THE DAIRY SUBSECTOR OF AMERICAN AGRICULTURE: ORGANIZATION AND VERTICAL COORDINATION

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FOREWORD

During the last decade, the topics of subsector organization and vertical coordination have become increasingly recognized as important factors in the organization and performance of the U.S. food system. However, little research has been conducted on these topics, in part because the methodology and conceptual framework for subsector analysis is not fully developed.

The North Central Regional Research Project NC 117 is examining the organization, coordination and performance of several commodity subsectors. Monograph 5 provides a comprehensive analysis of the U.S. dairy subsector. Future monographs will analyze the egg, beef and selected fruit and vegetable subsectors.

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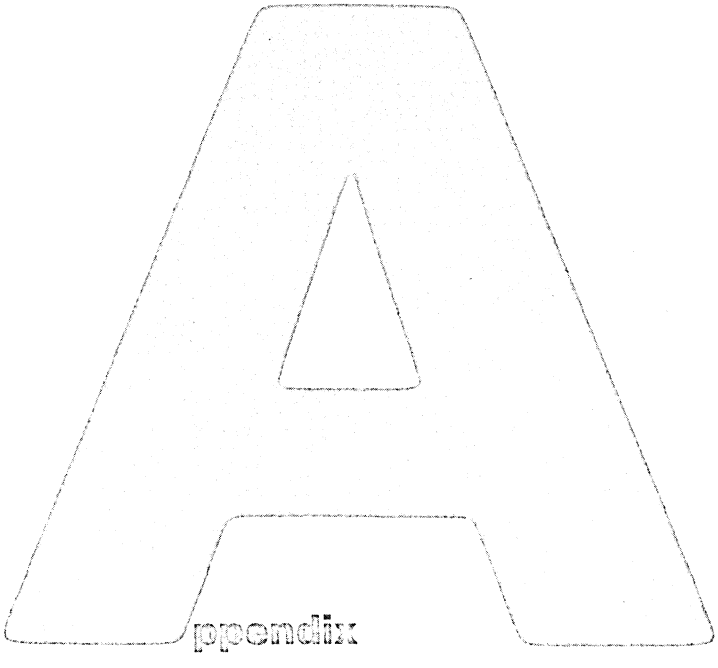
Supply and Demand Elasticities



This appendix reviews a number of recent supply and demand elasticities. Supply elasticity for U.S. and regional production is considered. Demand elasticities for several dairy products are discussed.

Supply Elasticities

Although considerable effort has been invested in the analysis of aggregate milk supply response, little consensus has been reached on either the factors which significantly affect milk production or the magnitude of the price elasticity. Analyses of aggregate U.S. production have typically used econometric analysis. Table A.1 provides a summary of the studies of aggregate U.S. production.

Three studies employ two stage least squares to simultaneously estimate cow numbers and production per cow. Zepp and McAlexander [83] using yearly changes for these two variables in a simplistic model, obtained prediction results that proved to be better than a recursive programming model. Wilson and Thompson [80] and Prato [53] estimate these two equations as part of simultaneous equation models of the dairy industry. The resulting inclusion of current milk prices in the structural equation indicated that the use of lagged prices may be more appropriate as this year's price never proved to be statistically significant.

Halvorson, [31] Wipf and Houck [81], and Hammond [32] use the partial adjustment hypothesis on annual U.S. data to estimate total milk production (see Table A.1). Wipf and Houch, and Hammond found the coefficient of adjustment to be about 0.6 while Halvorson's investigation found it to be about 0.4. All three specifications included milk price lagged one year and found it to be highly significant. Each study found milk supply to be inelastic in the short and long run with Halvorson obtaining a somewhat more inelastic response. Hammond was unable to obtain significance on any cost of production variables while the other two studies had some success, particularly Wipf and Houck with significant coefficients on grain prices and roughage available. Hammond found several measures of opportunity cost—beef price, land value, the unemployment rate, and hog price—to have significant coefficients while Wipf and Houck found the beef price to be very important. As is common with time series analyses of this type, all three studies recorded impressive R^2 values. Graphical ex post verification of the Hammond model provided impressive results.

Although no consensus is reached, it can be concluded from these studies that the short-run response to price is very inelastic due to the large fixed investments on dairy farms and that the long-run response is more elastic but still highly inelastic. Other variables affecting supply response are beef price and input prices particularly for feed.

Table A.1. Summary of Selected Studies of U.S. Milk Production Response

Author of Study	Time Series	Dependent Variables	Predetermined Variables: Milk Price	Lagged Milk Price	Lagged Dependent Variable	Roughage Supply	Concentrate Supply	Concentrate Price	Beef Price	Hog Price	Production Per Cow	Cow Numbers	Cows Bred Artificially	Labor Cost	Elasticity SR	Elasticity LR
Halvorson[a]	1927-57	Milk Production		S	S	S	I		I	I					.157	.403
Cromarty[b]	1929-53	Milk Production	S			S		S				S			.212	---
Wipf & Houck[c]	1945-64	Milk Production		S	S	S		S	S						.027-.140 .041-.192	
Prato[d]	1950-68	Cow Numbers	I		I			I	S		S			I	---	---
		Production Per Cow	I		S			I				I	S		---	---
Hammond[e]	1947-72	Milk Production		S	S				S	S			I	S	0.39	.145
Wilson & Thompson[f]	1947-63	Cow Numbers	I	I	S			I	S		I			I	.003	.521
		Production Per Cow	I	I								S	S			

I - Included but not significant at 5% level of significance.
S - Included and significant at 5% level of significance.

a Halvorson [31]
b Cromarty [22]
c Wipf [81]
d Prato [53]
e Hammond [37]
f Wilson [80]

Numerous authors have investigated milk supply response for various regions by econometric and programming analyses. Unfortunately, there is little consistency in the regional breakdowns used. Two recent studies have estimated supply response for each region in the U.S. Following a discussion of these two studies, hypotheses are drawn based on these and other studies.

Hammond employed the partial adjustment hypothesis to estimate milk supply response for the nine standard census regions using annual observations for 1947-1972. The supply elasticities and adjustment periods for each region are presented in Table A.2. Except for the Pacific region, the elasticities are very inelastic. Other variables found to be significant in many regions were beef price, proportion of cows bred artificially three years previous, index of real estate price, and wage rate. The absence of any variables to reflect feed prices is surprising.

The second regional analysis employs a recursive model of the milk production sector based on biological as well as economic considerations [27]. Jackson [36] estimated such a model for each of the ten regions in Figure 1-4. A polynomial lag was used to estimate structural equations for number of cows, yield per cow, concentrates fed per cow, number of heifers, and cull cow numbers. Table A.3 summarizes the elasticities obtained. These results suggest a more elastic response than Hammond and other studies with all regions except Lake States and Northeast exhibiting an elastic response. The pattern of the polynomial response suggests that the use of the partial adjustment hypothesis may be inappropriate.

Table A.2. Supply Elasticities and Adjustment Periods for Each Region in the Hammond Study.

	Price Elasticity[a]		
	Short Run	Long Run	Years to Adjust[b]
New England	0.219	0.359	3.19
Middle Atlantic	0.123	0.258	4.59
E. North Central	0.083	0.152	3.76
W. North Central	0.030	0.101	8.75
South Atlantic	0.142	0.227	3.02
E. South Central	0.109	0.299	6.50
W. South Central	0.183	0.285	2.86
Mountain	0.176	0.236	2.17
Pacific	0.374	1.040	6.71

[a] Although most of the elasticities are significantly different from zero, no test of the significance of the regional differences was performed.

[b] Number of years for 95 percent of total adjustment to occur.

Source: Hammond [32], pp. 18 and 21.

Although no consensus is reached on the regional elasticities, several hypotheses can be drawn. There is considerable evidence that the long-run supply response in many regions of the country is more elastic than the studies of U.S. production indicated. It is also quite clear that the major producing regions, Lake States and

Northeast, have a more inelastic response than other regions of the country. Further, the western region, which is rapidly expanding output, is characterized by an elastic supply response. These observations are consistent with expectations based upon the availability of alternative enterprises in the region, the level of commitment of the dairy farms in the region, and the capital market in the region.

Table A.3. Supply Elasticities for Each Region in the Jackson Study.

Region	Cow Number Elasticities[a]		Yield Elasticity[a]	Total Supply Elasticities[a]	
	S.R.[b]	L.R.[c]		S.R.[d]	L.R.[e]
Northeast	0.1254	0.6688	0.1361	0.2615	0.8049
Appalachia	0.6732	1.3107	0.7202	1.3934	2.0309
Southeast	1.3496	3.0659	0.1892	1.5388	3.2551
Lakes	0.0545	0.6537	0.1314	0.1859	0.7851
Cornbelt	0.2180	1.5505	0.4220	0.6440	1.9725
Delta	0.9949	2.2158	1.7773	2.1722	3.3931
N. Plain	0.0271	1.1905	0.3745	0.4016	1.5650
S. Plain	0.6167	1.8721	0.5524	1.1691	2.4245
Mountain	0.4650	1.1566	0.3177	0.7827	1.4743
Pacific	0.5748	9.7068	0.6319	1.2067	1.3387

a Although most of the elasticities are significantly different from zero, no test of the significance of the regional differences was performed.
b Short run is the sum of periods t and t-1.
c Long run is the sum of periods t to t-8.
d S.R. total supply elasticity = S.R. cow number elasticity + yield elasticity.
e L.R. total supply elasticity = L.R. cow number elasticity + yield elasticity.
Source: Jackson [36], p. 67.

Demand Elasticities

Most studies have concluded that the demand for dairy products, like that for most food items, is both price and income inelastic. Table A.4 summarizes several of the more recent studies of the demand for dairy products. Much of the work in this area has been with fluid products; the resulting price elasticities have generally been in the range of -0.2 to -0.6, and the resulting income elasticities have generally been in the range of 0.0 to 0.5. The recent work by Boehm and Babb [6] using data from the Market Research Corporation of America National Consumer Panel found the demand for fluid products to be very income inelastic and price inelastic in the short run, but price elastic in the long run. Using cross section data they obtained price elasticities that ranged from -0.833 for 1% milk to -1.701 for regular whole milk. Using the same data they estimated a time series model in which the price elasticities ranged from -0.12 to -1.18 with total fluid milk -0.14. They argue that the inelastic results from the time series model give the short-run response, and the elastic response from the cross section is the long-run result.

Table A.4. Price and Income Elasticities for Dairy Products

Author	Elasticity[a]			Type of Study
	Price		Income	
		A. Fluid Milk		
Brandow[b]	-0.285+		0.16+	All food elasticities
George & King[c]	-0.346+		0.204+	All food elasticities
Prato[d]	-0.5765*		----	334 Florida households
Boehm & Babb[e]	0.14	short run	0.052	Market Research Corporation of America Data-cross section
	-1.628*	long run		
		B. Frozen Dairy Products		
Brandow[b]	-0.55+		0.35+	All food elasticities
George & King[c]	-0.528+		0.331+	All food elasticities
Boehm & Babb[f]	-0.471*		0.07	MRCA - cross section
		C. Cottage Cheese		
Boehm & Babb[f]	-1.29*		0.168*	MRCA - cross section
		D. Cheese		
Brandow[b]	-0.7+		0.45	All food elasticities
George & King[c]	-0.46		0.25	All food elasticities
Boehm & Babb[g]	-0.851*		0.234*	MRCA - cross section
		E. Butter		
Brandow[b]	-0.85+		0.33+	All food elasticities
George & King[c]	-0.65+		0.32+	All food elasticities
Boehm & Babb[g]	-0.76*		0.17	MRCA - cross section
		F. Nonfat Dry Milk		
Boehm & Babb[g]	-2.24		-0.03	MRCA - cross section

[a] An asterisk (*) indicates that the elasticities were found to be significant at the 5% level of significance; a (+) indicates no test of significance was possible or was performed.

[b] Brandow, G.E., *Interrelations Among Demands for Farm Products and Implications for Control of Market Supply,* Bulletin 680, The Pennslyvania State University, August 1961.

[c] George, P.S. and G.A. King, *Consumer Demand for Food Commodities in the United States with Projections for 1980,* Giannini Foundation Monograph No. 26, Berkeley, California, March 1971.

[d] Prato, Anthony A., *Household Demand and Purchasing Behavior for Fluid Milk in Gainesvill, Florida,* Florida Agricultural Experiment Station, Agricultural Economics Report 19, March 1971.

[e] Boehm, William T. and Emerson M. Babb, *Household Consumption of Beverage Milk Products,* Indiana Agricultural Experiment Station Bulletin No. 75, March 1975.

[f] Boehm, William T. and Emerson M. Babb, *Household Consumption of Perishable Manufactured Dairy Products: Frozen Desserts and Specialty Products,* Indiana Agricultural Experiment Station Bulletin No. 105, September 1975.

[g] Boehm, William T. and Emerson M. Babb, *Household Consumption of Storable Manufactured Dairy Products,* Indiana Agricultural Experiment Station Bulletin No. 85, June 1975. The elasticities for nonfat dry milk are for instant milk sold in packaged form in retail stores. This may be much more price elastic than the regular powder sold to industrial users.

Most authors have concluded that the demand for most manufactured dairy products is more price and income elastic than the demand for fluid milk. The results reported by Boehm and Babb support the conclusion that the manufactured pro-

ducts are more income elastic, and also that fluid products are more price inelastic in the short run but not in the long run.[1]

For purposes of this report there is no need to describe or even to list all the demand elasticity studies for milk and dairy products. There are many of these, a much greater number than the studies of supply response. The demand studies go back to the early 1920's, and use data from various markets.[2] Methodologies differ among them.

These studies may be grouped into *short-run elasticities,* with (a) Small Price Changes, and (b) Large Price Changes and *long-run elasticities.* Those with large price changes are higher than with small. Likewise, the long-run are greater than short-run with small price changes. There may be some question here as to whether short-run response can be distinguished from long-run statistically.

1 These conclusions are reached from the results in Table 1-2 and from further analysis of the three publications authored by Boehm and Babb. [6, 7, 8]

2 Studies up through the early 1960's are listed in William D. Dobson, *An Analysis of Alternative Price Structures and Intermarket Competition in Federal Order Markets,* Ph.D. Thesis, Purdue University, Lafayette, Indiana, August 1969. Additional ones up through 1976 are listed in unpublished work by Emerson Babb, Purdue University and are available on request to the author.