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Wholesale-Retail Marketing Margin Behavior in the Beef and Pork Industries

John M. Marsh and Gary W. Brester

An econometric model is used to estimate real wholesale-retail marketing margins for beef and pork. From 1970 to 1998, these margins increased by 27% and 149%, while farm-wholesale margins declined. Wholesale-retail (WR) marketing margin increases have caused livestock producers to focus on the retail sector as a contributor to declining real livestock prices. Increases in WR margins may be related to increased demand and costs of value-added food products/services as well as increased market concentration in the retail grocery sector. Results indicate that retail factors, and to a lesser extent meat processing factors, significantly increased WR margins and decreased livestock prices.

Key words: livestock prices, retail concentration, retail costs, wholesale-retail marketing margins

Introduction

Real slaughter cattle and hog prices have declined over several decades. For example, from 1970 to 1998, real slaughter cattle and hog prices declined by 50.1% and 66.4% (figures 1 and 2). Some cattle and hog producers have argued that a variety of factors other than supply and demand conditions have been responsible for these trends. One factor receiving significant attention has been increased meat packer concentration because of its presumed correlation with anti-competitive behavior. This concern has generated a profusion of research related to meat packer concentration and livestock price discovery (for a comprehensive review, see Azzam and Anderson, 1996; Ward, 2002). In general, results of this research indicate that if packer concentration has reduced cattle and hog prices, the effects have been relatively small. As shown by recent research, negative impacts on livestock prices may have been offset by increased packer cost savings generated by scale economies and/or technological innovation (Azzam and Schroeter, 1995; Brester and Marsh, 2001; Morrison-Paul, 2001).

Livestock producers have also raised concerns about the impacts of increasing retail grocery store concentration on marketing margins and farm-level prices. Producers argue that retail consolidation translates into market power or collusive behavior and results in wider red meat marketing margins. The larger margins may result in lower live cattle and hog prices because of a lack of offsetting market power at those levels (*BEEF*, 2002; Cotterill, 1999; Schrimper, 2001).

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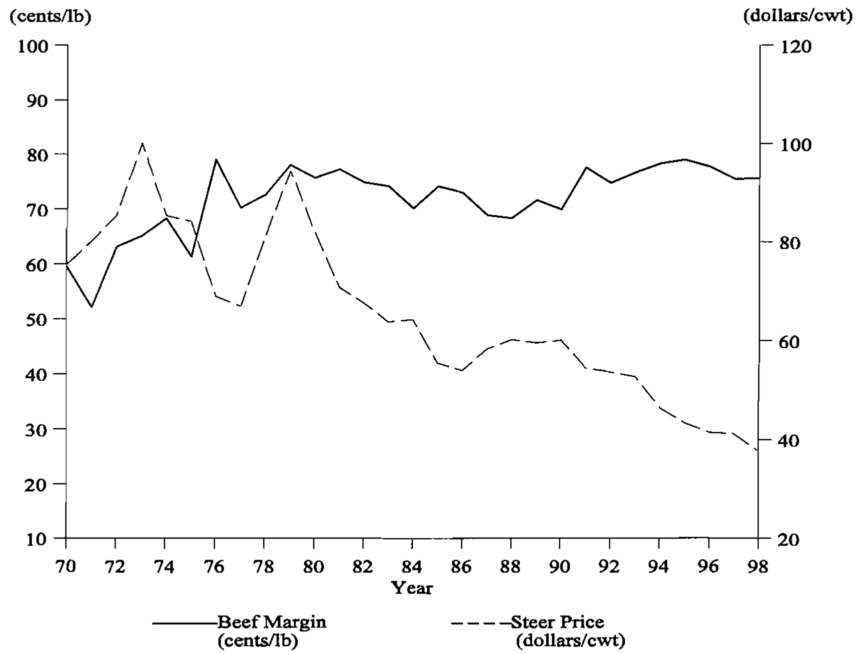

Figure 1. Real wholesale-retail beef margin and slaughter steer price, 1970–1998

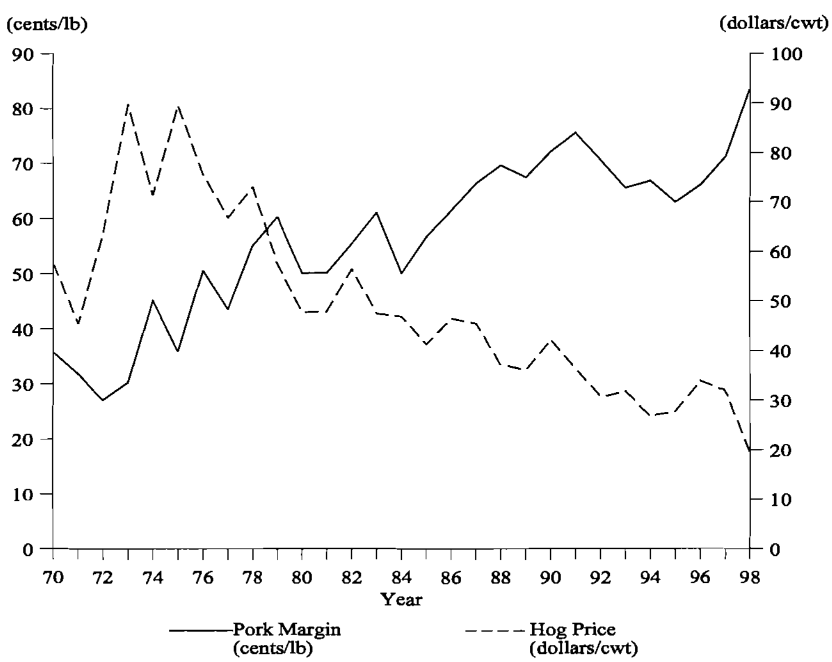

Figure 2. Real wholesale-retail pork margin and slaughter hog price, 1970–1998

Marketing margins are the result of demand and supply factors, marketing costs, and the degree of marketing channel competition. Thus, margins reflect aggregate processing and retailing firm behavior which influence the level and variability of farm prices and may influence the farmer's share of the consumer food dollar (Gardner, 1975; Tomek and Robinson, 1990; Wohlgenant, 1989). In the beef and pork industries, farm-wholesale (FW) and wholesale-retail (WR) marketing margins (which constitute the farm-retail margin) have experienced dynamic, albeit opposite, changes. For example, from 1970 to 1998, inflation-adjusted (1982–84 constant dollars) FW margins for beef and pork *declined* by 56.6% and 58.7%, respectively. Inflation-adjusted WR margins for beef and pork, however, *increased* by 27% and 149%, respectively (figures 1 and 2). Wholesale-retail margins constitute the largest portion of farm-retail marketing margins in the beef and pork sectors, i.e., about 80% for pork and about 84% for beef in 1998 [U.S. Department of Agriculture (USDA), *Red Meats Yearbook*, 2000]. The impacts of these margin changes on livestock prices are ambiguous. For example, cattle and hog producers could receive higher prices due to reduced FW margins, but lower prices because of increases in WR margins.

Our objective is to econometrically investigate the economic factors that have led to increases in real WR margins in the beef and pork sectors. In addition, we estimate the downstream effects of increasing WR margins on slaughter cattle and hog prices. A marketing margin model that incorporates the meat processing and retail grocery sectors is developed based upon primary and derived demand and supplies in the red meat marketing channel. The primary focus is on the effects of market concentration and the demand and supply (costs) of value-added products and services within the retail grocery industry. The model also accounts for the effects of changes in meat packer concentration and meat processing technology on WR margins.

Conceptually, the economic performance of the retail and meat processing sectors may affect WR margins and livestock prices. A plethora of studies have investigated the impacts of meat packing concentration on FW marketing margins and livestock prices (see Azzam and Anderson, 1996; Ward, 2002). However, few studies have investigated the effects of upstream (i.e., retail) factors on beef and pork WR margins and livestock prices. Such research is needed for two reasons. First, livestock producers are particularly concerned about sources and ultimate effects on livestock prices of increases in real WR beef and pork marketing margins. In particular is the substantial increase in retail grocery store consolidation. Second, although livestock producers generally support development of value-added meat products and services, they also question if such development affects livestock prices. We suggest the development of value-added retail products/services (reflected in reduced grocery store productivity and increased food labor costs) and increased retail grocery store concentration may have significantly increased real beef and pork WR margins and decreased real livestock prices.

Retail Grocery Store Concentration and Productivity

Retail grocery store concentration has increased steadily over the past 30 years. As illustrated by figure 3, the four-firm concentration ratio in large metropolitan areas has increased from 51.4 in 1970 to 74.4 in 1998, or 44.7%. In the same period, U.S. Department of Labor/Bureau of Labor Statistics (BLS) data indicate output per employee hour in the retail grocery industry decreased by 18.2%. Output per employee hour (or productivity) has been used as a measure of technological change in food processing (Brester and Marsh, 2001; Gisser, 1982). Taken at face value, one might conclude the retail grocery store sector has experienced a "decline" in technology. However, the retail grocery industry has adopted/developed many new technologies. Examples include management information systems which have increased the efficiencies of product invoicing, employee payrolls, logistics, and warehouse management. Other technological innovations have been universal product codes, point-of-sale scanning, and improved coordination/ integration with food chain suppliers (Food Marketing Institute, 2001). Technological changes have also occurred at the food processing level. These changes include new capital and processing methods which have reduced unit wholesale costs, new packaging and product development (i.e., convenience foods), food safety (i.e., HACCP), and transportation technologies.

A driving force in the decline in retail grocery productivity may have been an increase in the demand for value-added food services and the increased labor requirements needed to produce these services (Schrimper, 2001). Consumers are increasingly demanding more service, convenience, and food product diversity. Some of these demands are met by food processors. However, retailers have also responded to these demands by increasing in-store promotions, labeling, special customer ordering, delicatessens, salad bars, and bakeries. With respect to meats, the ratios of real per capita consumption expenditures of beef and pork to real cattle and hog prices reflect this service demand phenomenon. These ratios have increased substantially since 1970 (figure 4). For example, the ratio of beef expenditures to cattle price increased from 1.12 in 1970 to 3.33 in 1998. The ratio for pork increased from 1.93 in 1970 to 4.02 in 1998. During this period, per capita beef consumption declined while per capita pork consumption was relatively unchanged even though real livestock prices declined.

Additional marketing costs emanating from increased demands for marketing services have likely not been entirely borne by consumers. If additional costs of providing food services for certain products are not completely passed on to consumers, then other departments or profit/cost centers in food stores may increase their margins to offset these costs. Unbranded products could be likely candidates for this subsidization, and retail fresh beef and pork cuts are among the largest unbranded items in the grocery sector. Also, as grocery stores have provided more marketing services, they compete more directly with food service establishments. Therefore, to remain cost competitive, grocery stores have increased in size with the result of increased market concentration in the retail grocery industry (Cotterill, 1999).

We note that retail grocery store productivity as measured by the BLS refers to overall store operations. Its relationship to productivity in retail meat departments could be problematic since retail grocery stores have diverse food and nonfood profit centers (Food Marketing Institute, 2001). However, the BLS has recently developed a data series (beginning in 1988) which measures output per employee hour in meat and fish markets. This productivity measure also trended downward, declining by 5.1% from 1988–89 to 1997–98 (overall retail productivity declined by 5.4% for this period). The correlation coefficient for the two productivity measures is about 0.70. In addition, a recent government report indicated that from 1987 to 1997, overall unit labor costs increased by 4.1% for retail grocery stores. Concurrently, unit labor costs for meat and fish markets increased by 3.4% (U.S. Department of Labor/BLS, 1999).

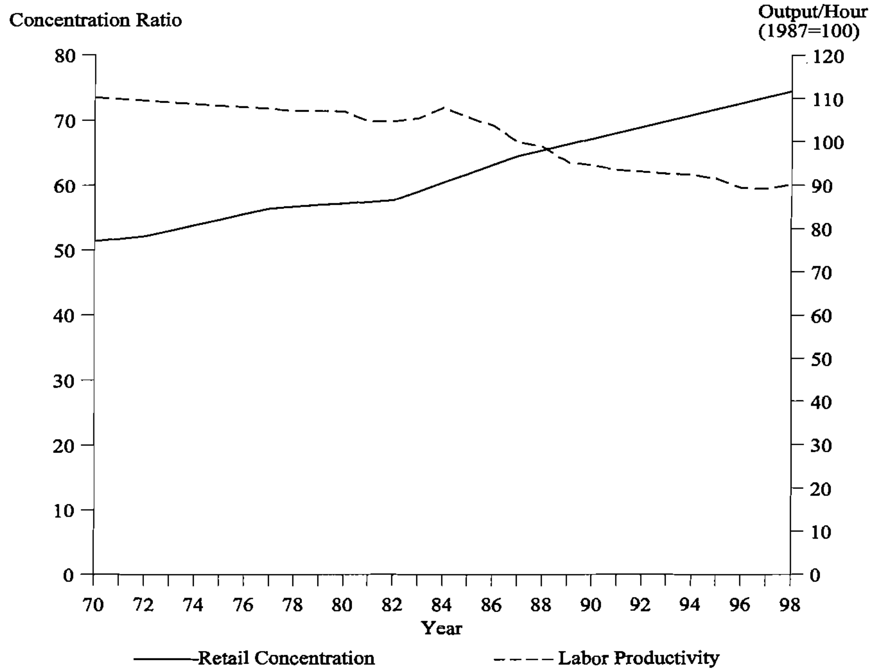

Figure 3. Four-firm concentration and labor productivity in retail grocery industry, 1970–1998

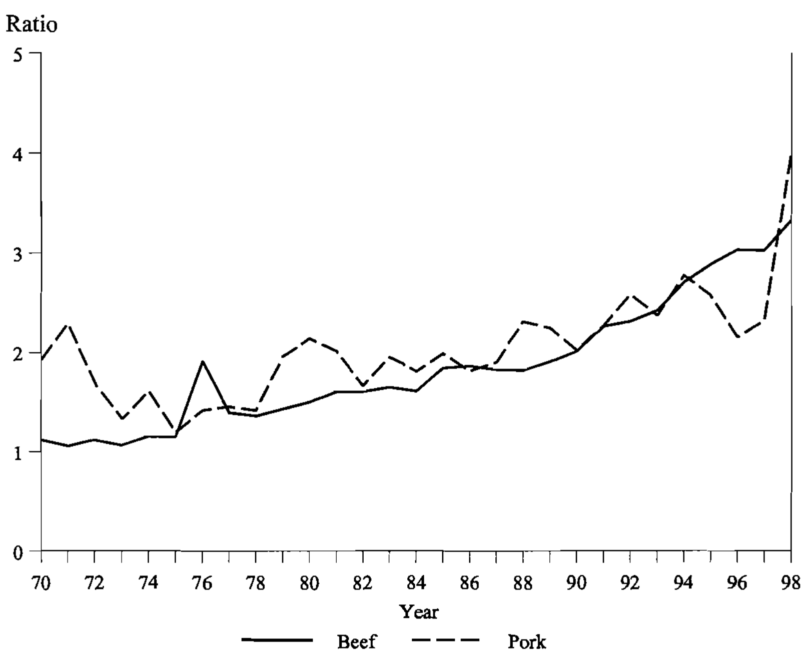

Figure 4. Ratios of real per capita consumption expenditures of beef and pork to real slaughter cattle and hog prices, 1970–1998

Model Development—Previous Research

Numerous studies have investigated the economic behavior of farm-wholesale (FW) marketing margins and livestock prices (see a comprehensive summary by Azzam and Anderson, 1996; Brester and Marsh, 2001; USDA, 1996; Ward, 2002). Much of the FW margin emphasis has been statistical testing of oligopoly/oligopsony market power by meat packers and in some cases quantifying market risk (Azzam and Pagoulatos, 1986; Schroeter, Azzam, and Zhang, 2000; Ward, 2002). Time-series and cross-section data have been employed in various regional and national models to estimate factors determining FW margins. Explanatory variables generally included quantities produced, wages and other marketing costs, and market concentration. Trend has been specified in some studies as a proxy for technological change, usually in industry-level cost functions for food processing (Ball and Chambers, 1982; Gisser, 1982; Goodwin and Brester, 1995; Melton and Huffman, 1995). However, Brester and Marsh (2001) used measures of industry productivity to represent technological changes in FW margins for beef and pork.

Some studies have analyzed the behavior of total margins, or the farm-retail (FR) price spread. These studies identified retail demand, farm-level supply, and marketing input costs as major factors underlying the structure of FR margins. Competitive firm behavior was either assumed or statistically tested in these investigations (Gardner, 1975; Holloway, 1991; Lyon and Thompson, 1993; Wohlgenant, 1989).

Fewer studies have focused on red meat margin behavior at the wholesale-retail level of the marketing chain. Hall, Schmitz, and Cothern (1979) investigated increases in beef wholesale-retail margins. They hypothesized that increases in retail wage rates and four-firm concentration in retail supermarkets accounted for WR margin increases. Applying an error components model to a pooled sample of 19 Standard Metropolitan Statistical Areas (SMSAs) for the years 1967–1973, their results indicated positive and statistically significant effects of each variable. Multop and Helmuth (1980) analyzed wholesale-retail price spreads. Beef carcass-to-retail margins were estimated using quarterly data for the years 1969–1978. Beef packing concentration, wage rates, interest rates, and slaughter steer price were specified as explanatory variables. Their results showed a significant positive relationship between packer concentration and the WR margin. Schroeter, Azzam, and Zhang (2000) measured market power in the wholesale beef market using monthly (1990–1997) data. They found little evidence of oligopoly power by meat packing firms but some evidence of oligopsony power by retail grocery firms.

Model Development—Specification

We develop structural inverse demand and ordinary supply functions at the retail and wholesale (processing) levels to identify the arguments expected to determine WR margins. Marketing level demands, supplies, and input costs provide the general framework to develop margin relationships (Brester and Marsh, 2001; Gardner, 1975; Holloway, 1991). Retail and wholesale inverse demand and ordinary supply functions are based on consumer and firm optimization behavior, i.e., utility maximization yielding negatively sloped primary demands, and profit maximization yielding negatively sloped input demands and positively sloped output supplies (Brester and Marsh, 2001; Varian, 1992;

Wohlgenant, 1989). Market clearing equilibriums and variable input proportions between meat output and marketing services are assumed (Azzam, 1992; Holloway, 1991; Wohlgenant, 1989). The inverse demands and supplies are expressed as follows:

Retail Sector:

(1) $P_r^d = \psi_1(Q_r^d, P_s, Y, N)$ (primary retail demand)

(2) $Q_r^s = \psi_2(P_r^s, C_L, P_w, M_c; K_r)$ (derived retail supply)

(3) $Q_r^d = Q_r^s = Q_r$ (retail quantity clearing)

(4) $P_r^d = P_r^s = P_r$ (equilibrium retail price)

Wholesale Sector:

(5) $P_w^d = \psi_3(Q_w^d, C_L, P_r, M_c; K_r)$ (derived wholesale demand)

(6) $Q_w^s = \psi_4(P_w^s, C_L, M_c, P_L, T_w; K_w)$ (derived wholesale supply)

(7) $Q_w^d = Q_w^s = Q_w$ (wholesale quantity clearing)

(8) $P_w^d = P_w^s = P_w$ (equilibrium wholesale price)

Equation (1) represents real retail demand price (P_r^d) as a function of retail per capita quantity demanded (Q_r^d), weighted real price of retail substitutes (P_s), real per capita consumption expenditures (Y), and consumer demand for new meat products/services (N). Equation (2) specifies per capita retail supply (Q_r^s) as a function of real retail supply price (P_r^s), real food labor costs (C_L), real wholesale price of meat (P_w), and real food marketing costs excluding labor (M_c). Demand for new products/services (N) is represented by output per employee hour in the retail grocery industry, and the cost of supplying new products/services is represented by labor costs in food manufacturing and retailing (C_L) (Barkema, Drabenstott, and Novack, 2001). Equation (2) also recognizes that retailers market meat within a given market structure, represented by four-firm concentration of retail grocers (K_r). Equations (3) and (4) represent retail quantity and price equilibriums.

Equations (5) and (6) represent inverse wholesale demand and supply relationships. Real wholesale demand price (P_w^d) of equation (5) depends upon wholesale per capita quantity demanded (Q_w^d), real food labor costs (C_L), real retail price (P_r), real food marketing costs excluding labor (M_c), and retail market structure or concentration (K_r). Per capita wholesale supply (Q_w^s) of equation (6) is a function of real wholesale price (P_w^s), real food labor costs (C_L), real food marketing costs excluding labor (M_c), real price of livestock (P_L), and technology at the processing level (T_w). Processing technology is measured as output per employee hour in the red meat product industries. Equation (6) indicates processors supply meat within a given market structure, represented by four-firm concentration in meat packing (K_w). Equations (7) and (8) provide wholesale quantity and price equilibriums.

Margin Relationships

Equations (1) through (8) represent the structure needed to derive wholesale-retail marketing margins for beef and pork. By definition, a WR margin is given by:

$$M_{wr} = P_r - P_w, \tag{9}$$

where M_{wr} is the wholesale-retail margin, and P_r and P_w are the respective equilibrium retail and wholesale prices given in equations (4) and (8). Using market-clearing conditions, these prices can be expressed as a function of relevant quantities and demand-supply shifter variables. Since M_{wr} is a general function of the equilibrium prices P_r and P_w, it is therefore a function of the structural demand and supply arguments. The general margin relationship is written as:

$$M_{wr} = m_1(Q_r, Q_w, P_s, Y, N, C_L, M_c, P_L, T_w, K_r, K_w). \tag{10}$$

The following modifications are made to equation (10): (*a*) because Q_r contains production information from Q_w (and the two are highly collinear), Q_r is omitted; and (*b*) because quantity supplied, Q_w, is a function of beginning stocks, domestic production, and imports, the variable is replaced by these three arguments. The separate arguments permit examining the impacts of foreign competition and inventory adjustments on marketing margins as well as the impact of domestic production. Lopez and Lopez (2001) emphasized the importance of separating imports from domestic production in such models because of differences in price-cost margins and scale economies in the processing sector. Thus, the WR margin equation used for empirical estimation in the beef and pork sectors is specified as:

$$\begin{aligned} M_{wr}^j = m_2(&Q_{wp}^j, Q_{wi}^j, Q_{wk}^j, P_s^j, Y, N, C_L, M_c, P_L^j, \\ &T_w, K_r, K_w^j, \mu^j), \quad j = b, p, \end{aligned} \tag{11}$$

where subscripts wp = wholesale production, wi = wholesale imports, and wk = wholesale stocks, and superscript $j = b$ = beef and $j = p$ = pork. Variable definitions for the beef and pork margin equations are given in table 1.

Equation (11) indicates WR margins depend upon a comprehensive set of factors including meat quantities, substitute prices, consumer expenditures, the demand for new products and services, food service labor costs, food marketing costs excluding labor, livestock procurement costs, market concentration at the retailing and processing levels, and technological change at the processing level. A random error term (μ) is added (a discussion of its properties follows). Because of biological factors involved in livestock production/finishing, dynamics are added to equation (11) by including a one-period lag on the input price of livestock (P_L).

The inclusion of the demand for value-added services (N) and the cost of these value-added services (C_L) in the margin equation permits testing the hypothesis about the effects of retail grocery productivity (N) on WR margins. First, because N is correlated with meat department productivity, then a statistically significant coefficient of N would suggest meat department productivity impacts WR margins. Second, meat departments

Table 1. Variable Definitions and Means for the Beef and Pork Margin Equations

Variables	Description	Means
M_{wr}^{b}; M_{wr}^{p}	Real wholesale-to-retail marketing margins for beef and pork, respectively (¢/lb.)	71.87; 65.52
Q_{wp}^{b}; Q_{wp}^{p}	Per capita wholesale production of beef and pork, respectively (carcass weight, lbs.)	98.88; 64.32
Q_{wt}^{b}; Q_{wt}^{p}	Per capita imports of beef and pork, respectively (carcass weight, lbs.)	0.90; 0.29
Q_{wk}^{b}; Q_{wk}^{p}	Per capita cold storage holdings of beef and pork, respectively (carcass weight, lbs.)	0.19; 0.12
Q_{L}^{c}; Q_{L}^{h}	Commercial slaughter of cattle and hogs, respectively (mil. head)	28.16; 86.63
W_{L}^{c}; W_{L}^{h}	Average liveweight of commercial cattle and hog slaughter, respectively (lbs.)	1,111.14; 246.44
P_{s}^{b}; P_{s}^{p}	Weighted real retail prices of beef and poultry, and pork and poultry, respectively (¢/lb.)	178.95; 134.23
P_{f}^{b}	Real price of feeder steers, Medium No. 1, 600–650 lbs., Oklahoma City ($/cwt)	70.53
B_{L}^{c}; B_{L}^{h}	Real farm by-product value of cattle and hogs, respectively (¢/lb.)	16.82; 6.11
Y	Real per capita personal consumption expenditures ($)	10,496.00
C_{L}	Index of food manufacturing and food retailing labor costs (1967 = 100)	327.94
M_{c}	Index of marketing costs excluding labor (1967 = 100)	284.42
P_{L}^{c}; P_{L}^{h}	Real price of Choice steers, No. 2–4, 1,100–1,300 lbs., Nebraska direct, and real price of barrows and gilts, No. 1–3, 230–250 lbs., Iowa/S. Minnesota, respectively ($/cwt)	65.20; 49.18
N	Index of output per employee hour in grocery retailing (1987 = 100)	102.43
K_{r}	Four-firm concentration ratio in grocery retailing	61.83
K_{w}^{b}; K_{w}^{p}	Four-firm concentration ratio in beef packing (all cattle slaughter) and in pork packing (all hog slaughter), respectively	42.14; 37.51

could be subsidizing value-added delicatessens and other services (C_L). Rejection of the null hypothesis of the equality of the coefficients of N and C_L would indicate grocery store productivity affects meat department pricing and WR meat margins.[1]

Data and Estimation

Annual data from 1970 to 1998 are used to estimate the beef and pork WR margins of equation (11). Domestic production, meat import and cold storage variables, WR margin variables, retail beef, pork, and poultry prices used in calculating weighted substitute prices (domestic production used as weights), and livestock (slaughter steer and hog) prices were obtained from the USDA's *Red Meats Yearbook* and various issues of the USDA's *Livestock, Dairy, and Poultry Situation and Outlook* reports. USDA's WR margin

[1] A reviewer suggested the test to determine if meat departments subsidize the costs of value-added services provided by other store departments. This is a critical issue as it could help explain why WR margins have increased even though the USDA indicates meat price data used in estimating WR margins do not reflect time-evolving value-added products or services.

for beef is calculated as a weighted average of BLS prices of retail beef cuts from Choice Yield Grade 3 carcasses less the value of wholesale quantity-equivalent beef required to produce a single pound of retail cuts. USDA's WR margin for pork is calculated as a weighted average of BLS prices of retail pork cuts from pork carcasses less the value of wholesale quantity-equivalent pork required to produce a single pound of retail cuts.

Consumer expenditures, the Consumer Price Index (CPI, 1982–84 = 100), and the population series were obtained from the *Economic Report of the President* (Congress of the U.S., Council of Economic Advisors, 2003). Food labor cost and marketing cost, excluding labor, were taken from Elitzak (1999) and USDA's *Agricultural Outlook* series. Food labor cost is calculated based on BLS data of wage rates in food manufacturing and retailing. The quantity variables and consumer expenditures were divided by population, while WR margins, prices, consumer expenditures, food labor cost, and other marketing costs were deflated by the CPI.

Meat processing technology is represented by output per employee hour in the red meat products industry (processing level), and retail grocery productivity (a proxy for the demand for food services) is represented by output per employee hour in grocery retailing. Both variables were obtained from the U.S. Department of Labor's *Monthly Labor Review*.

Four-firm concentration ratios for beef and pork packing (slaughtering) were taken from Nelson (1985) and USDA's *Packers and Stockyards Statistical Report* for 2001. Four-firm concentration ratios for grocery retailing were obtained from Kaufman, Newton, and Handy (1993) and from Cotterill (1999). Kaufman, Newton, and Handy estimated their concentration ratios based on multiple SMSAs and constant group (173) SMSAs. Cotterill estimated the retail concentration ratios based on constant group (94) SMSAs.[2] Observations for this variable were only reported for interval years of 1954, 1958, 1963, 1967, 1972, 1977, and 1982 (Kaufman, Newton, and Handy), and 1987 and 1998 (Cotterill). Therefore, we estimate concentration ratios for the missing years using linear interpolation between the observed data points.

The dependent variables and many of the independent variables of the margin model were nonstationary as determined by the augmented Dickey-Fuller (ADF) unit root test. However, the ADF test of the margin equation residuals (OLS) rejected the null hypothesis of nonstationarity, indicating the WR margin equations were cointegrated. Thus, the model was estimated with data in levels (Johnston and DiNardo, 1997).

The Hausman specification test was applied to domestic production, imports, stocks, and retail substitute prices in the beef and pork margin equations. Results of the Hausman test failed to reject the null hypothesis of exogeneity at the $\alpha = 0.05$ level for any of the variables in both margin equations.

The disturbance terms of each margin equation were assumed to have zero means and constant variance; however, their time-series properties could cause them to be autocorrelated (Greene, 2000). Contemporaneous correlations may occur because of cross-effects between margins, i.e., substitute relationships between beef and pork, or cost and technology sharing between the meat sectors (Hahn and Green, 2000). In addition, a common misspecification in both equations could occur (Johnston and DiNardo, 1997).

[2] The published four-firm concentration ratios (percentages) by Kaufman, Newton, and Handy (1993) for the constant group SMSAs were: 1958 = 48.7, 1963 = 49.4, 1967 = 50.2, 1972 = 52.2, 1977 = 56.4, and 1982 = 57.8. The four-firm concentration ratios (percentages) published by Cotterill (1999) were 1987 = 64.5 and 1998 = 74.4. There appears to be a larger jump from the 1982 to 1987 interval than experienced in the previous five-year intervals. However, the series is quite linear.

As a result of the above tests and assumptions, the model is estimated by iterative seemingly unrelated regressions (ITSUR) using the Quantitative Micro Software (*EViews* 3.1) software program. Because of the inclusion of AR error terms, the model is estimated using a nonlinear, iterative generalized least squares (GLS) algorithm. The equations are estimated in double-log form with the estimated coefficients interpreted as elasticities.

Empirical Results

General Issues

Results of the ITSUR margin model are given in table 2. The beef and pork margin equations were initially corrected for AR(1) error structures. The adjusted R^2s are 0.79 for beef and 0.92 for pork, and the respective standard errors of the margin equations are 4.2% and 8.5%. However, these statistics require careful interpretation since transformation of the margin equations (due to contemporaneously correlated errors) yields measures of fit that are purely descriptive (Greene, 2000, pp. 467, 618). The asymptotic t-ratios show most system variables are statistically significant, i.e., 19 of the 26 parameter estimates are significant at the $\alpha = 0.10$ level or better.

Meat Quantities, Substitutes, and Consumer Expenditures

For the WR beef margin equation, imports and stocks are positive and statistically significant. For the WR pork equation, production and imports are positive and statistically significant. The positive margin effect of pork production suggests increases in pork production increase the costs of marketing services (Tomek and Robinson, 1990). Although the beef and pork import coefficients are positive, positive or negative import impacts on price-cost margins are theoretically plausible depending upon price elasticities of demand (Lopez and Lopez, 2001). If derived wholesale demand is more inelastic than retail demand, increases in imports (additions to supply) would increase the margin. The margin could also increase if meat imports require relatively more processing than domestic meat. Note that cold storage holdings (stocks) also involve added costs, and therefore could increase margins. The cross-effects of weighted retail prices are not significant in the beef equation but are significant in the pork equation. Hahn and Green (2000) estimated a system of equations representing wholesale-retail margins of beef, pork, and poultry meats, and found all cross-price effects to be insignificant.

Consumer expenditure elasticities are negative and significant in both equations. Both coefficients are relatively elastic (−1.81 and −1.97 for beef and pork, respectively). Increases in food expenditures are likely manifest in additional meat consumption at away-from-home eating establishments (Schrimper, 2001). Thus, increases in per capita expenditures may cause consumers to substitute away from meat purchased at grocery stores toward meat consumed at eating establishments. Given that WR margins are actually measures of differences between wholesale prices and retail grocery store prices, increases in consumer expenditures may reduce WR marketing margins.

Table 2. Regression (ITSUR) Results of Wholesale-Retail Margins for Beef and Pork (double-logs)

	WR Margin Equations	
Regressors / Statistics	Beef Margin	Pork Margin
Constant	8.965	-2.683
	(1.744)	(-0.381)
Production (Q_{wp})	0.338	0.597
	(1.342)	(2.259)
Imports (Q_{wi})	0.453	0.267
	(4.421)	(2.415)
Stocks (Q_{wk})	0.339	-0.145
	(4.367)	(-1.485)
Substitutes (P_s)	0.068	0.564
	(0.616)	(1.905)
Expenditures (Y)	-1.810	-1.969
	(-4.095)	(-2.394)
Labor Cost (C_L)	0.654	1.634
	(1.975)	(2.376)
Retail Productivity (N)	-1.734	-4.568
	(-3.679)	(-4.622)
Technology Meats (T_m)	0.870	0.858
	(3.053)	(1.787)
Retail Concentration (K_r)	2.040	4.857
	(4.762)	(2.776)
Packer Concentration (K_w)	-0.019	-0.091
	(-0.167)	(-0.356)
Marketing Cost (M_c)	-0.407	0.237
	(-3.518)	(0.841)
Slaughter Price (P_{L-1})	0.216	0.471
	(1.922)	(4.560)
Adjusted R^2	0.794	0.916
Standard Error of Regression	0.042	0.085

Notes: Numbers in parentheses are asymptotic t-values. Critical t-values at the $\alpha = 0.10$ and $\alpha = 0.5$ levels are 1.703 and 2.052, respectively (27 degrees of freedom). Degrees of freedom are $mn - k$, where m = number of equations, n = number of observations, and k = number of parameters estimated.

Labor Costs and Productivity

Food labor costs are significant in both margin equations. The positive coefficients are theoretically consistent, indicating that increased input costs of value-added services widen marketing margins (Tomek and Robinson, 1990). The coefficient is relatively larger for pork (1.63), perhaps reflecting more extensive processing and product differentiation of pork products relative to beef products (MacDonald et al., 2000). The labor cost elasticity for beef (0.65) is slightly larger than the wage rate elasticity (0.40) in the WR beef margin reported by Hall, Schmitz, and Cothern (1979).

The labor productivity variables for meat processing and grocery retailing were significant but had opposite margin effects. Output per employee hour has increased in red meat processing, while output per employee hour has declined in grocery retailing—the latter likely reflecting increased demand for labor-intensive marketing services. The empirical results reject the null hypothesis of zero impacts of retail grocery productivity (representing demand for value-added products and services) on beef and pork WR margins. The marginal impacts are negative, indicating that reductions in retail labor productivity have increased WR red meat margins. The estimated coefficients are elastic, i.e., -1.73 for the beef margin equation and -4.57 for the pork margin equation. Moreover, these coefficients are statistically different from the respective beef and pork food labor cost coefficients of 0.65 and 1.63, suggesting retail grocery productivity does affect meat departments. This effect can be in the form of meat departments subsidizing value-added services or changing productivity within meat departments. Cotterill (1999) notes that labor productivity and management ability are critical components of price-cost markups and prices charged to consumers. Our empirical results imply retailers pass changes in grocery store productivity on to consumers and wholesaler/processor suppliers of meat products.

As stated, WR beef and pork margins are also significantly affected by labor productivity (technology) in meat processing. The elasticity coefficients are positive and about equal, 0.87 for beef and 0.86 for pork. In the price discovery process, meat packers and processors have a more direct impact on wholesale prices than on retail prices. Therefore, a positive effect of meat processing technology on WR margins could be the result of reducing wholesale (boxed) beef and pork prices due to cost savings.

Market Concentration

The estimated coefficients of retail grocery concentration are positive and significant for both beef (2.04) and pork (4.86), indicating WR margins widen with increased market concentration. Cotterill (1999) found retail food prices increased as local supermarket concentration increased in Connecticut and Pennsylvania. Hall, Schmitz, and Cothern (1979) also found positive effects of food grocery market concentration on beef WR margins; however, the elasticity coefficient was much smaller (0.40).

These previous studies attribute positive relationships between retail food prices and retail market concentration to the exercise of market power. Yet, the effect of meat packer concentration on both WR margins was not statistically significant. Other studies have concluded meat packers exercise little oligopoly power in the wholesale market (Ward, 2002). However, Multop and Helmuth (1980) estimated beef carcass-retail margins and found a positive relationship between meat packer concentration and the WR margin. They concluded that packer market power extended to the retail sector in terms of higher prices, and thus caused wider margins.

Marketing Costs and Livestock Prices

Marketing costs (other than labor) were significant in the beef WR margin equation, but not in the pork WR margin equation. Increases in these costs are expected to widen the margins; thus, the negative coefficient (-0.41) for beef appears contrary to theoretical reasoning. Livestock prices are major input costs in packer production of boxed beef. Lagged livestock prices in both equations are positive and significant, indicating increases in these input costs increase beef and pork WR margins.

Table 3. Effects of Changes in Selected Retail Variables on Beef and Pork Margins and Livestock Prices, 1987–1998

	Exogenous Variables				
Endogenous Variables	Grocery Productivity (N)	Food Labor Cost (C_L)	Consumer Expenditures (Y)	Retail Concentration (K_r)	Meat Technology (T_m)
Beef Margin (M_{wr}^{b})	13.5%	-3.6%	-31.9%	31.2%	2.0%
	(0.89¢/lb.)	(-0.24¢/lb.)	(-2.11¢/lb.)	(2.06¢/lb.)	(0.13¢/lb.)
Steer Price (P_L^{c})	-8.1%	2.1%	19.2%	-18.7%	-1.2%
	(-\$1.82/cwt)	(\$0.49/cwt)	(\$4.32/cwt)	(-\$4.22/cwt)	(-\$0.27/cwt)
Pork Margin (M_{wr}^{p})	35.6%	-9.0%	-34.7%	74.3%	2.0%
	(6.48¢/lb.)	(-1.64¢/lb.)	(-6.32¢/lb.)	(13.5¢/lb.)	(0.36¢/lb.)
Hog Price (P_L^{h})	-5.7%	1.5%	5.5%	-11.8%	-0.32%
	(-\$1.48/cwt)	(\$0.37/cwt)	(\$1.44/cwt)	(-\$3.08/cwt)	(-\$0.08/cwt)

Notes: Table entries represent changes in WR margins and livestock prices ("Endogenous Variables" column) due to 1987–1998 changes in the variables given under "Exogenous Variables" columns. The top entries in each row are in percentages, and the bottom entries are in cents per pound (for margins) and in dollars per hundredweight (for prices). The changes in the exogenous variables from 1987–1998 were as follows: $N = -7.8\%$, $C_L = -5.5\%$, $Y = 17.6\%$, $K_r = 15.3\%$, and $T_m = 2.3\%$. During this period, the WR beef margin increased by 9.5% (or 6.6¢/lb.), and the WR pork margin increased by 25.7% (or 18.2¢/lb.).

Changes in Retail Labor Productivity and Food Labor Costs

The significant coefficients of retail labor productivity (demand for new products and services) and food labor costs (costs of new product and services) are important aspects of the empirical results. Given recent data trends, the impacts of these variables (and others following) on beef and pork margins can be estimated (table 3). For example, from 1987 to 1998, output per employee hour in the retail grocery sector decreased by 7.8%, and real food labor costs decreased by 5.5%. Concurrently, real beef and pork WR margins increased by 9.5% (6.6¢/lb.) and 25.7% (18.2¢/lb.). Based on our elasticity estimates, reduced labor productivity increased the beef margin by 13.5% (0.89¢/lb.), and reduced labor costs decreased the beef margin by 3.6% (0.24¢/lb.). Similarly, declining retail grocery productivity and food labor costs respectively increased the pork margin by 35.6% (6.5¢/lb.) and decreased the pork margin by 9% (1.6¢/lb.).[3] Thus, the net effect of these value-added demand and supply components was to increase the WR beef margin by 9.9% (0.65¢/lb.) and the WR pork margin by 26.6% (4.9¢/lb.).

Changes in Market Concentration and Processing Technology

Retail grocery concentration and meat processing technology have experienced similar trends. For example, from 1987–1998, retail grocery concentration increased by 15.3%

[3] For example, the impact of retail labor productivity on the pork margin is: (*a*) the retail product and service costs coefficient (-4.568) multiplied by the 7.8% reduction in labor productivity = a 35.6% increase in the pork WR margin, and (*b*) 35.6% multiplied by 18.2¢/lb. increase in the margin = 6.5¢/lb. These calculations are made ceteris paribus. That is, while reductions in labor productivity caused relatively large increases in the margins, other factors in the model caused reductions in the margins.

and processing technology increased by 2.3%. Thus, retail concentration contributed to an increase in the WR beef margin of 31.2% (2.06¢/lb.) and an increase in the WR pork margin of 74.3% (13.5¢/lb.) (table 3). The retail concentration effects on WR margins clearly dominate the net effects of retail grocery productivity and food labor wages, which emphasizes the importance to meat producers of retail grocery mergers and acquisitions. This is particularly so since meat packer concentration did not significantly affect WR beef and pork margins.

Meat processing technology was expected to be an important determinant of WR meat margins because value-added meat products also emanate from processors (i.e., retail-ready meat products). Based on the elasticity coefficients, the 2.3% increase in meat technology increased the WR beef margin by 2% (0.13¢/lb.) and the WR pork margin by 2% (0.36¢/lb.) (table 3). Thus, these cost savings apparently reduce wholesale prices but reduce retail prices less so.

It is important to note that several variables partially offset factors which increase the WR meat margins. Paramount is real per capita consumer expenditures, which increased by 17.6% from 1987–1998 (table 3). Based on the elasticity coefficients (-1.81 for beef and -1.97 for pork), the WR beef margin decreased by 31.9% (2.1¢/lb.) and the WR pork margin decreased by 34.7% (6.3¢/lb.) from 1987–1998.

WR Margins and Livestock Prices

Livestock producers have a vested interest in marketing margin behavior because of the potential impacts on farm prices. That is, economic factors determining WR margins affect wholesale (boxed) meat prices, and consequently meat packer demand for cattle and hogs. Assuming livestock supplies are predetermined (due to biological factors), a general inverse demand model for live cattle or hogs is given by:

$$(12) \qquad P_L^{dj} = f_1(Q_L^{dj}, W_L^{dj}, B_L^j, M_{wr}^j, e^j) \qquad \text{(inverse demand)}$$

$$(13) \qquad Q_L^{sj} = \text{predetermined} \qquad \text{(supply)}$$

$$(14) \qquad Q_L^{dj} = Q_L^{sj} = Q_L \qquad \text{(market clearing quantities)}$$

$$(15) \qquad P_L^{dj} = P_L^{sj} = P_L, \quad j = c, h \qquad \text{(market clearing prices)}$$

where $j = c$ = cattle and $j = h$ = hogs. Variable definitions are provided in table 1. Equation (12) indicates inverse livestock demand (P_L^d) depends upon quantity of slaughter livestock demanded (Q_L^d), average livestock weights demanded (W_L^d), by-product values (B_L), and the wholesale-retail margin (M_{wr}). A priori, an exogenous increase (decrease) in M_{wr} is expected to decrease (increase) derived livestock demand and prices (Tomek and Robinson, 1990). Note that information related to marketing costs, retail demand, processing technology, etc., normally expected to impact derived demand is subsumed in the WR margin variable. The error term (e^j) is assumed to have zero mean and constant variance, but may be autoregressive and contemporaneously correlated (Greene, 2000). Because of rigidities in livestock price adjustments at the farm level, dynamics can be included in equation (12) by including a lagged dependent variable (Marsh, 2001).

The comparative statics of equation (12) permit calculating the effects of retail factors on livestock prices. For example, the effect of a 1% increase in retail grocery productivity (N) on farm demand price would be (using logarithms):

$$\frac{\partial \ln(P_L^d)}{\partial \ln(N)} = \frac{\partial \ln(M_{wr})}{\partial \ln(N)} * \frac{\partial \ln(P_L^d)}{\partial \ln(M_{wr})}, \tag{16}$$

which states that the percentage change in livestock demand price (P_L^d) due to a 1% increase in retail grocery productivity (N) is equal to the percentage change in the WR margin due to a 1% increase in N (first right-hand-side term) multiplied by the percentage change in P_L^d due to the percentage change in M_{wr} (second right-hand-side term). In this case, the retail impact on farm price assumes a zero supply response and a unidirectional flow from the WR margin to inverse derived demand.

Cattle and hog prices represented in equation (12) are jointly estimated by iterative three stage least squares (IT3SLS). The estimator allows for the endogeneity of M_{wr}^j and W_L^{dj} in the inverse demand equations and for contemporaneously correlated errors. The data are estimated in levels using a double-log model.

The IT3SLS regressions are presented in table 4. Variable definitions are given in table 1. The equations were initially estimated as a Koyck model with first-order lags on the dependent variables and corrections for AR(1) errors. However, average weight of hogs was highly collinear with several regressors, and lagged slaughter hog price was not statistically significant. Upon omitting these two variables, all remaining variables are significant at the $\alpha = 0.05$ level.

Our focus is on the relationship between WR meat margins and cattle and hog prices. Results show margins demonstrated the expected negative effects in both price equations. In the cattle price equation, a 1% increase in the WR margin decreases cattle price by 0.38%. In the hog price equation, a 1% increase in the WR margin decreases hog price by 0.16%. Long-run estimates for the cattle price equation are obtained by dividing each short-run elasticity by one minus the difference equation coefficient (Nerlove and Addison, 1958, p. 874). Thus, a 1% increase in beef WR margin reduces cattle price by 0.6%. The smaller pork coefficients indicate less sensitivity of farm price to WR margin changes, which could reflect the substantial vertical coordination and contract production that has evolved in the pork industry.

The estimated coefficients of equation (12) are used in equation (16) to determine the impacts of WR margins on livestock prices. Of particular interest are the farm price effects of retail grocery concentration and productivity, meat processor technology, and consumer expenditures (table 3). USDA data show, from 1987 to 1998, real slaughter cattle and hog prices declined by \$22.54/cwt (35.4%) and \$26.02/cwt (57.3%), respectively. Based on the long-run elasticities, table 3 indicates farm prices of cattle and hogs were negatively impacted both by increased retail grocery concentration and decreased retail grocery productivity. For example, increased retail grocery concentration decreased cattle and hog prices by \$4.22/cwt (18.7%) and \$3.08/cwt (11.8%), respectively. Decreased retail grocery productivity decreased cattle and hog prices by \$1.82/cwt (8.1%) and \$1.48/cwt (5.7%), respectively.

Relative to the retail sector, smaller negative effects were caused by increases in meat processing technology. Increases in meat processing technology tended to increase WR meat margins. It appears meat processor cost savings were passed on to purchasers of

Table 4. Regression (IT3SLS) Results for Beef and Pork Slaughter Prices

	Slaughter Equations	
Regressors / Statistics	Cattle Price	Hog Price
Constant	17.257	9.706
	(7.150)	(9.428)
WR Margins (M_{wr})	-0.383	-0.159
	(-4.917)	(-2.055)
Slaughter Quantity (Q_L)	-0.970	-1.361
	(-5.769)	(-6.419)
Average Weight (W_L)	-1.552	
	(-5.629)	
By-products (B_p)	0.404	0.494
	(11.689)	(7.841)
Dependent – 1 (P_{L-1})	0.364	
	(6.851)	
Adjusted R^2	0.985	0.974
Standard Error of Regression	0.032	0.061

Notes: Numbers in parentheses are asymptotic t-values. Critical t-values at the $\alpha = 0.10$ and $\alpha = 0.5$ levels are 1.684 and 2.021, respectively (44 degrees of freedom). Degrees of freedom are $mn - k$, where m = number of equations, n = number of observations, and k = number of parameters estimated. Dependent – 1 is the first-order lag on the dependent variable.

wholesale meat products through price reductions. Ceteris paribus, reductions in wholesale meat prices translated into lower livestock prices.

Increased consumer expenditures and decreased real food labor costs supported livestock prices during this period. The effects of consumer expenditures were particularly robust in the beef industry, increasing cattle price by $4.32/cwt (19.2%), thereby offsetting some of the negative impacts of retail concentration and productivity. Expenditure increases also increased hog prices by $1.44/cwt or 5.5%, but only partially offset retail concentration and productivity effects. The decrease in food labor costs supported steer and hog prices by $0.49/cwt and $0.37/cwt, respectively (table 3).

Conclusions

Results of our econometric model reveal that multiple factors affect real wholesale-retail margins in the beef and pork sectors. In turn, WR margins significantly affect meat packer demand, and hence prices of live cattle and hogs. Real cattle and hog prices are more affected by factors at the retail grocery level than factors at the meat-packing level. Specifically, increased retail grocery concentration and declining retail grocery productivity (demand for new products and services) significantly increased real WR margins and reduced real livestock prices. Meat processing technology played a relatively small role, and meat packer concentration had an insignificant effect on WR margins and livestock prices. Other factors caused lower WR margins and higher livestock prices, particularly the increase in consumer expenditures. Overall, when evaluating the effects of upstream factors on livestock prices (ignoring demand and supply factors at the farm and finishing levels), increased retail grocery store concentration was responsible for 19% of the decline in cattle prices from 1987 to 1998. Reductions in retail grocery store productivity were responsible for 8% of declines in cattle prices over the same period. Increased retail concentration and reductions in retail productivity were responsible for 12% and 6% of the reductions in hog prices from 1987 to 1998.

Consumers are generally demanding better food quality, improved food safety, more food services, and more diverse (value-added) products, while meat processors and retailers incur additional costs to meet these demands. For example, the ratio of food labor wages to retail grocery store productivity increased by about 6% over the sample period. This finding suggests livestock producers would benefit (price-wise) from new value-added products/services if consumers also demand more farm-based components in final retail products. Our model shows that increasing consumer expenditures decrease WR margins and increase farm prices.

The negative impact of retail grocery concentration warrants a caveat. Ceteris paribus, the model indicates increased retail grocery concentration reduced real cattle and hog prices. The concentration effect could be interpreted as anti-competitive and/or collusive behavior among firms within the retail grocery industry. Conversely, retail grocery stores have become larger to take advantage of distribution and labor efficiencies, and to compete with national store chains. Increased size may allow firms to better negotiate with input suppliers—i.e., larger retailers often note they are able to offer consumers lower prices because of their ability to purchase large volumes or secure lower prices from suppliers. Our model is unable to distinguish which of these effects occur within the retail grocery sector. Clearly, this issue represents an important future research endeavor.

Finally, it should be remembered that retail grocery concentration data were not reported for each sample-period year, thus requiring interpolation. Moreover, our study is national in scope, which can mask local and regional concentration impacts.

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