevails. Capital stock exerts a strong positive influence on farm level demand except for meat. Income effects are similar to those found in the retail-demand equations, (18). The own price elasticities are much higher for the nonfarm inputs than they are for the farm outputs.

Perhaps as interesting as the reduced

TABLE 4. Matrix of Elasticities for Reduced Form Farm Level and Processing Inputs Demand (16) $\ln Q = (\Omega_1 + \Omega_3\Gamma\Phi_1\Pi_1)\ln F + (\Omega_2 + \Omega_3\Gamma\Phi_1\Pi_2)\ln W + \Omega_4 K + \Omega_3\Gamma\Phi_2\ln z + \Omega_3\Gamma\Phi_3\ln y$.

	Farm Prices					Other Input Prices						
Quantities	Meat	Dairy	Poultry	Other Food	Fruits and Veg.	Labor	Packaging	Transport	Other	Capital	Nonfood Prices	Income
Meat	−0.52	0.00	0.01	0.02	−0.05	−0.01	0.04	−0.05	−0.14	−0.03	−0.26	1.11
Dairy	0.03	−0.47	0.03	−0.01	0.03	−0.04	−0.03	−0.10	0.06	0.82	0.41	−0.56
Poultry	0.18	0.08	−0.30	0.00	−0.11	0.52	−0.11	−0.21	−0.13	1.21	−0.08	−0.10
Other Food	0.00	0.21	−0.08	−0.13	0.03	−0.01	−0.12	0.05	0.53	0.62	−0.12	0.05
Fruits and Veg.	−0.07	−0.06	−0.04	0.07	−0.69	−0.09	−0.07	−0.29	0.28	0.31	0.23	0.19
Labor	0.00	−0.01	0.03	−0.04	−0.02	−0.91	0.04	0.23	0.18	−0.13	−0.06	0.48
Packaging	0.00	−0.16	−0.12	−0.08	−0.08	0.29	−0.67	0.03	0.68	−1.03	−0.01	0.08
Transport	−0.06	−0.07	−0.13	−0.03	−0.23	1.33	−0.07	−0.98	0.17	−0.52	0.64	1.38
Other	−0.08	0.02	−0.04	0.08	0.10	0.26	0.20	0.03	−1.09	1.30	0.19	−0.02

TABLE 5. Matrix of Flexibilities for Reduced Form Farm Level Prices
(19) $\ln F = \Delta \ln Q - \Delta(\Omega_2 + \Omega_3\Gamma\Phi_1\Pi_2)\ln W - \Delta\Omega_4 \ln K - \Delta\Omega_3\Gamma\Phi_2 \ln z - \Delta\Omega_3\Gamma\Phi_3 \ln y$.

	Quantities					Other Input Prices						
Farm Prices	Meat	Dairy	Poultry	Other Food	Fruits and Veg.	Labor	Packaging	Transport	Other	Capital Stock	Nonfood Prices	Income
Meat	−1.96	−0.15	−0.04	−0.23	0.14	−0.01	0.05	−0.08	−0.19	0.21	−0.51	2.09
Dairy	−0.21	−2.10	−0.26	0.13	−0.03	0.05	−0.06	−0.28	−0.01	1.97	0.81	−0.96
Poultry	−1.38	−0.65	−3.61	0.12	0.65	1.91	−0.28	−0.72	−0.87	4.61	−0.52	0.70
Other Food	0.52	−3.00	1.83	−7.62	−0.77	−1.25	−0.87	0.26	4.73	5.21	0.82	−1.54
Fruits and Veg.	0.35	−0.07	0.45	−0.79	−1.58	−0.38	−0.17	−0.32	0.97	0.50	0.43	0.05

form elasticities are the reduced form flexibilities which are given by (21) and found in Table 5. It is often assumed that the supply of farm output is exogenous in the short run. Under that condition, and assuming the equality of supply and demand for farm output, the determination of farm prices is,

$$\begin{aligned}\ln F = &\Delta \ln Q - \Delta(\Omega_2 + \Omega_3\Gamma\Phi_1\Pi_2)\ln W \\ &- \Delta(\Omega_4 + \Omega_3\Gamma\Phi_1\Pi_4)\ln K \\ &- \Delta\Omega_3\Gamma\Phi_2 \ln z - \Delta\Omega_3\Gamma\Phi_3 \ln y \qquad (21)\end{aligned}$$

where $\Delta = (\Omega_1 + \Omega_3\Gamma\Phi_1\Pi_1)^{-1}$ and Δ is the matrix of farm price flexibilities. Hence, $I + \Delta$ is the matrix of gross revenue flexibilities, where I is the identity matrix. First, all own-quantity flexibilities, the diagonal elements of Δ, are less than minus one. As a result, gross receipts for all items fall when farm output increases.

The flexibility of this fall is given by one plus the relevant diagonal element of Δ. Hence, a 1 percent increase in meat output will cause a 0.96 percent decrease in gross revenue to livestock farmers. Consider the related question, how much will livestock revenue fall if the output of each farm category is increased by 1 percent? The answer is the sum of the elements of the meat row of Δ^{-1} plus one, or, −1.24. Similar flexibilities for dairy, poultry, other food and fruits and vegetables are −1.47, −3.87, −8.04, and −0.64. The value share weighted sum of these flexibilities indicates that a 1 percent increase in all categories of farm output will result in a 2.94 percent fall in gross receipts to farmers.

Also of considerable interest are the effects on farm prices of increases in processing and distribution costs, consumer income, nonfood prices, and capital stock. The flexibilities of gross revenue by category will be identical to those for farm price for these items. Hence, an increase in the transport costs of 1 percent will result in a 0.08 percent fall in gross livestock receipts. Increases in input costs depress farm receipts for most products. The effect of nonfood prices is of mixed sign while increases in income raise farm prices substantially, except dairy and other food. Last, the impact of increases in capital stock in the processing and distribution sector is to always increase gross receipts. With the possible exception of own quantity, capital stock has the greatest influence on gross farm receipts. Hence, the major determinants of farm level prices are income, nonfood prices (i.e., consumer demand), own farm level quantities, and capital stock. The role of capital stock as a determinant of conditional demand has been ignored in previous studies of farm output demand.

Summary and Conclusions

This paper treats the demand for farm output as a set of interrelated factor demands. To measure these demand relations, a theory of the firm was presented which explicitly recognized the role of capital stock in determining the conditional demand for inputs. The model was empirically implemented using aggregate annual data on farm level and processing and distribution inputs. The farm level outputs were meat, dairy, poultry, fruits and vegetables, and other food. The processing and distribution inputs were labor, packaging, transportation, and all other.

These factor demand and retail price functions are conditioned on output and capital stock, as well as all input prices. Retail demand equations from a previous study were substituted into the conditional input demand functions. The resulting reduced form demand functions give farm output for each category as a function of its farm price, the farm prices of other goods, the prices of other factors, capital stock, disposable income and nonfood retail prices.

The estimates of these demand functions showed five main characteristics. First, the demand for each category of farm output is price-inelastic in each case and is less elastic than its retail counterpart. Second, the rôle of capital stock is significant in determining the demand for farm output. The average elasticity of farm output demand with respect to capital is 0.51. Third, there is no statistically significant substitution among the various farm outputs and very little substitution between farm outputs and the other inputs. There is, however, moderate substitution among the other inputs, especially for labor. Fourth, increases in processing and distribution input prices have a significant depressing effect on farm output demand. Fifth, consumer income and nonfood prices have a significant impact on farm demand.

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