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CASE STUDIES IN THE TRANSMISSION OF FARM PRICES

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It is rather common to question the efficiency of markets in transmitting price information. What are the form and length of lags, if any, between changes in raw farm product prices and in retail prices? Is the response to price increases and decreases symmetric? Do serious imperfections exist in pricing mechanisms for foods? Has the structure of price transmission changed with the passage of time and hence are markets more or less imperfect now than in the past?

Such questions tend to be raised more frequently when prices are rising and decision makers are concerned about inflation. But it has been difficult to obtain specific and useful answers. Thus, although numerous studies have been undertaken (e.g., Heien 1980, King, Lamm, and Lamm and Westcott), further research is justified by the search for clearer answers to some of the questions posed. Also, if acceptable models of price transmission can be developed, then they can be used to monitor changes in retail prices.

Four case studies are reported here: the transmission of farm product prices underlying the retail prices of beef, bread, eggs, and margarine. The case study approach permits careful study of selected issues. For eggs, for example, retail prices in individual cities were analyzed to determine the comparability of results across cities and to see whether aggregation might obscure the price transmission process. In other cases, the structural stability of results with the passage of time is considered, or various estimation methods compared, or the symmetry of price response considered.

The report starts with a brief review of concepts underlying the study of the transmission of farm product prices. The empirical results for the four commodities constitute the major part of the report.

Conceptual Background

Models of marketing margin behavior typically provide a general framework for static equilibrium analysis (e.g. Gardner), but are relatively unconcerned about short-term distributed lag processes for price transmission. Thus, it is perhaps useful to make a distinction between models which explain the level of marketing margins and those which describe the price transmission process. Heien (1980), however,

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has integrated a concept of price transmission, or markup pricing, with a model of margin-level behavior.

The farm-retail price relationship must, of course, be estimated net of the effects of other variables influencing retail prices. These "other variables" can be discussed conveniently in terms of the cost curves for marketing services. That is, the retail price of an individual food product can be divided into components related to farm inputs and to marketing inputs.

The cost curves for marketing services depend on the level of prices for these inputs and the nature of technology. As input prices increase obviously the cost functions shift upward, and other things constant, marketing margins increase. Technical improvements would lower per unit costs, other factors constant. Popkin, in his stage of processing model, which is similar to the price transmission equations discussed below, argues for using unit costs rather than input prices, but in practice the alternate variables result in similar empirical results.

In addition to shifts in cost curves, one can think in terms of movements along cost curves. For example, the volume of the farm input in any particular month might be considered exogenous to the system, and as farm marketings change, the associated quantity of marketing inputs changes. If one makes the simplifying assumption that the elasticity of substitution between the farm input and the marketing input is zero, the quantity of marketing input would increase (or decrease) in direct relation to the increase (or decrease) in the amount of farm product marketed. If the marginal cost function for marketing services is upward sloping, then larger marketings by farmers, which require larger quantities of marketing services, imply larger marketing margins, other factors held constant. Heien (1980), however, treats marginal costs as constant by assuming constant returns to scale. But the returns to scale argument is essentially a long-run concept, and hence one can question its validity for short-run price transmission phenomena. In any case, whether or not the quantity of the farm input is a useful argument in the function is an empirical question.

Consequently, even though the central research interest in this report is in the transmission of prices of the raw farm input to the retail level, the prices of marketing inputs, the level of technology in marketing, and the quantity of farm product flowing through the marketing system are potentially important variables in the price transmission function. In other words, the farm-retail price relationship should be estimated net of these other variables.

Much of the emphasis in constructing models in the sections which follow is on the transmission process. Lags are thought to occur in the process. An efficient market, by definition, transmits prices instantly, and prices at particular junctures in the system apparently are transmitted rather efficiently. For example, changes in "farm gate" prices for a particular commodity seem to occur almost instantaneously across the U.S. But lags apparently occur as inputs move (vertically) through the marketing system. Time is required as farm inputs are transported, stored, processed, and moved through the wholesale and retail sectors. Thus, for example, a higher price for soybeans at the farm is not instantly translated into higher prices for margarine at retail. Such lags evolve from what might be termed the normal inertia of the marketing system.

A second, closely-related source of lags is the cost of price changes. Repricing and remarking goods, particularly at the retail level, is costly and can generate ill-will among consumers. Consequently, retailers may change prices only as new supplies move into the store. Thus, repricing is less of a problem for perishables than for items with a long shelf life. But, even for perishables, consumers are sensitive to frequent movements in prices, particularly when they are upward, and retailers may have some reluctance to change prices frequently.

Third, price reporting and collection methods may exaggerate actual lags. For example, if retail prices are observed at a point in time each month, then by definition, price changes at different market levels can be observed only once a month. Price reporting methods may make essentially instantaneous adjustments appear to be up to a month in length.

Fourth, the market may have observable imperfections, such as a poor information transmission system or noncompetitive firms, which contribute to lags in prices. A common conjecture, for example, is that food manufacturers and/or retailers have sufficient market power to pass cost increases through to consumers rapidly while not passing price decreases on to consumers, thereby retaining a larger margin as excess profits. If this hypothesis were true, then the response of retail prices to decreases and increases in farm prices should be asymmetric. Government intervention in the form of price controls is another type of imperfection which may influence price adjustments.

Given the hypothesized lags between retail and farm prices, the general model used in the research which follows is to make retail prices a distributed lag function of farm prices. An alternate hypothesis is that farm and retail prices are simultaneously determined, but other research (Heien 1980; Lamm and Westcott) suggests that causation often runs from farm to retail prices, especially for monthly data. In addition to farm prices, retail prices are made a function of marketing costs--typically wage rates--and sometimes of farm input variables.

Beef

In the context of inflation, beef prices, as a major component of food budgets, have been the focus of much concern, and beef receives relatively strong emphasis in this report. One issue relates to the nature of beef price behavior at different levels of the marketing system. Do price changes differ in direction and intensity at the farm, wholesale and retail levels?

A second issue relates to transmittal of marketing and material input cost changes through the different levels of the system and how these costs are reflected in output price changes. Are physical or operational efficiencies reflected in the pricing pattern at different levels of the beef-marketing system?

A third issue relates to the role of market power in determining beef prices. Is any one level of the market sufficiently strong to control prices at another level and is this reflected in the cost-price transmission rate?

This study provides insight into these three policy issues: transmission of farm input prices, cost-price transmission, and the role of market power at the farm, wholesale and retail levels of the national beef market. Taking an historical perspective, we first identify dominant patterns in beef price behavior and discuss some of the critical cost and institutional factors that influence these patterns. Then, the empirical relationship between retail beef prices and changing costs, changing market structure, wage and price controls, and farm and wholesale prices is analyzed.

General Background

The study period for beef is January 1960 through April 1978. During the first eight years (1960-67), retail beef prices remained fairly constant. They then began a continuous rise, moving from a low of $0.73 to $1.00 per pound in 1969, and between 1971 and 1973 they rose sharply, jumping from $0.97 to $1.45 per pound. From 1974 through April 1978, average beef prices leveled off but they oscillated much more than in the previous 14 years--from $1.20 to $1.63 per pound. Thus, retail beef prices doubled in ten years with half of the increase occurring in the two-year period from 1971-73.

The rising trend and larger fluctuations around the average were also dramatic for farm and wholesale prices. Wholesale prices, for instance, rose from a $0.50 per pound low in 1964 to a $1.12 high in 1973, and after 1973, fluctuated from a $1.23 high in 1973 to an $0.80 low in 1977. Between the two periods 1960-1967 and 1968-1978, variability doubled for farm, wholesale and retail prices (Table 1). All three market levels manifested similar increases in price instability. After wage and price controls (1974-1978), however, the increase in retail price instability was much greater than that of farm or wholesale price instability. The variance of retail price change increased by roughly 130% while the variances of carcass and farm price changes increased by 50% and 70%, respectively.

Describing price spreads provides a bit more information about the marketing system which generates these price changes. From 1960-1969, the farm-to-retail spread widened slowly, and then from 1969-1978 it widened much more rapidly. It also widened more rapidly than the farm-to-wholesale spread from 1969 to 1978. The wholesale-to-retail spread was twice as large as the farm-to-wholesale in 1960 and grew to be four times as large by 1969. This difference of a factor of four held through 1973 on the average, but shifted between a factor of four and five from 1973 to 1978. The farm-to-wholesale spread fluctuated less than the wholesale-to-retail spread over the entire period.

Table 1. Comparison of Retail, Wholesale and Farm Monthly Price Variability for Selected Periods

Period	Variance of Percentage Change		
	Retail	Carcass	Farm
Total			
1960/2-1978/4 (219)[a]	7.62	21.10	31.91
Changing Concentration and Inflation			
1960/2-1967/12 (95)	2.76	9.36	13.62
1968/1-1978/4 (124)	5.91	20.52	28.94
Wage and Price Controls			
1960/2-1970/12 (131)	2.56	9.61	12.96
1971/1-1974/4 (40)	8.82	30.03	44.22
1974/5-1978/4 (48)	20.07	45.83	74.13

[a]Number of monthly observations shown in parentheses.

Labor, transportation and packaging combined with corporate profits were the major components of the overall price spread for beef in 1974 (Table 2). Transportation does not figure at all in the wholesale-retail beef spread, but is fairly important for the farm-wholesale spread. Labor and packaging costs are important in both the farm-wholesale and wholesale-retail spreads.

All three of these major cost components have increased dramatically in recent years. From 1972 through 1978, hourly earnings of workers in processing and retailing increased 62%, container and packaging prices 80%, and fuel prices 162% (USDA 1979, p. 15). Both the general inflationary processes at work in the United States and the rising world fuel prices since 1973 have been identified by USDA as major causes of these cost increases.

In addition to the changing picture for price spreads between 1960 and 1978, structural changes also were taking place at both the retail and wholesale levels. The retail food industry has become more concentrated while the meatpacking industry became less so until 1967, when its concentration began to increase. The wholesale market for beef is generally considered a national market, and consequently food retailers buy in a national market. But on the selling side, retail markets are analyzed best on a metropolitan basis.

In 1954, the wholesale and retail concentration levels were nearly the same for the two industries--the top 20 meatpacking firms held at least 60% of their market. By 1967 meatpacking had become less concentrated and market share was more evenly distributed among the top 20 meatpacking firms. Retail concentration in metropolitan areas, however, increased to approximately 80% between 1954 and 1972. After 1967, and probably starting about 1970, the decline in meatpacking concentration was reversed and increased to its previous level of about 60% by 1978.

The beef market is moderately concentrated at the wholesale and retail levels, but the knottier questions relate to conduct and performance. The structure of the beef industry, its conduct and ultimate performance all are found within the framework of changing general economic conditions, technological possibilities, labor union activities and government regulations. The most important of these factors are outlined in Table 3.

The introduction of boxed beef was perhaps the major technological change in the period under analysis. The advantages to retailers of using the boxed beef program include:

1. greater flexibility in choice of cuts and quantities ordered,
2. elimination of special meat deliveries,
3. elimination of work in the supermarket cooler,
4. reduced space needed for cooler storage,
5. increased merchandising activity,
6. extended marketing life for the barrier-bagged product, and
7. improved department yield (Kochsperger, p. 449).

Table 2. Major Components of the Farm-Wholesale and Wholesale-Retail Price Spreads for Beef, 1974

Component Items	Farm-Wholesale (percent)	Wholesale-Retail (percent)
Labor	26.6	56.0
Packaging	3.6	12.4
Transportation	9.7	-
Corporate Profits	9.6	8.7
Business Taxes	1.2	3.3
Interest, Repairs, etc.	1.2	3.3
Depreciation	4.8	.9
Advertising	1.2	4.5
Rent	2.4	1.5
Energy	3.7	1.5
Other/Not Allocated	30.0	8.7
Total	100.0	100.0

Source: USDA. Cost Components of Farm-Retail Price Spreads for Selected Foods. Agricultural Economic Report No. 343, July 1976.

Table 3. Change Factors Influencing Trends in Meatpacking Concentration in Two Major Periods

Influential Factors	Institutional Changes in Meat Packing: 1950s to Mid-60s	Institutional Changes in Meat Packing: Mid-60s thru 70s
1) Transportation	- Auction buying replaces terminal dispersing supply across grain belt. - Locate near supply. - Limited econ. of scale.	- Direct buying replaces auction. - Supply concentrating in feedlots in grain belt. - Locate near supply; more concentrated. - Increasing economies of scale as supply transport cost reduced. - Larger firms better able to withstand petroleum cost shock.
2) Grades and Inspection	- Guaranteed standardization so small firm could assure buyer of same quality control as large. - No size or location advantage. - Ease of entry. - Retail buyers knowledge of grades reduced packer's advantage: more competition for sales.	- Grade uniformity well established facilitating nonprice competition - Retail interest in prod. input stability more than low price: size incentive. - 1967 inspection act increased sanitary req's and costs of compliance: size incentive, barrier to entry.
3) Technology	- Rail system skilled labor intensive producing sides and quarters. - Labor as major fixed cost since low substitution between labor and machines. - Strong union due to skill level and big five history. - Incentive to enter industry. - Lower costs for smaller firm since less likely to be under union pressure. - Fewer workers makes efficiencies easier for smaller firms due to lower per unit labor costs.	- Boxed system unskilled but still labor intensive producing primals and sub-primals. - Disassembly line reduced need for skilled labor & for unions; increased use of labor-saving machines in storage and transport because of "boxing" and palletization. - Volume advantage since labor more variable cost than fixed. - Barriers to entry rise as investment in plant and equipment increases.
4) Packaging/Storage	- Bifurcation between packers and processors. - Economics of scale for processors not for packers. - Allowed product differentiation for processors not packers.	- Specialization among packers. - Economies of scale for boxers not for slaughterers. - Product differentiation for boxers through customizing.

In the period after 1967, the retail food sector provided a responsive market for boxed beef. The largest chain stores expect to purchase 90% of their beef in boxed form in the 1980s. This and the fact that 20 retail firms had access to over 75% of the retail beef market in the metropolitan U.S. provided incentives to meatpacking firms to increase their size and attempt to supply most of the needs of one or more of these largest chains (Grinnel et al.; U.S. Cong.). Such an arrangement could potentially be beneficial to both the retailer and meatpacker, reducing uncertainties in procurement especially in terms of volume and quality. Ultimately, this could assure each segment a more stable profit margin.

In the context of the foregoing, three major policy issues revolve around beef price behavior. One concern is the upward trend in prices since 1960. A second concern is the speed with which cost changes are translated into price changes. Changes in the speed of transmission and the possibility of different cost-price responses in periods of rising and falling prices are major sub-issues. A third, and related, concern is whether poor performance (if any) is related to market concentration or other imperfections. These issues are addressed below.

Empirical Analysis

The present analysis relies heavily on price transmission models to delve into the cost-price relationships between the farm, wholesale and retail levels of the beef market. Using the labor, transport and beef input costs appropriate to each level of the industry, the analysis ascertains the length and form of lagged responses of prices at one market level to changes in the output prices of a lower level of the beef market. The possible differences in these relationships between times of rising beef input prices versus stable or declining prices is estimated. Initially, the analysis covers the entire period from January 1960 through April 1978. This allows establishing essential differences between the pricing behavior of the two levels. Subsequently, various time periods were selected to reflect major changes in the structure of the beef marketing system.

The first time breakdown in the analysis is for two periods from January 1960 through December 1967 and from January 1968 through April 1978. The split between 1967 and 1968 roughly coincides with the major structural shifts toward increasing concentration that occurred in the meatpacking industry and also with the inflationary process of the US economy.

The second time breakdown introduces the effects of policy actions aimed at containing inflation (Dunlap and Fedor). The periods were selected to allow for the effects of wage and price controls: (1) before controls, January 1960 through December 1970; (2) during controls, January 1971 through April 1974;[1] and (3) after controls May 1974 through April 1978.

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[1]Phase IV of price controls continued until April 30, 1974, but because of the high rate of inflation in 1973, prices were frozen June 13

In specifying the models, retail and wholesale output prices are assumed to be a function of material input (beef) prices and marketing costs. Specifically, retail beef price (RP) is presented as a function of carcass prices (WP), retail wages (RETWAGE), and diesel fuel prices (FUEL). Similarly for the wholesale output price, carcass price (WP) is specified as a function of farm beef prices (FP), meatpacking wages (BFWAGE), and diesel fuel prices (FUEL). The fuel variable was included to reflect the major changes in transportation costs that occurred as a result of increasing petroleum prices over the period of analysis. Despite their importance, packaging costs were not included as a variable, given a lack of continuous data series from 1960-1978.

The retail, carcass and farm price series for beef and the wage and fuel series are nominal rather than deflated since the purpose of the analysis is to understand the behavior of nominal and not relative prices. Also, different deflators would be required for each level of the market which would make comparison between levels of the market impossible.

The method of ordinary least squares was first used for each equation, but the error terms were severely autocorrelated. Thus, the method of generalized least squares (GLS), assuming a first-order autocorrelation, was applied (TROLL), and only these results are reported.

No specific lag was chosen a priori. A series of models with successively longer lag lengths were estimated in an attempt to identify the most appropriate models for both retail and wholesale levels. These equations were estimated for the period January 1960 to April 1978 with 220 monthly observations (Tables 4 and 5).

The results support the hypothesis that lagged input prices help explain retail beef prices. The general statistics for each of the models are quite similar with reasonably large t-ratios. The null hypothesis of zero autocorrelation cannot be rejected at the one-percent level (after the correction for autocorrelation). The values of sum of squared residuals (SSR) and of rho are quite similar for all equations, and the coefficient values typically remain stable as each successive lag is added. Nonetheless, the t-ratios fall below normally acceptable significance levels when the third month is added to the farm-wholesale model and when the fourth month is added to the wholesale-retail model, and these coefficients are quite unstable when another lag is added. Hence, with the support of Heien's and King's results, the two-month model for farm-wholesale and the three-month model for wholesale-retail are deemed most appropriate for the remaining analysis. The models for the analyses of selected periods are:

$$WP_t = B_0 + B_1 (FP_t) + B_2 (FP_{t-1}) + B_3 (FBWAGES_t) + B_4 (FUEL_t);$$

$$RP_t = B_0 + B_1 (WP_t) + B_2 (WP_{t-1}) + B_3 (WP_{t-2}) + B_4 (RETWAGE_t) + B_5 (FUEL_t).$$

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to August 12, 1973. This period and its aftermath perhaps had the largest impact on meat prices.

Table 4. Successive Estimates of Lag Responses for Beef Price Transmission, Farm to Wholesale, 1960-1978

	I	II	III	IV	V
CONSTANT	.047 (5.63)[a]	.036 (4.75)	.038 (4.75)	.034 (4.33)	.29 (3.65)
FP_{t-0}	.921 (60.66)	.889 (53.73)	.889 (53.64)	.889 (53.81)	.890 (54.60)
FP_{t-1}	--	.076 (4.65)	.083 (4.56)	.081 (4.44)	.078 (4.34)
FP_{t-2}	--	--	-.015 (.89)	-.027 (-1.47)	-.029 (-1.62)
FP_{t-3}	--	--	--	.028 (1.69)	.007 (0.41)
FP_{t-4}	--	--	--	--	.042 (2.58)
$BFWAGE_t$	.009 (1.99)	.005 (1.25)	.006 (1.44)	.005 (1.18)	.004 (0.89)
$FUEL_t$	.218 (4.44)	.213 (4.99)	.210 (4.81)	.208 (4.93)	.201 (4.87)
SSR	.023	.021	.021	.020	.020
d	2.08	1.90	1.90	1.92	1.93
ρ	0.68	0.63	0.64	0.63	0.62

[a]t-statistics shown in parentheses.

Table 5. Successive Estimates of Lag Responses for Beef Price Transmission, Wholesale to Retail, 1960-1978

	I	II	III	IV	V
CONSTANT	.154 (3.21)[a]	.072 (2.30)	.037 (1.38)	.032 (1.19)	.033 (1.14)
WP_{t-0}	.671 (16.24)	.590 (15.96)	.605 (16.79)	.607 (16.81)	.606 (16.71)
WP_{t-1}	--	.343 (9.14)	.302 (7.72)	.304 (7.72)	.304 (7.70)
WP_{t-2}	--	--	.136 (3.75)	.130 (3.32)	.129 (3.31)
WP_{t-3}	--	--	--	.020 (.55)	0.19 (.49)
WP_{t-4}	--	--	--	--	-.0019 (-.05)
$RETWAGE_t$	.146 (4.75)	.105 (4.77)	.089 (4.69)	.086 (4.55)	.086 (4.50)
$FUEL_t$	-0.09 (-.35)	-.07 (-.35)	-.08 (-.46)	-.07 (-.44)	-.07 (-.45)
SSR	.118	.085	.080	.080	.080
d	1.89	2.12	2.06	2.05	2.06
ρ	.91	.85	.82	.81	.81

[a]t-statistics shown in parentheses.

For wholesale to retail, nearly the full impact of the change in carcass beef prices was felt at the retail level in three months (Table 6). Approximately 60% of the response occurred in the first month with the remainder occurring smoothly in the next two months. For farm to wholesale prices, almost all of the impact, 89%, was felt in the current month with the remainder in the second month.

Hypothetically, the "no lag" equation would represent perfect competition, where price changes at all levels occur in the same month since the physical processing of beef at both levels requires roughly two weeks. In the wholesale-retail case, the improved results with the use of lagged prices supports the notion that lags exist in the adjustment of retail prices to changing wholesale prices. For farm-wholesale, the evidence indicates a more competitive pricing situation. Only a one-month lag appears to exist, and there was little change in the SSR with the addition of the lagged farm price.

The impact of changes in marketing costs was not estimated with lags because of the potential collinearity and the complexity of specifying and estimating models with more than one lag structure. As expected, retail wages were significant in the wholesale-retail relationship. A one-cent change in wages is associated with a nine-cent change in retail price of a pound of choice beef. The meatpacking wages coefficient had a small t-ratio in the farm-wholesale equation. Although unexpected, this does not necessarily represent the variable's actual importance. Rather, the statistical result is perhaps caused by collinearity with other variables. Diesel fuel, as a proxy for transport costs, was not significant for the retail level, but was important in the wholesale level equation. A one-dollar change in fuel costs is associated with a 21-cent change in carcass price of beef. This may be attributed, in part, to procurement practices where retail contracts on a freight-on-board basis leave transport costs to the meatpacker, and the fuel variable may be picking up part of the labor cost effect.

Structural Change

The data were broken into two subsets, 1960 through 1967 and 1968 and after, to obtain additional insight into the cost-price transmission process. Following the administered price hypothesis, one would expect the pre-1968 results for farm-wholesale to be different from those for the wholesale-retail level because meatpacking was less concentrated than the retail level before 1968. After that time, meatpacking concentration increased. In addition, price controls were in place in the early 1970s, and the mid to late 1970s were characterized by rapid inflation and greater instability in commodity prices (discussed more fully in next subsection).

Substantial change occurred in the estimated relationships both at wholesale and retail levels (Table 7). Prior to 1968, at the wholesale-retail level, 74% of the change in retail price was related to wholesale price changes in the preceding three months. This impact was distributed fairly evenly over that period. After 1967, nearly 100% of the change in

Table 6. Price Transmission for Farm to Wholesale and Wholesale to Retail Levels of the Beef Market, 1960-1978

Farm-Wholesale		Wholesale-Retail	
CONSTANT	.036 (4.75)[a]	CONSTANT	.037 (1.38)
FP_t	.889 (53.73)	WP_t	.605 (16.79)
FP_{t-1}	.076 (4.65)	WP_{t-1}	.302 (7.72)
$BFWAGES_t$	.005 (1.25)	WP_{t-2}	.136 (3.75)
$FUEL_t$	.213 (4.99)	$RETWAGE_t$	.089 (4.69)
		$FUEL_t$	-.08 (.46)
SSR	.080	SSR	.080
d	1.90	d	2.05
ρ	.63	ρ	.81

[a]t-statistics in parentheses.

Table 7. Price Transmission in Two Time Periods for Wholesale and Retail Levels of the Beef Market

	Farm-Wholesale			Wholesale-Retail	
	2/1960 - 12/1967	1/1968 - 4/1978		3/1960 - 12/1967	1/1968 - 4/1978
CONSTANT	.03	.032	CONSTANT	.07	-.001
	(.50)	(1.62)		(.65)	(-.01)
FP_t	.87	.89	WP_t	.32	.62
	(27.28)	(41.60)		(5.86)	(13.29)
FP_{t-1}	.05	.08	WP_{t-1}	.27	.31
	(1.49)	(3.59)		(3.52)	(6.05)
$BFWAGES_t$	-.02	.01	WP_{t-2}	.15	.14
	(-4.38)	(.90)		(2.70)	(2.85)
$FUEL_t$	.83	.20	$RETWAGE_t$	.05	.10
	(1.71)	(3.10)		(5.47)	(2.96)
			$FUEL_t$	1.26	-.189
				(1.69)	(-.74)
SSR	.0023	.0183	SSR	.0054	.0707
d	1.94	1.85	d	2.05	2.02
ρ	.33	.62	ρ	.34	.82

carcass price was passed on to retail in three months, and most of the change occurred in the coefficient of current wholesale price. The farm-wholesale results shifted less dramatically. The coefficient for last month's farm price, however, almost doubled to .08 and had a large t-value after 1967. In contrast, the pre-1968 t-value of 1.49 suggests that the lagged farm price variable contributed little to explaining changes in carcass price. The lengthening cost pass-through and larger coefficient of past month's farm price might be interpreted narrowly to support the contention that meatpacking is acting more like a concentrated industry in the second period.

Just as the impact of the beef input costs changed, so, too, did the impact of marketing costs. For wholesale to retail, fuel has a positive coefficient and a t-value of 1.69 in the first subperiod, but the coefficient is negative with a small t-value in the second period. This decrease in size and importance is unexpected given the sharp increases in fuel prices. However, the change is plausible insofar as procurement contracts before 1968 did not have freight on board (FOB) clauses as standard practice and left retailers to assume delivery from numerous small packers. After 1967, this may have been reversed as FOB contracts became the norm for retail procurement, and the result is consistent with the zero transport cost reported by the USDA in wholesale-retail price spreads. The decline also coincides with the fact that "boxed beef" served to reduce transport costs substantially between packer and retailer.

For the farm to wholesale level, fuel has a larger t-value but a smaller coefficient in the post- than pre-1967 period. This may be linked, at least statistically, to the shifting importance of the farm price variable. After 1967, the coefficient of lagged farm price grew as that for fuel shrank and the t-ratios of the prices variables grew, indicating that transportation costs became relatively less important in the carcass pricing process.

The wage variables at each level also are difficult to interpret. For farm to wholesale, wages were insignificant after 1967 and had a negative coefficient with a t-ratio of 4.38 before 1967. One might argue that higher wages forced meatpackers to lower selling prices and increase volume in an attempt to improve the ratio of variable to fixed costs. But this was a period of little trend in prices and margins, and the results may be merely an artifact of the sample period.

For the wholesale to retail equation, wage coefficients have high t-values in both subperiods, but in the post-1967 period, the wage coefficient increased by a factor of two from .05 to .10. This is perhaps related to retailers' attempts to protect against inflation's tendency to reduce profit margins by passing cost increases through as price increases immediately. Or perhaps, the wage variable is acting as a trend variable in a period of inflation. Hence, the coefficient of the wage variable may be a proxy for a group of cost increases, which are not explicitly represented in the model.

It is difficult to draw a definitive conclusion regarding the reasons for the change in the length and strength of the lag coefficients on the basis of this breakdown of the data into subperiods associated with changing levels of concentration. The cost pass-through appears to have lengthened from the farm to wholesale level, a level which experienced an increase in concentration. But the cost pass-through from wholesale to retail quickened, despite the continued higher level of average concentration in local retail markets.

Price Response to Wage and Price Controls

More insight into the underlying structural reasons for any change in the price transmission process can be provided by further breaking up the entire time period into different sub-time periods for analysis. Most important is to allow for the impact of wage and price controls on the price-cost transmission process. The period during which wage and price controls were in effect was, by definition, a period of structural change. Retail beef prices, in particular, were controlled such that prices were not allowed to fluctuate freely.

A logical breakdown, therefore, would be into the following three time periods:

1) January 1960 through 1970, before controls;
2) January 1971 through April 1974, during controls; and
3) May 1974 through May 1978, after controls were removed.

The same regression techniques can be applied to both the farm-wholesale and wholesale-retail models over these three time periods. Then, by examining the changing nature of the estimated coefficients, evidence as to the influence of the wage and price controls, can be obtained.

Several details about the operations of the controls, however, should be kept in mind. First, the controls attempted to regulate the relationship between costs and prices. Second, packers and retailers were subject to controls, but farm-level producers were exempt. Beef prices themselves were frozen only two months beginning June 13, 1973 (Dunlop and Fedor, pp. 41-46). The freeze was especially disruptive, as farmers withheld animals from market during the freeze, and many overweight animals were marketed after the freeze. Farm-level beef prices dropped 50% in about a one month period after the freeze. Third, the regulations themselves changed frequently during their imposition. In sum, the control period was not a homogeneous period, and the interpretation of results for this period must be made with caution.

The results for the three time periods are presented in Tables 8 and 9. The results for the wholesale-retail level show a quickening response to changing carcass prices after controls (Table 8). That is, the coefficients of current and one period lagged carcass prices increased from the earlier to the later periods. During and after controls, price adjustment was largely completed in periods t and t-1, while in the initial period WP_{t-2} had a large t-ratio. This changing pattern of coefficients supports Scherer's contention that wage and price controls served to cement the "beat inflation" pricing process, especially in industries like retail food, which are able to exercise

Table 8. Price Transmission in Periods Before and After Wage and Price Controls, Wholesale-Retail Level

	Before (3/1960-12/1970)	During (1/1971-4/1974)	After (5/1974-4/1978)
CONSTANT	-.14 (-1.35)	-.37 (3.36)	.27 (1.05)
WP_t	.38 (7.73)	.49 (9.24)	.67 (7.38)
WP_{t-1}	.27 (4.80)	.44 (7.15)	.23 (2.45)
WP_{t-2}	.15 (3.05)	.01 (.21)	.16 (1.67)
$RETWAGES_t$	.06 (3.58)	.24 (4.57)	.106 (1.46)
$FUEL_t$	2.28 (2.71)	-0.24 (-.15)	-.85 (-.87)
SSR	.0098	.0069	.0545
d	2.31	1.67	1.95
ρ	.79	.52	.76

Table 9. Price Transmission in Periods Before and After Wage and Price Controls, the Farm-Wholesale Level

	Before (2/1960-12/1970)	During (1/1971-4/1974)	After (5/1974-4/1978)
CONSTANT	-.03 (-.69)	.01 (.23)	.12 (1.38)
FP_t	.87 (31.07)	.87 (22.82)	.89 (25.63)
FP_{t-1}	.07 (2.50)	.05 (1.37)	.05 (1.37)
$BFWAGES_t$	-.01 (-2.59)	.01 (.69)	NA NA
$FUEL_t$	.98 (2.84)	.32 (3.42)	.13 (.51)
SSR	.0037	.0049	.0101
d	2.01	1.92	1.63
ρ	.39	.30	.69

some control over their selling prices (p. 356). In a sense, the market becomes more efficient as carcass price changes are now passed on more rapidly than in the 1960s.

In addition, the sum of the lagged wholesale price coefficient changes over time from .80 in the before-controls period to .94 during controls and to 1.06 after controls. That is, before controls only 80% of a change in carcass price was passed through to retail prices within three months, as compared to 94% during controls, and to 100% after controls. Input costs then, were more completely passed through to retail prices after the imposition of wage and price controls, again indicating an increase in pricing efficiency as a result of controls. (A greater than 100% pass-through, as indicated by the sum of 1.06 after controls, is unrealistic. The larger than 1.00 sum may be due to errors in data or sampling error.)

In terms of marketing costs, the precontrol results show retail price responding positively to changes in both wage and fuel costs, but the fuel coefficient is suspiciously large. The wage coefficient is similar to that of the two-period analysis (Table 7). During controls, the wage coefficient quadruples--increasing from .06 to .24, while the fuel coefficient became negative. After controls, fuel remains negative and the wage coefficient drops in magnitude and has a smaller t-value. Why wage changes would have had a greater impact on retail prices during controls than either before or after controls is somewhat puzzling. During controls, retailers may have become particularly sensitive to wages, as the most important component of their marketing costs. Retailers may have reacted more strongly to wage changes during controls, attempting to ensure that wage cost changes were reflected in retail prices whenever possible.

Similar to the results for retail prices, the effect of lagged farm prices on carcass prices appears to have declined (Table 9). Before controls were imposed, roughly a seven-cent change would occur in the carcass price from a one-cent change in the past month's farm price of beef, and the t-ratio was 2.56. Although the weight of the lagged farm price coefficient remained at .05 during and after controls, its t-values fell to 1.37. During and after the controls, the lagged farm price did not have a significant influence on the carcass price. Since the weight of the current farm price coefficient also rose slightly, from .87 to .89, these results provide evidence that wage and price controls served to speed rather than dampen the cost pass-through process of the meatpacking industry.

Wholesale prices were influenced significantly prior to wage and price controls by marketing costs. However, during controls, the wage variable's influence became insignificant as seen in the t-value of .69. After controls were removed, the coefficient of the wage variable was so small that it was not reported. The weight of the fuel coefficient also declined markedly during the controlled period, but the t-value associated with it rose somewhat. Just as the retail wage coefficient rose during controls and dropped off afterwards, so too, the fuel coefficient in the wholesale model had a t-value of .51 after controls, indicating its loss of explanatory power.

These results suggest that the imposition of wage and price controls resulted in a change in the cost-price transmission process for beef. Judging from the change over time in the magnitude and significance of the coefficients, the wage and price controls seemed to have had the opposite effect to that desired by policymakers. Rather than slowing, the rate of cost pass-through for beef inputs quickened during controls and stabilized at the higher rate after controls were removed. This occurred for both the retail food and meatpacking industries. Since farm and carcass values were passed on to the retail level on about a one-to-one basis, however, one can argue that the speedup in price pass throughs is, in effect, an improvement in performance of the market.

Asymmetric Price Response

The possibility of asymmetric price responses also was studied for the periods before, during and after price controls. The null hypothesis posits no difference in the cost-price transmission process at either market level whether material input costs are rising or falling. For statistical testing, a dummy variable is created for each market level to define rising and falling prices. In the farm-wholesale equation, $D = 1$ when $FP_t - FP_{t-1} > 0$, and $D = 0$ when $FP_t - FP_{t-1} \leq 0$. Likewise, in the wholesale-retail equation, $W = 1$ when $WP_t - WP_{t-1} > 0$, and $W = 0$ when $WP_t - WP_{t-1} \leq 0$. These proxy variables, "D" and "W", are used to create interaction terms which permit slope coefficients to change.

For example, the full model and the model under the null hypothesis for the farm-wholesale relationship are as follows:

$$WP = B_0 + B_1FP_t + B_2FP_{t-1} + B_3\ BFWAGES_t + B_4\ FUEL_t + \alpha_0 D +$$

$$\alpha_1(D \cdot FP_t) + \alpha_2(D \cdot FP_{t-1}) + \alpha_3(D \cdot BFWAGES_t) + \alpha_4(D \cdot FUEL_t), \text{ and}$$

$$WP_t = B_0 + B_1FP_t + B_2FP_{t-1} + B_3\ BFWAGES_t + B_4\ FUEL_t.$$

The full models for both market levels were estimated over the full time period and over the time periods corresponding to before, during and after controls, and for the lag lengths shown in Tables 8 and 9. The same auto-correlation correction procedure, as described earlier, was used. The sums of squared residuals from the estimations were used to calculate F-statistics which were compared to the table values in a formal test of the null hypothesis for each level.

In general, the null hypothesis of a symmetric price response could not be rejected at either level before, during or after controls or for the entire time period. Wholesalers and retailers do not appear to have treated increases in farm or carcass prices in a manner different than decreases. Several large F-statistics were obtained, however, by the "judicious" selection of sample periods and models, but the preferred models fitted to the three subperiods support the hypothesis of symmetry. Thus, the most important change which, as discussed above, appears to be associated with wage and price controls is the increase in the speed and fullness of the pass-through of farm and carcass prices to the retail level.

Limitations

The USDA and BLS data series were chosen because they are readily accessible, are used by many policy makers, and seem to be internally consistent. Although nationally aggregated data are not the optimal aggregation for the farm to wholesale analysis, these data were used to facilitate comparison between the levels. The choice of the cutoff dates for the data subsets associated with possible structural change was made in the face of time and financial constraints and hence was not explored fully. Finally, the analysis perhaps could have profited from the introduction of lags for marketing cost variables.

One limitation of analyzing the impact of imperfect competition on the price spread stems from differing degrees of competition at different marketing levels within the same industry (Tomek & Robinson, p. 135). A second stems from the difficulty in determining the outcome of the trade-off between lower costs from increased physical efficiencies and excess costs that may result from the exchange relationships.

Methodological problems faced by the analysts of the administered price hypothesis stem from statistical and data limitations and from the formulation of a testable hypothesis (Scherer, p. 354), which is attributable to a lack of strong theoretical underpinnings for the empirical analysis (Beals, p. 36). The BLS producer and wholesale price series and the Census of Manufacturers data on concentration are criticized most commonly for the former being list prices that fail to consider discounting (Kelton, pp. 29-30) and the latter for its limits on the time series and disaggregated analysis (p. 32).

Conclusions

With these limitations in mind, the analysis provides interesting insights into the pricing processes at work in the national beef market. Although no evidence of asymmetry in the price-cost response pattern of either retail or wholesale beef prices was found, the analyses showed support for the different pricing patterns at the farm-wholesale and wholesale-retail levels of the beef market. Retail beef prices were found to respond more slowly to wholesale price changes than wholesale beef prices respond to changes in farm prices. Moreover, greater stability in beef prices was associated with the higher levels in the marketing chain which were also the more concentrated industries.

The results for the wholesale-retail relationship revealed a quickening response to changing beef carcass and marketing costs in the 1968-78 period. This faster response is not consonant with the traditional administered price hypothesis, but may be explained as a logical response, as the pace of general inflation quickens and as inflation itself becomes chronic (Scherer).

Observed price behavior in the 1970s, however, may have been influenced more by high levels of inflation and the attendant price controls in the early 1970s than by changes in concentration. Instability increased severely at all market levels, especially for wholesale and retail beef prices, after the removal of controls. Moreover, the response pattern of both wholesale and retail prices to prior input costs quickened significantly during and after the imposition of controls. There also was a much stronger response to marketing costs during controls and virtually no measurable effect after their removal. Thus, wage and price controls apparently were not effective in slowing the rate of cost-price transmission nor in lessening the importance of costs in the pricing patterns of the wholesale and retail levels of the beef industry. But, the more rapid transmission of prices through the marketing system is consistent with a more efficient pricing mechanism.

Bread

Like the other cases in this report, the rationale for estimating the farm to retail price transmission lags for bread is to provide additional information that may be useful to the U.S. Department of Agriculture's food price monitoring effort and its efforts to devise a more realistic measure of marketing margins, a measure which would incorporate the time lags that occur from the farm to the retail store in the processing and distribution of certain foods (see Comptroller General and Barrowman, et al.). This case study, however, places considerable emphasis on comparing estimation methods for distributed lag models.

A markup pricing model is used, in which retail prices of bread were made a function of current and lagged input prices, where the number of lags depends upon the stage of processing at which the price determination process is being studied. Recent studies using this approach for bread and for bakery products in general include those by Heien (1980, 1976), Westcott and Quinn, and Lamm and Westcott. Heien (1980, 1976) examined the lag relationship between the retail price for bread and its wholesale price. Lamm and Westcott used the farm price of wheat as input costs and as determinants of the retail prices of bakery products and cereals, and Westcott and Quinn modelled retail prices of bakery products and cereals as a function of lagged farm values of wheat, measured as the farm product equivalent of the items priced at retail.

An important consideration, when using the markup-pricing model, is the direction of causality. The markup-pricing model assumes farm-level prices cause retail food prices, which may not be an appropriate assumption for highly integrated industries, or for commodities subject to extreme seasonality or inventory behavior.

Heien (1980, 1976) and Lamm and Westcott tested for direction of causality using an approach developed by Granger and by Sims (1972a,b). Heien's (1980, 1976) results for bread showed the direction of causality running from wholesale to retail. Lamm and Westcott's results show a joint causal relationship between wheat prices and prices for bakery and cereal products, but they estimated only the unidirectional relationship of retail prices as a function of farm prices.

In the present study, no tests for direction of causality were made; a unidirectional relationship between farm-level input prices and retail prices was assumed. Retail prices of bread[2] were made a function of current and lagged farm prices of wheat[3] and a labor cost[4] variable. The cost of labor is perhaps the most important shift variable as labor costs for bread at the processing and wholesale levels amount to about 13% of the retail price. The data used were monthly, over the time period May 1968 (or January 1969, depending upon the length of the lag) through May 1978. The farm price, retail price, and labor cost data series were detrended to remove time dependence from the data. The detrending algorithm regresses the original data vector, X, against time, t, and uses the residual values from the regression, i.e., the actual X values minus the fitted X values, as the new data vector for the analysis. (The form of regression used in the detrending procedure is $X_t = \alpha + \beta t + t^2 + e_t$.)

Additional input costs considered important to represent in the model were packaging and transportation costs, which make up about 3% and 1%, respectively, of the retail price of bread (USDA, 1976). However, packaging cost data were not consistently available over the time period analyzed and transportation costs, when represented by a rail freight cost variable, were totally insignificant in early phases of estimation, so it was dropped from consideration.

Results from the present study's estimation of the lag relationship for bread are presented and discussed below. These results are seen to

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2/The retail prices of white bread used in the model are U.S. average monthly prices of a standard loaf of white bread, averaged over 56 urban areas and weighted by the urban area populations. In calculating the average price within an urban area, the white bread prices found in three different types of food stores are also weighted by their relative volume of food sales in that urban area. The U.S. average retail prices are reported in cents per pound by the U.S. Bureau of Labor Statistics, but are represented in the price transmission model as fractions of dollars.

3/Farm price data are monthly average cash prices, in dollars per bushel, of No. 1, ordinary protein, Hard Red Winter wheat, on-track prices reported at the close of the Kansas City Market, from U.S. Department of Agriculture, Wheat Situation.

4/Labor cost data are monthly averages of hourly earnings, in dollars, for production and nonsupervisory workers employed in bread and other perishable bakery goods (except cookies and crackers) manufacturing establishments (SIC Δ 2051), from U.S. Bureau of Labor Statistics, Employment and Earnings in the U.S. Averages of hourly earnings do differ from wage rates because earnings reflect not only changes in hourly and incentive wage rates, but also such variable factors as premium pay for overtime and the like. However for that reason, earnings may be a better proxy for actual monthly labor costs to the processing/wholesale sector than wage rates.

agree in some respects with those presented by Heien (1980, 1976), Westcott and Quinn and Lamm and Westcott, but while our results do indicate the presence of up to a five-month lag between farm and retail prices, the lag coefficients themselves are small. This is due partly to the units of measure of the variables, but also may be due to the assumption made of unidirectional causality. Most likely, however, the low magnitudes are simply reflections of the high degree of processing that occurs in the transformation of wheat to bread.

Alternate Estimation Methods

Comparisons are made of the results from different methods of estimation of the lag relationship for bread. Which estimator is "best" for estimating cost-price transmission rates is often a difficult decision and one to which little *a priori* information can be applied. Further, the choice of the method, with its associated constraints, can influence the results obtained (Maddala). Here, the results from three different methods of estimating lag relationships are compared in order to shed some light on the possible differences produced by different methods. Compared are (1) the Hannan spectral analytic methods, (2) ordinary least squares (OLS), and (3) an Almon lag procedure, using a second degree polynomial.

The Hannan "efficient" method is essentially a generalized least squares procedure (Maddala, p. 379). Its principal advantages are that constraints, for which there may be little theoretical justification, are not imposed on the lag distribution and that the residual terms need not be serially independent. The approach has been applied primarily to the estimation of macroeconomic lag relationships, especially to the determination of the direction of causality in macroeconomic variables (see Sims, 1972a,b and Cargill and Meyer, 1972).

The theory underlying this distributed lag estimation procedure was developed by Hannan (1963, 1965, 1967), and the method is reviewed by Maddala (p. 378f). The process used for the bread model[5/] was to divide the periodogram of the residuals into equal intervals and use an unweighted average of the values in each interval to estimate the spectrum. The characteristics of the spectrum are then used to transform the data to give the efficient, generalized least squares estimates, b_j.

That is, in the model

$$y_t = \sum_{0}^{r} \beta_j x_{t-j} + e_t,$$

asymptotically efficient estimates of the independent parameters are represented by

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[5/]The spectral estimates were obtained using a rectangular smoothing window at 14 lags.

$$b_j = \frac{1}{2m} \sum_{k=-m+1}^{m} \frac{f_{yx-j}(\theta_k)}{f(\theta_k)} \qquad (j = 0, \ldots, r),$$

where $f_{yx-j}(\theta_k)$ is the estimated cross spectrum between the y_t and each lagged x at frequency θ_k, and $f(\theta_k)$ is the estimated residuals' spectrum at frequency θ_k. (m is the lag length of the covariance functions and determines the width of the band over which the frequencies are averaged in obtaining the spectral estimates.)6/

If x_t is a linear process:

$$f(\theta_k) = f_y(\theta_k) - \frac{|f_{yx}(\theta_k)|}{f_x(\theta_k)}$$

where f_y is the estimated spectrum of y_t and f_x the estimated spectrum of x_t. The b_j are known as Hannan "efficient" estimates.

Empirical Results

For the bread model, y_t are retail bread prices in dollars per one-pound loaf, and the x_{t-j} are lagged farm prices of wheat in dollars per bushel. Results are shown in Table 10, with the ratio of the estimated coefficient, b_j, to its standard error shown in parenthesis.

A test for serial correlation developed by Durbin indicates that the above described weighting process corrected for any serial correlation present in the error term. The test consists of plotting the cumulated periodogram computed from the least-squares residuals and applying a small-sample modification of the Kolmogorov-Smirnov test against an excess of high or low frequency variation in the errors of the regression model. (Durbin shows how a pair of lines, representing a bounds test for the Kolmogorov-Smirnov test statistics, can be drawn on the graph in which the periodogram is plotted, and the hypothesis of, for example, positive serial independence conclusively rejected or accepted according to whether the sample periodogram path crosses the upper line or fails to cross the lower line. The test is inconclusive when the plot falls between the two lines.) This test gives a more comprehensive picture of

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6/The data were detrended to approach the stationarity assumptions needed for spectral estimation, but no seasonal adjustments were made. Although filtering the data to adjust for seasonality should increase the efficiency of the spectral estimates, it is important to apply the same filter to all series for the Hannan estimates, and it is not clear if this is feasible or desirable for the bread and beef data. Government price support programs for wheat, implemented at various points over the observed time period, have likely changed the pattern of the seasonality so that correction with a single filter is unlikely.

Table 10. Hannan Efficient Estimates of Price Transmission for Bread, May 1968 - May 1978

Lag	b_j	$\frac{b_j}{s_b}$
Intercept	-.0005	(-.25)
0	-.0002	(-.22)
1	-.0020	(-.99)
2	.0081	(3.57)
3	-.0018	(-.84)
4	.0069	(3.15)
5	.0036	(1.65)
6	.0006	(.29)
7	.0035	(1.04)
8	.0015	(.64)
R^2	.55	
D.W.	1.93	

the departure from serial independence than is provided by the d statistic which is a powerful test primarily against a first-order autoregressive alternative.

Maddala has suggested comparing the unconstrained lag coefficient estimates from the Hannan spectral or frequency domain approach with the unconstrained ordinary least squares (OLS) estimates from a time domain approach in order to determine the relative usefulness of the spectral approach. If unconstrained OLS, either under an assumption of serial independence of the error terms or under an assumption of a first-order autoregressive alternative, is found to produce satisfactory estimates in terms of efficiency and consistency, the development of the less restrictive (in terms of assumptions regarding the error terms), but more computationally difficult, Hannan estimates would be unnecessary.

The OLS estimates for the bread model are also based on detrended data, and in the final estimation stage, are corrected for first-order correlation. A search is performed for the estimate of rho, the autocorrelation parameter, which yields the lowest sum of squared residuals. Since the final estimates are corrected for first-order correlation, the results shown in Table 11 are GLS estimates. For both the Hannan efficient[7/] and GLS methods of distributed lag estimation, the lag length has to be specified a priori. An eight-month lag was chosen on the basis of the relatively high degree of processing wheat must undergo in its transformation to bread. While the choice of eight months is arbitrary, it seems to be reasonable. Westcott and Quinn assumed a maximum lag length of nine months for such highly processed foods as bread, cereals and bakery products.

When the OLS estimates in Table 11 are compared with the Hannan efficient estimates of Table 10, they are seen to be very similar in sign, magnitude, and ratio of the coefficient to its standard error. Thus, there seems to be little difference between the estimates produced by OLS corrected only for first-order autocorrelation and the efficient estimates produced by the Hannan spectral method. Cargill and Meyer (1974) too have found in a Monte Carlo comparison, for sample sizes of up to 100, of the OLS, Almon and Hannan[8/] methods of distributed lag estimation that OLS was the best choice in terms of relative efficiency, small bias and robustness. OLS was found to be the best choice even when the independent variable and the residual processes were highly autocorrelated. Thus, the simpler OLS estimation procedure should be preferred for small sample sizes in general and for the case of the farm-retail bread price data in particular.

7/The efficiency of the estimates have been found to depend somewhat on the length of the lag being correctly prescribed. If a greater lag length than its true value is specified, the efficiency of the coefficient is somewhat reduced (see Doran for an elaboration of this point).

8/The Hannan method compared by Cargill and Meyer was the Hannan "inefficient" method which under their assumptions of a constant signal-to-noise ratio, i.e., constant $fx(\theta_k)/f_u(\theta)_k$ for all k, produces asymptotically efficient estimates, the same as the Hannan efficient estimates.

Table 11. OLS Estimates (Corrected for First-Order Autocorrelation) for Price Transmission for Bread, January 1969 - May 1978

Lag	b_j	$\frac{b_j}{s_b}$
Intercept	-.0016	(-0.33)
0	-.0015	(-1.22)
1	.0007	(.36)
2	.0066	(3.24)
3	-.0010	(- .50)
4	.0069	(3.31)
5	.0027	(1.30)
6	.0003	(.16)
7	.0021	(.99)
8	.0019	(.90)
D.W.	2.23	

Both the OLS and Hannan results have small ratios of the coefficients to standard errors for lags after the fifth month. On this basis, an additional distributed lag model was estimated by OLS (again using detrended data and corrected for first order autocorrelation) with a five-month lag and a labor cost variable added, results shown in Table 12. The signs and magnitudes of the lag coefficients did not change by much as a result of shortening the lag specification or of adding the wage variable.

Interpretation of Results

The estimates shown in Table 12 suggest that the impact of current and lagged wheat price on the retail price of bread may be somewhat seasonal or cyclical in nature. The wheat price coefficient of the current month is negative in sign as is the third month lag coefficient. (However, the third month lag coefficient is insignificant by usual standards of significance.) This oscillation in sign might be due to seasonal fluctuations in the wheat price data. In terms of the magnitude of the estimated coefficients, the strongest impacts on retail bread price occur in the second, fourth and fifth months following an initial change in the price of wheat.

The size of the lag coefficients are quite small and are similar in magnitude to those reported elsewhere for bread, indicating that, as expected for such a highly processed food as bread, only a relatively small part of an increase in the price of the raw farm commodity is reflected in a price increase at the retail level. Small lag coefficients also were reported by Heien (1980, 1976) in his OLS estimates of the rate of price transmission from wholesale to retail for bread. The coefficient he reported for the first month lag, the longest lag he estimated, was .0026, significant at the five percent level. Relatively low magnitudes also were reported by Westcott and Quinn. Their first to eight month lags for transmission of wheat prices ranged from .005 to .053, although nearly all their estimated coefficients were significant, perhaps because of the use of an Almon lag procedure.

In the current study, the sum of the current and lagged wheat price coefficients of .0136 gives an estimate of the long-run impact of a unit change in the price of wheat on the price of bread. That is, a one-dollar increase in the price of a bushel of wheat will, after a five month lag, result in a total increase of 1.36¢ in the retail price of a one-pound loaf of bread.

The coefficient of .0143 on the labor cost variable implies that a one-dollar increase in hourly earnings for bread processing workers will result in an increase of 1.43¢ in the retail price of bread. This result seems reasonable, although the labor costs represented in the model may be acting as a proxy for other input prices which have been omitted in the analysis.

For a final comparison, the present study also employed an Almon second-degree polynomial lag estimation procedure, again making a correction for first-order autocorrelation and using detrended data. These

Table 12. OLS Estimates (Corrected for First-Order Autocorrelation) of Revised Model of Price Transmission for Bread, January 1969 - May 1978

Variable	b_j	$\frac{b_j}{s_b}$
Intercept	-.0031	(- .36)
Lag Price:		
0	-.0018	(-1.53)
1	.0005	(.25)
2	.0062	(3.05)
3	-.0005	(- .23)
4	.0065	(3.25)
5	.0027	(1.54)
Labor Cost	.0143	(1.51)
D.W.	2.32	

results are shown in Table 13. The estimated lag and labor cost coefficients are similar in magnitude to those obtained with the OLS and Hannan methods, except that the third month lag is changed in sign, from negative to positive and has a large t-value. With Almon estimation, all lag coefficients are significant at at least the 10% level. This change in t-values is probably due to the Almon method distributing the lag coefficient over whatever lag length is specified, a characteristic often responsible for the "plausible" shapes for the lag distributions fitted by the Almon method (Maddala).

Summary

The five-month lag between a wheat price increase and its reflection in a retail price increase for bread which was found in this study seems reasonable in that bread is relatively highly processed. The small magnitudes of the coefficients on lagged wheat prices also may be explained by the processing factor. However, the slight oscillation in signs and significance levels of the lag coefficients suggests a need for correction for seasonal variation in wheat prices and/or estimation of the rate of price transmission first at the farm-wholesale level and then at the wholesale-retail level.

If further estimation is performed, the results presented here suggest there will be little difference in the lag structures and coefficients obtained under OLS, Hannan or Almon lag methods of estimation. OLS, perhaps corrected for first-order correlation, as the most computationally simple method, should then be preferred. At least OLS will give a good first approximation and should be used before going on to more sophisticated estimation methods.

Eggs

The transmission of prices of eggs was studied because eggs undergo relatively little change in moving from farmers to the consumers. Lags, if any, should be short. In addition, farm-retail price data are available by city, which permits analysis of disaggregated prices. Lag structures are estimated by city, and tests are made of whether lags differ in periods of rising and falling prices. Also, estimates are made of whether a unit change in the farm prices is exactly passed through to the retail level.

Data

Retail and comparable farm prices of eggs are available by month through June 1978, and the period January 1967-June 1978 was used in the study. Five of the 12 cities available were selected for geographic diversity: New York, Chicago, Atlanta, Denver, and Los Angeles. Separate equations are fitted for each city.

The average prices for the sample period are shown in Table 14, ranked from highest to lowest retail price (also largest to smallest

Table 13. Almon Second-Degree Polynomial Model for Price Transmission for Bread, January 1969 - May 1978

Variable	b_j	$\frac{b_j}{s_b}$
Intercept	-.0026	(- .32)
Lag Price:		
0	-.0014	(-1.45)
1	.0011	(1.71)
2	.0029	(3.73)
3	.0038	(5.07)
4	.0040	(5.64)
5	.0035	(2.86)
Labor Cost	.0173	(1.83)
D.W.	2.36	
ρ	.955	

Table 14. Average Prices of Eggs, January 1967 - June 1978

City	Retail Price	Farm Price	Price Spread
		(cents per dozen)	
New York	72.3	41.0	31.2[a]
Chicago	66.9	38.7	28.5
Atlanta	65.9	40.3	25.6
Denver	63.9	43.0	20.9
Los Angeles	62.8	44.3	18.5
5-city average	66.4	41.5	24.9

[a] The average spread may differ slightly from R_t-F_t due to rounding.

price spread). There has been some tendency for prices to trend upward, but prices of eggs are variable. As a part of the subsequent analysis, the direction of monthly price changes is used, and the number of price increases almost equals the number of decreases. For the entire sample period, there are very few cases of no change from one month to the next.

Monthly wage rates for the retail food sector in the U.S. is the measure of input prices used in the study. Heien's (1980, p. 15) research indicates that wage rates and unit labor costs give similar results. In preliminary analyses, price indexes for energy and for containers and packaging materials were considered as explainers of changes in retail prices. But the coefficients of such variables had small t-ratios and the cost variables, other than wage rates, were dropped from the final regression models.

Measures of volume of eggs marketed <u>by city</u> by month are not available, and the omission of this variable may be the most serious specification error in the model. In an annual model of marketing margins for eggs, the quantity of eggs marketed was positively related to the margin (Hallberg and Stucker, p. 54).

Alternate Models and Estimation

Given the data limitations, the basic model makes retail price a distributed lag function of farm prices plus the wage rate variable lagged one month. The initial specification used an unrestricted model with lag lengths up to 4 months.

$$(1) \quad R_t = \alpha + \sum_{i=1}^{4} \beta_i F_{t-i} + \mu W_{t-1} + e_t,$$

where R = retail price, cents per dozen,
F = farm price, cents per dozen,
W = wage rate, dollars per hour, and subscripts represent time in months.

The variables R and F differ for each city, while the wage rate is an average for the U.S.

An alternative specification assumes a geometric form distributed lag. One conceptualization is in terms of "habit" or, more precisely, the inertia built into past retail prices. Let

$$R_t = a + \beta F_t + \mu W_t + \sum_{i=1}^{\infty} \alpha_i R_{t-i} + e_t$$

and assume $\alpha_i = \alpha\lambda^{i-1}$, $0 < \lambda < 1$.

Substituting and expanding the summation term

$$R_t = a + \beta F_t + \mu W_t + \alpha R_{t-1} + \alpha\lambda R_{t-2} + \alpha\lambda^2 R_{t-3} + \dots + e_t.$$

Multiplying this equation by λ and lagging one period,

$$\lambda R_{t-1} = a\lambda + F_{t-1} + \mu\lambda W_{t-1} + \alpha\lambda R_{t-2} + \alpha\lambda^2 R_{t-3} + \dots + \lambda e_{t-1}.$$

Subtracting and rearranging terms,

$$R_t = (1+\lambda)a + \beta F_t - \beta\lambda F_{t-1} + \mu W_t - \mu\lambda W_{t-1} + (\alpha+\lambda)R_{t-1} + v_t$$

or

$$(2) \quad R_t = \pi_0 + \pi_1 F_t + \pi_2 F_{t-1} + \pi_3 W_t + \pi_4 W_{t-1} + \pi_5 R_{t-1} + v_t.$$

This equation presents several problems in estimation and interpretation. One is the nonlinearity, or "overidentification," such that in the unrestricted least squares fit, two estimates of λ are available, π_2/π_1 and π_4/π_3. In general, they will be different. For this data set, however, W_t and W_{t-1} are highly collinear, and as a practical matter, one of the variables must be dropped from the model. Thus, the equation used is

$$(3) \quad R_t + \pi_0 + \pi_1 F_t + \pi_2 F_{t-1} + \pi_3 W_{t-1} + \pi_4 R_{t-1} + v_t.$$

The estimate of λ is computed from the estimated ratio π_2/π_1, and the coefficient of W_{t-1} is interpreted as a proxy for the combined effects of W_t and W_{t-1} (and perhaps other input prices which have been trending upward in the sample period).

A simpler alternate view is to assume each regressor has the same geometric (Koyck) lag with the lag in farm price starting after the initial period.

$$R_t = a + \beta F_t + \frac{\alpha(1-\lambda)}{1-\lambda L} F_{t-1} + \frac{\mu(1-\lambda)}{1-\lambda L} W_{t-1} + e_t,$$

where L is the one time period lag operator.

This equation can be rearranged in autoregressive form as

$$(4) \quad R_t = (1-\lambda)\, a + \beta F_t + (\alpha-\alpha\lambda-\beta\lambda)F_{t-1} + \mu(1-\lambda)W_{t-1} + \lambda R_{t-1} + v_t.$$

Under this interpretation, λ is estimated directly as the parameter of R_{t-1}. Then, obtaining α, one can estimate the effect of lagged F's from the estimated weights

$$\alpha(1-\lambda),\ \alpha(1-\lambda)\lambda,\ \alpha(1-\lambda)\lambda^2,\ \dots \qquad \text{(Johnston, p. 298).}$$

The regressors in equation (3) also can be justified on still another conceptual basis. That is, conceptually different models have identical regressors. Of particular concern,

$$R_t = a + \beta F_t + \mu W_t + e_t$$

$$e_t = \rho e_{t-1} + v_t$$

gives the same regressors as in equation (2). In this case, the parameter of R_{t-1} is merely ρ. Or, in interpreting equation (3), $\pi_1=\beta$, $\pi_2=-\beta\rho$, and $\pi_4=\rho$, so that $\pi_1\pi_4=-\pi_2$. The empirical results can be checked to determine whether this identity exists.

The equations were fitted by ordinary least squares, and when autocorrelation in the error terms appears to be a problem, generalized least squares is used. Specifically, a search procedure (BINSEARCH in TROLL) is used to find the autocorrelation coefficient which minimizes the sum of squared residuals.

To test for asymmetry of price responses, a dummy variable was defined as follows.

$$D_{1t} = 1 \text{ when } F_t > F_{t-1} \text{ or } F_t - F_{t-1} > 0$$

$$= 0 \text{ when } F_t < F_{t-1} \text{ or } F_t - F_{t-1} < 0.$$

For the few cases when $F_t-F_{t-1} = 0$, the adjacent changes were examined for sign and the no change periods were assigned a zero or one based on the direction of these adjacent changes. The dummy variable also is used to create interaction terms. Hence, in the full model, both slope and intercept parameters are permitted to differ, and the hypothesis of whether the parameters for rising prices equal the parameters for falling prices can be tested.

Empirical Results

Empirical results for equation (1) are presented in Table 15, while the results for equation (3) are presented in Table 16. Equation (1) basically views current retail price as a function of current and past farm prices. Using the habit persistence interpretation of equation (3), retail price is viewed as a function of current farm prices and the persistence of the influence of past retail prices on current prices. But, as we shall see, both equations lead to qualitatively similar results.

In preliminary estimates of equation (1), lags in farm prices up to 4 months were considered. Variables were retained if their t-ratios were one or larger. The final models (Table 15), based on GLS estimates, had two period lags for the Atlanta, Denver and New York City equations and one month lags for Chicago and Los Angeles. Since eggs move into consumption within a week or two of production, a one-month lag is understandable; two-month lags are a bit unexpected.

The sum of the coefficients of F indicate whether farm prices are exactly passed through to the retail level. For the Atlanta, Denver and Chicago models, the hypothesis that the sum equals one cannot be

Table 15. GLS Estimates for the Unrestricted Distributed Lag Model for Eggs[a]

City	explanatory variables					ρ^d	s (cents)	d	Σ of F coef.	Mean of dep. var. (¢/doz.)
	Inter.	F_t	F_{t-1}	F_{t-2}	W_{t-1}					
New York	8.33 (6.64)[b]	0.96 (39.61)	0.10 (3.85)	0.05 (1.97)	5.55 (13.34)	0.51	1.66	2.10	1.11[c]	72.8
Atlanta	9.82 (7.35)	0.79 (24.92)	0.18 (5.21)	0.07 (2.12)	4.32 (9.90)	0.37	2.23	2.23	1.04	66.3
Denver	13.09 (10.48)	0.87 (28.65)	0.13 (3.89)	0.04 (1.16)	1.87 (3.99)	0.42	1.97	1.99	1.04	64.3
Chicago	15.33 (9.61)	0.87 (22.54)	0.17 (4.38)	-	3.38 (6.10)	0.39	2.70	2.14	1.04	67.3
Los Angeles	5.19 (1.15)	0.82 (23.83)	0.09 (2.48)	-	5.40 (2.14)	0.84	2.20	2.44	0.91[c]	63.0
5-city Average	9.79 (13.74)	0.89 (47.87)	0.13 (6.13)	0.02 (1.07)	4.03 (16.11)	0.37	1.20	2.16	1.04	66.8

[a] Based on 134 observations, 1967-5 to 1978-6; the first 4 observations are lost in lagging preliminary models contained up to 4 lags.

[b] Coefficients in parentheses are t-ratios.

[c] Sum of coefficients significantly different than one.

[d] ρ is the estimated first-order autocorrelation coefficient; s is the estimated standard deviation of the residuals and d is the Durbin-Watson statistic.

Table 16. OLS Estimates for Geometric Distributed Lag Model for Eggs[a]

City	explanatory variables					$\bar{R}^2$	h^b	s (cents)	eq. (2) parameters	
	Inter.	F_t	F_{t-1}	W_{t-1}	R_{t-1}				π	α
New York	4.38 (4.91)[a]	0.96 (39.25)	-0.36 (4.52)	2.88 (6.48)	0.46 (6.67)	0.99	0	1.68	.37	.09
Atlanta	6.44 (5.73)	0.79 (24.71)	-0.09 (1.23)	2.80 (6.34)	0.34 (4.69)	0.98	-1.46	2.24	.12	.22
Denver	7.51 (6.05)	0.87 (27.74)	-0.25 (3.16)	0.96 (3.12)	0.42 (5.35)	0.98	0.14	1.96	.29	.13
Chicago	10.23 (6.42)	0.88 (21.95)	-0.18 (2.00)	2.24 (4.76)	0.33 (4.05)	0.97	0.31	2.77	.20	.13
Los Angeles	0.49 (0.55)	0.81 (23.52)	-0.67 (12.13)	1.23 (2.94)	0.83 (16.45)	0.98	-2.84[c]	2.23	.82[d]	.01
5-city Average	6.74 (7.76)	0.90 (47.78)	-0.16 (2.15)	2.76 (8.09)	0.30 (4.07)	0.99	0.42	1.21	.18	.12

[a] t-ratios in parentheses.

[b] h is Durbin's statistic for testing for autocorrelation when the model contains the lagged dependent variable; s is the estimated standard error of the residuals.

[c] Hypothesis of zero autocorrelation is rejected.

[d] In this equation $\pi_1 \pi_4 = .67$ and $\pi_2 = -.67$ so that the parameter of R_{t-1} is perhaps best interpreted as an autocorrelation coefficient (see text).

rejected. For New York and Los Angeles, the hypothesis is rejected. In New York, the sum is 1.1, suggesting that retail prices rise and fall by more than the amount of the change in farm prices. In Los Angeles, the sum is 0.9, suggesting that retail prices change less than amount of the farm price. The latter result is somewhat implausible, and it should be noted that the various Los Angeles equations were the poorest performers, based on various statistical measures. The Los Angeles price transmission structure appears to be different than for the other cities, and the model used may be especially inappropriate for Los Angeles.

The wage rate variable should be interpreted basically as a proxy for marketing input prices, which trended upward in the sample period. For equation (1), the price of a dozen eggs is estimated as increasing from about 1.9 cents per dozen for each one dollar increase in wages in Denver to about 5.5 cents in New York City. Equation (3) - Table 16 - gives a similar qualitative result; namely the wage rate variable has the smallest coefficient in Denver and the largest in New York. These coefficients, however, are about half as large in equation (3), ranging from 1.0 to 2.9. The wage coefficient is most unstable in the Los Angeles equations, being second largest for equation (1) and next to smallest for equation (3).

If the results for the geometric form model are interpreted in terms of the habit persistence model, then the coefficients of the lagged retail prices are computed as

$$\alpha_i = \alpha\lambda^{i-1}, \ i = 1, 2, \ldots .$$

For New York, for example, using coefficients in Table 16,

$$\alpha_1 = (.09)(.37)^0 = .09.$$

$$\alpha_2 = (.09)(.37)^1 = .03.$$

$$\alpha_3 = (.09)(.37)^2 = .01. \ \ldots$$

Clearly the effect of past retail prices is small, especially after t-1. The same is true for the other cities.

If the New York City equation is interpreted as a Koyck model like equation (4) above, then $\lambda=.46$, $\beta=.96$, and $\alpha-\alpha\lambda-\beta\lambda=-.36$, so $\alpha = .082$. Thus, the successive coefficients of the lagged farm prices are .082, .037, .017, ...[9] The effects of past prices are small and die away rapidly. Given this result, the model with lagged F omitted might be considered, and the coefficients of lagged R for the respective cities

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[9] Computed as $W_1 = \alpha(1-\lambda)$, $W_2 = \alpha(1-\lambda)\lambda$, $W_3 = \alpha(1-\lambda)\lambda^2$.

are small, implying rapid adjustment of retail prices to changes in farm prices (results not shown).

The geometric form equation for Los Angeles clearly has problems. The error term apparently has autocorrelation (h=-2.84). Moreover, the coefficients of F_{t-1} and R_{t-1} have unusual magnitudes relative to the other equations, and following arguments given in the previous section, the results are perhaps generated by an autoregressive process in the error term rather than via a distributed lag effect in the prices. The estimated value of λ is very large, which taken by itself implies a lengthy adjustment period. But, under the habit persistence interpretation, α is small so that the products of α and λ^{i-1} -- the coefficients of the lagged R's -- are small.

In general, the null hypothesis of a symmetric price response cannot be rejected (Table 17). The response of retail prices to decreases in farm prices is typically the same as for increases. The one seeming exception is for Los Angeles. But, as we have seen, the coefficients of these equations are not always logical, and the geometric-form model has autocorrelated residuals. The model may be seriously misspecified for Los Angeles, and with autocorrelation, the F test is suspect. Thus, no strong statement can be made about asymmetry in Los Angeles, and since symmetry appears to be the rule, these are the results which were discussed (above).

Implications of Results

On balance, the price transmission process for eggs seems reasonably efficient. Current retail price is typically a function of current farm price and farm prices lagged one or two months. A two-month lag seems unnecessarily long relative to an efficient market, but it is shorter than the three-month lag between retail and wholesale prices found by Heien for aggregate U.S. data for the 1960-1976 period.

In three of the five cities, the farm price change was exactly passed through to retail. In New York City, the retail prices are estimated as changing by more than the farm price. But this is true both for increases and decreases, as the response appears to be symmetric, although over the sample period prices trended upward.

The hypothesis of symmetric price responses also cannot be rejected for Atlanta, Chicago and Denver data. The hypothesis is rejected for Los Angeles, but typically less than the full change in farm prices is passed through. In a model permitting differing coefficients for price increases and decreases, 0.92 of price declines were passed through while 0.95 of price increases were passed through. The Los Angeles models, however, have statistical problems, and hence no firm conclusions can be reached from these equations.

The difference in performance of models among cities - especially for Los Angeles - does suggest that the price transmission process can differ among cities. Although the egg market can be viewed as national

Table 17. Tests of Symmetry of Price Response Hypothesis

City	Model-estimation Method	Computed F	Significant 5%	Significant 1%
New York	Unrestricted lag - GLS	0.29	No	No
	Geometric lag - OLS	0.48	No	No
Atlanta	Unrestricted lag - GLS	0.44	No	No
	Geometric lag - OLS	0.50	No	No
Denver	Unrestricted lag - GLS	0.67	No	No
	Geometric lag - OLS	0.77	No	No
Chicago	Unrestricted lag - GLS	1.18	No	No
	Geometric lag - OLS	2.44	Yes	No
Los Angeles	Unrestricted lag - GLS	2.64	Yes	No
	Geometric lag - OLS	4.03	Yes	Yes

NOTE: Based on 134 observations. Full geometric model has 10 parameters, and 5 under the null hypothesis of symmetry of price response. The unrestricted model also has 10 parameters when there are 2 lags in F or 8 with one lag (Chicago and Los Angeles), and the number of parameters under the null hypothesis is either 4 or 5. Hence, the F values have either 5 and 124 degrees of freedom or 4 and 126 degrees of freedom. A conventional F statistic is computed using the SSE from the full model and the one under the null hypothesis.

in scope with common economic forces, marketing arrangements and structure can vary geographically. Our models unfortunately do not capture these structural differences in explicit variables.

Margarine

Margarine was chosen for study as a manufactured food product. The value of the farm component of the retail product averaged 33.4% of the retail price in the 1967-78 period. According to the 1972 Census of Manufacturers, the four largest companies in the soybean oil industry -- a principal farm ingredient in margarine -- accounted for 54% of the value of shipments, and margarine manufacturing appears to be moderately concentrated.

The main objectives of the analysis for margarine are to explore lag lengths and to determine whether retail prices respond symmetrically to increasing and decreasing farm prices. Soybean oil prices were especially volatile in the 1970s, making margarine an ideal product for examining the symmetry hypothesis. The farm value variable used in the analysis had a standard deviation of 7.3 cents, over half of the average value, which is a relatively large variation.

Data and Models

Variants of two basic models were explored. One makes retail price a distributed lag function of farm prices (value of farm input).

$$(5) \quad R_t = \alpha + \sum_{i=0}^{n} \beta_i F_{t-i} + \Omega W_{t-1} + \mu Q_t + e_t$$

where R = retail price of margarine (see Table 18),
F = value of farm inputs,
W = wage rates,
Q = margarine production,
t = month and i = lag = 0, 1, 2, ..., n.

A second model is basically a geometric form distributed lag specification analogous to the model fitted to egg prices. Various alternative specifications were considered, and the one reported here is

$$(6) \quad R_t = \pi_0 + \pi_1 F_t + \pi_2 F_{t-1} + \pi_3 W_{t-1} + \pi_4 Q_t + \pi_5 R_{t-1} + v_t.$$

In addition, a dummy variable was defined (as for eggs) which equalled one when farm value declined and zero when farm value increased. This dummy was used to create interaction terms with each regressor; hence, both the intercept and slope coefficients were permitted to change in periods of rising and falling prices. This model was then used to test the null hypothesis of equal parameters for the two periods.

Table 18. Average Values of Margarine Variables, Months, May 1967 - June 1978

Variable	Unit	Value
Retail Price (R)	cents per lb.	41.9
Farm Value (F)	cents per lb.	14.0
Wage Rate (W)	dollars per hr.	3.34
Production (Q)	million lb.	195.3

The full data set ran from January 1967 through June 1978, 138 observations. Lagging variables reduced the number of observations for specific equations.

Empirical Results

Equation (5), when fitted by OLS, had a very strange pattern of coefficients as lagged values of farm prices were added, and the residuals were highly autocorrelated. In addition, visual inspection of the residuals suggests that they became larger with the passage of time. When the equation was corrected for autocorrelation, the coefficients of F declined smoothly after period t.

Thus, a geometric lag after period t seems like a reasonable specification, and estimates of equation (6) are reported in Table 19. The residuals of the OLS equation appear autocorrelated (h = 3.16), and the equation was refitted by GLS assuming first-order autocorrelation. The residuals of this equation are not autocorrelated, and interestingly the GLS estimates of the slope coefficients are similar to the OLS estimates.

In some respects, the results are reasonable. The wage rate coefficient has a positive sign and a large t-ratio. The importance of margarine production in the model is tenuous, but the coefficient is positive, which is plausible. That is, if margarine production is viewed as a proxy for movements along the cost curves for marketing services, then larger production would be associated with a larger marketing margin and larger retail prices.

Current and lagged farm values have important influences on the current price of margarine. A one-cent change in the current value is associated with a 0.1 cent per pound change in current retail price of margarine. The coefficient of farm price lagged one period is twice as large, and then the effect of past prices is specified as declining geometrically.

The least plausible part of the model is the large coefficient of the lagged dependent variable and the correspondingly large t-ratio. A large part of the variation in the dependent variable is merely associated with its lagged values, and interpreted as a geometric-form distributed lag model, the results imply a long lag -- over 14 months for a 95% adjustment of retail prices to a change in farm prices.

Heien (1980) found a four-month lag between a change in wholesale prices and a change in retail prices, but a number of his lag coefficients are negative. As mentioned above, preliminary estimates using an unrestricted lag model similar to Heien's found a long, smooth lag. Thus, while the results obtained by us must be treated with some skepticism, they suggest a rather imperfect price transmission process for margarine, in that long lags are required for adjustments of retail prices to input prices.

Inserting dummy variables and interaction terms to test the symmetry of price response hypothesis did not improve results. That is, in the

Table 19. Estimates of a Price Transmission Equation for Margarine[a]

Variables	OLS	GLS
Intercept	0.211 (0.047)[b]	1.972 (0.376)
F_t	0.093 (3.616)	0.115 (4.986)
F_{t-1}	0.231 (7.740)	0.210 (7.928)
W_{t-1}	0.878 (6.039)	0.922 (4.859)
Q_t	0.051 (1.934)	0.038 (1.306)
R_{t-1}	0.803 (61.571)	0.801 (48.427)
$\bar{R}^2$	.998	--
d	1.46	1.95
h	3.16	.30
ρ	--	.30

[a] Observations on dependent variable run from May 1967 to June 1978.

[b] t ratios in parentheses.

geometric-form model the most important explanatory variable was the lagged dependent variable. The hypothesis of symmetry (equal parameters for declining and rising farm prices) cannot be rejected. In this sense, the price transmission process does not have an imperfection.

Summary and Implications

The price transmission process has been rather widely studied in recent years, but the case studies reported here do contribute additional insights to the empirical relationships of retail prices to current and past prices of inputs. Retail prices were found to respond symmetrically to positive and negative changes in farm-based input prices. The estimated equations suggest also that wage rate increases are passed on to consumers symmetrically both when farm input prices are declining and increasing.

The length of lags in price transmission do imply imperfections in the process. Farm-retail lags of up to two months were found for eggs when the process probably shouldn't take over two weeks. The results for eggs, however, vary by city, and in some instances the lag was just one month. Given the timing of farm and retail price collection and the use of monthly data, a lag of a few weeks might be observed only as a one month lag.

For beef, most of the farm price is transmitted to the wholesale level immediately, although the farm price lagged one month has a coefficient with a large t-ratio. Prices are passed from wholesale to retail at a slower rate with a two or three month lag implied by the results. Thus, about four months appear to be required for retail prices to adjust to changes in farm prices, and this seems long relative to the physical process of moving beef through the marketing system. There is evidence, however, that prices for beef are being passed-through more rapidly now than in past years.

For bread and margarine, changes in farm prices are passed on to the retail level at a rather slow rate. This perhaps should be expected for highly processed products, and the lag of five months between a change in the price of wheat and a complete adjustment in the price of bread seems reasonable. The 14+ months lag in the relationship of retail margarine prices to changes in the value of farm inputs suggests an imperfect price transmission process, but it also may reflect biased estimates from an imperfect model.

With respect to the form of lags for beef and eggs, the coefficients of the farm price variables are largest in the initial period and then decline rapidly. For bread, the magnitudes of the coefficients of current and past farm prices are erratic, and the form of the lag is not absolutely clear. A tendency appears to exist for small coefficient followed by larger coefficients, and then a smaller coefficient--a "humped" form. If a second degree polynomial constraint is imposed on the coefficients, they do have a smooth humped shape. For margarine, the evidence suggests that the initial impact of farm on retail prices is small, followed by a larger coefficient in t-1, and then a long smooth decline in coefficients. A geometric lag fits the margarine data well, although as discussed above, doubt exists about the length of the lag.

One cannot help but be struck by the fundamental difference in the nature of farm inputs used in eggs and beef and those used in bread and margarine. Eggs and beef are produced continuously and sold at retail soon after they are produced. Soybeans (soybean oil is the principal farm product in margarine) and wheat are produced once a year and consumed throughout the year. The volume of soybeans processed, for example, is fairly constant throughout the year, and the flow of oil from crushers has had little or no seasonality (Houck et al., p. 48). But, the procurement of beans by processors is seasonal; crushers have sufficient capacity to store 25 to 30% of the annual amount crushed (p. 49). Hence, observed monthly prices may not reflect acquisitions costs. The potential use of futures markets by processors of wheat and soybeans further complicates the identification of acquisition costs.

Prices are, of course, being reevaluated continuously, and these price changes are reflected in changing values of inventories. In this sense, the opportunity cost of the farm input is changing, and current price could be viewed as an appropriate measure of the cost of the farm input. In sum, current, observed farm prices for the grains may or may not be appropriate measures of input costs. If they are not, then the variables used in price transmission models, such as ours, may be seriously in error.

A disconcerting feature of the various studies of price transmission is the differences in empirical results. For example, our results for the transmission of wholesale beef prices appear to differ importantly from those obtained by Heien (1980). Thus, we have reservations about using the available research, including our own, for monitoring the price transmission process or as a basis for computing marketing margins.

In considering additional research, we as a profession need to ask whether the available secondary data are adequate for estimating price transmission processes with the precision necessary for forecasting and for making policy decisions. Or, if improved data cannot be obtained, additional insights are needed to make effective use of existing data.

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