Journal of Agricultural and Resource Economics 34(2):213–236

Evaluating the Farmer's-Share-of-the-Retail-Dollar Statistic

Gary W. Brester, John M. Marsh, and Joseph A. Atwood

Conventional wisdom appears to support the thesis that declines in USDA's farmer's-share-of-the-retail-dollar (FS) statistics are indicators of low returns to agricultural production. We estimate changes in cattle and hog FS statistics and their relationship with producer surplus (PS) for changes in various exogenous factors. The method accounts for correlations among structural parameter estimates while simulating multivariate distributions of joint parameter realizations. The simulations indicate that relationships between FS and PS depend on the source of exogenous shocks. The lack of informational content in FS statistics suggests these data should not be used for policy purposes.

Key words: farmer's share of the retail dollar, marketing margins, producer surplus, total response elasticities

Introduction

> *The established method of reporting farmer's share and* [*price*] *spread as a percentage of the consumer's food dollar has contributed to a wide misunderstanding of the true economic relation of agriculture to food processing and distribution. It has made them appear as competitors for a fixed value, rather than as partners in the production of greater value.* — Atchley (1956, pp. 1577–1578)
>
> *Now, I am not calling for government action on this particular matter, but I just want to point out that the farmer's share of the retail dollar paid for red meat has fallen substantially. Since 1970 the farmer's share of the retail price of beef has fallen from 64 percent to 49 percent, while for pork the farmer's share has fallen from 50.5 percent to 34.8 percent.* — Hon. Senator Tom Harkin (June 10, 1998)

Farmer's-share-of-the-retail-dollar (FS) statistics represent the value of raw agricultural commodities as a proportion of consumer at-home food expenditures. The U.S. Department of Agriculture (USDA) calculates FS statistics for a broad range of agricultural commodities. As Brester (2006) notes, conventional wisdom often considers FS statistics (and their counterparts, marketing margins) as proxies for farm/ranch profitability and producer welfare. Furthermore, some have argued that decreases in FS statistics (and, by construction, increases in farm-to-retail marketing margins) are indicators of anti-competitive behavior in the food processing industry (Taylor, 2002; USDA, 2000).

Gary W. Brester, John M. Marsh (retired), and Joseph A. Atwood are professors, all in the Department of Agricultural Economics and Economics, Montana State University. We greatly appreciate the comments provided by Michael Boland, James Brown, and Vincent Smith on earlier drafts, the research assistance of Fritz Baird, the contributions of William Baumgartner, and the efforts of the reviewers and editor.
Review coordinated by George C. Davis.

Agricultural economists have long noted that such relationships cannot be justified on theoretic grounds (Atchley, 1956). For example, Tomek and Robinson (1972) cautioned:

> The per unit margin (farm-retail spread) statistics and especially the related concept of the farmer's share of the consumer's dollar are subject to misinterpretation. This concept is perhaps the most frequently quoted, but misused, number published by the USDA. There is a tendency to use the number to indicate the 'well-being' of farmers or to indicate that marketing costs are 'too high.' In fact, the farmer's share statistic has little to say about either problem (pp. 115–116).

Nonetheless, FS statistics (and farm-retail marketing margins) continue to be misused by economists and policy makers in judicial proceedings, legislative actions, and agricultural policy debates. For example, reductions in the FS beef statistic (and associated increases in farm-wholesale beef marketing margins) was a focus of expert economic testimony for the plaintiffs in *Pickett et al. v. Tyson Fresh Meats, Inc.* (2004) who sought damages allegedly caused by anti-competitive behavior in the beef packing industry. U.S. Senate Committee Field Hearings on 2007 Farm Bill legislation generated many references to declining FS statistics as an indication of anti-competitive behavior by food processors. In particular, the president of the Colorado Independent Cattle Growers testified that "The impact of packer concentration and abusive contracting practices is evident in the declining share of each beef retail dollar that actually reaches cattle ranchers. The actual share of each retail dollar earned on beef was 47 cents in 2005, down from 56 cents in 1993" (Zalesky, 2007). In terms of legislative actions, reductions in FS statistics were presented as reasons for concern regarding food processing concentration to the U.S. Senate Committee on Agriculture, Nutrition, and Forestry (U.S. Senate, 2004; Nelson, 2007). Furthermore, declines in FS statistics have been offered as a rationale for continued or increased agricultural subsidies (*Food Systems Insider*, 2007).

The widespread misuse of FS statistics is curious given that economic theory provides no support for their use as a proxy for producer welfare. In addition, the USDA clearly indicates that its farmer's share data "… do not measure farm profitability or income" (USDA/ERS, 2008). One reason for the inappropriate use of these metrics may be that relationships between FS statistics, marketing margins, and producer surplus (PS) have not been empirically established (Brester, 2006). While the abuse of FS statistics and marketing margins transcends most agricultural commodities, the most publicized have occurred with respect to legislative and judicial actions related to the cattle and hog processing sectors.

This study constructs joint empirical distributions of changes in FS statistics and farm-level producer surplus measures. The joint distributions are generated from a dynamic structural model of U.S. beef and pork markets. The structural model is used to estimate changes in long-run prices and quantity equilibria resulting from various exogenous shocks. The methodology is robust as it accounts for correlations among estimated structural parameters and is flexible in that it allows for the imposition of theory-based parametric inequality restrictions.

Background

FS statistics are a product of the Agricultural Marketing Act of 1946. The Act directed the USDA to measure, analyze, and disseminate farm-to-retail price spread data (Elitzak, 1999). These data were presumed to be useful to consumers, producers, and policy makers for evaluating the effects of changes in industry costs, profit margins, and productivity on food prices and the economic well-being of agricultural producers. An FS statistic for a specific commodity is readily calculated as:

$$(1) \qquad FS_i = \left[(P_{fi} * C_i) - B_i \right] / P_{ri} \,,$$

where P_{fi} is the farm-level price of commodity i, C_i is a commodity-specific conversion factor that represents the amount of farm-level quantity needed to produce one unit of retail product, B_i is a commodity-specific by-product value, and P_{ri} is the retail-level price of commodity i. FS statistics are computed assuming fixed factor input proportions.

As illustrated by figure 1, between 1913 and 2006, the FS statistics for all U.S. agricultural commodities and for meat products have trended downward (Been, 1949; USDA/ERS, 2007). This downward trend has often been used as evidence of a general decline in the standard of living of agricultural producers. The FS statistic for meat products reached a peak of 74% in 1945, but was only 33% in 2006. Figure 1, however, also illustrates that over this same time period, real per farm net income has trended upward. Thus, FS statistics may not always be positively correlated with producer surplus, and consequently may not be reasonable indicators of producer well-being.

FS statistics and their counterparts, marketing margins, also provide little or no indication of imperfect competition/marketing power in the food processing industry. For example, refined beet sugar is essentially the same product today as it was 75 years ago. During the 1960s, all beet sugar refineries were owned and operated by investor-held firms. The FS statistic for sugar beet producers averaged 52% over those 10 years.[1] Over the past 40 years, the ownership of sugar beet refineries has changed such that farmer-owned cooperatives currently control almost all refining capacity. Yet, the FS statistic for sugar beets has displayed a statistically significant downward trend and, in the past 10 years, has averaged 33%. In addition, although the U.S. sugar industry is highly protected by tariff-rate quotas, rivalry among sugar beet processing firms in the output market remains intense even as the farm-retail marketing margin has widened (Brester and Boland, 2004).

Figures 2 and 3 illustrate relationships between FS statistics and producer surplus and provide background for the research methodology. Figure 2 shows the relevant market linkages for a vertical, two-sector model of the beef (and synonymously, pork) marketing chain. The industry is separated into a slaughter (i.e., farm) sector and a retail sector. To simplify the illustration, fixed input proportions between slaughter cattle and marketing services are assumed in these figures. The retail sector is comprised of consumer demand for beef (D_r) and the supply of beef (S_r) offered by retailers. The "farm" sector is represented by beef packing plants' demand for slaughter cattle (D_f), and the supply of slaughter cattle (S_f) by feedlots. The intersection of demand and supply at each level determines relative market-clearing prices (P_r) and (P_f) and market-clearing quantity (Q_0). The difference in equilibrium prices ($P_r - P_f$) represents the "farm"-retail price spread or marketing margin (M_0).

The relationship between changes in FS statistics and changes in producer's surplus depends upon the source of exogenous shocks (Gardner, 1975; Marsh and Brester, 2004; Wohlgenant, 1989). Figure 2 illustrates the effects of an increase in the cost of labor on the

[1] FS statistics for sugar beets were developed using average annual U.S. prices received for sugar beets, annual U.S. sugar extraction rates, average annual U.S. sugar processor by-product credits for the years 1981–1992 (the period for which data were available), and average U.S. retail refined sugar prices.

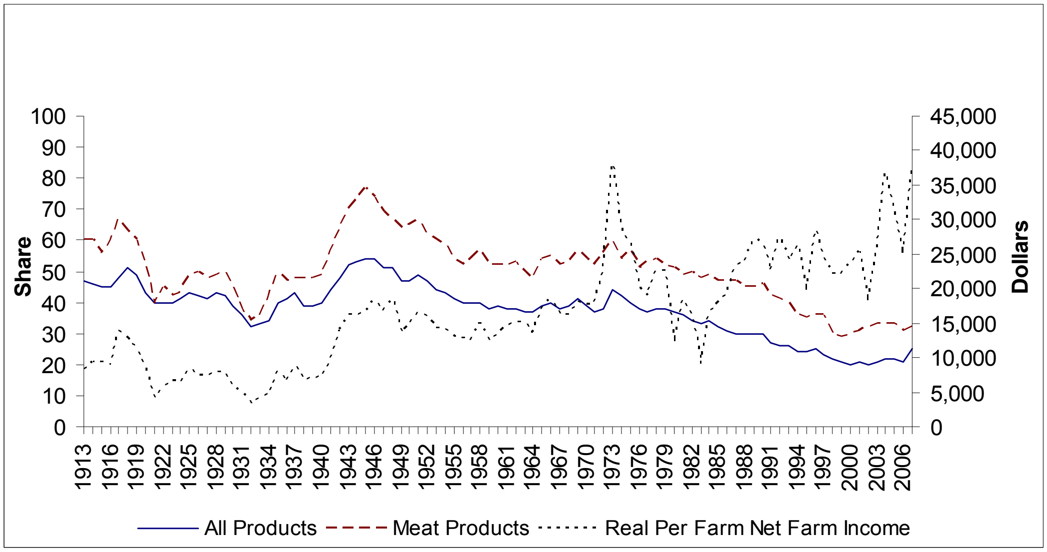

Figure 1. Farmer's-share-of-the-retail-dollar statistic for all agricultural products, meat products, and real (2000) per farm net farm income, 1913–2006

beef (pork) industry. This cost increase, represented by a shift of the derived supply for beef from S_r to $S_r^{'}$, generates a new equilibrium retail price ($P_r^{'}$), slaughter price ($P_f^{'}$), and quantity (Q_1). The new, larger marketing margin is represented by M_1. In this case, the FS statistic would decline because the lower slaughter price is necessarily a smaller percentage of the higher retail price. In addition, producer surplus would obviously decline from area (A + B) to area B as slaughter cattle price and quantity decline. Thus, an increase in the cost of labor increases the marketing margin and reduces both the FS statistic and producer surplus.

Figure 3 illustrates the effects of an increase in consumer demand from D_r to $D_r^{'}$ in the beef sector. In this case, the derived demand for slaughter cattle increases from D_f to $D_f^{'}$. Retail prices, farm prices, and quantities all increase. Given the relative elasticities used to construct figure 3, the marketing margin increases from M_0 to M_1 and, because the retail price increases proportionally more than the slaughter price, the FS statistic declines. However, farm-level producer surplus increases from area A to area (A + B). Thus, an increase in consumer demand increases the marketing margin, reduces the FS statistic, but increases producer surplus.

Ultimately, changes in farm-level producer surplus, marketing margins, and FS statistics depend upon supply and demand elasticities and the size and source of shocks to the marketing chain (Gardner, 1975; Marsh and Brester, 2004; Wohlgenant, 1989). Specifically, marketing margins are accounting residuals representing differences in prices between marketing levels. Such price differences exist (and change) because of the aggregate buying and selling behavior of firms who provide a wide variety of marketing services. Hence, marketing margins represent an arithmetic compilation of the costs of a broad range of economic activity that occurs between farm gates and consumer plates.

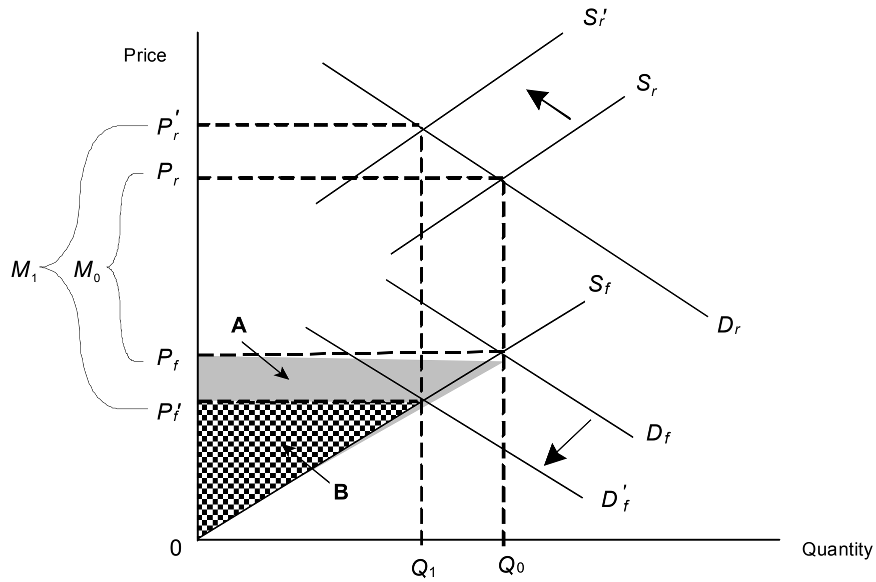

Figure 2. Effects on the marketing margin and producer surplus from an increase in food processing labor costs

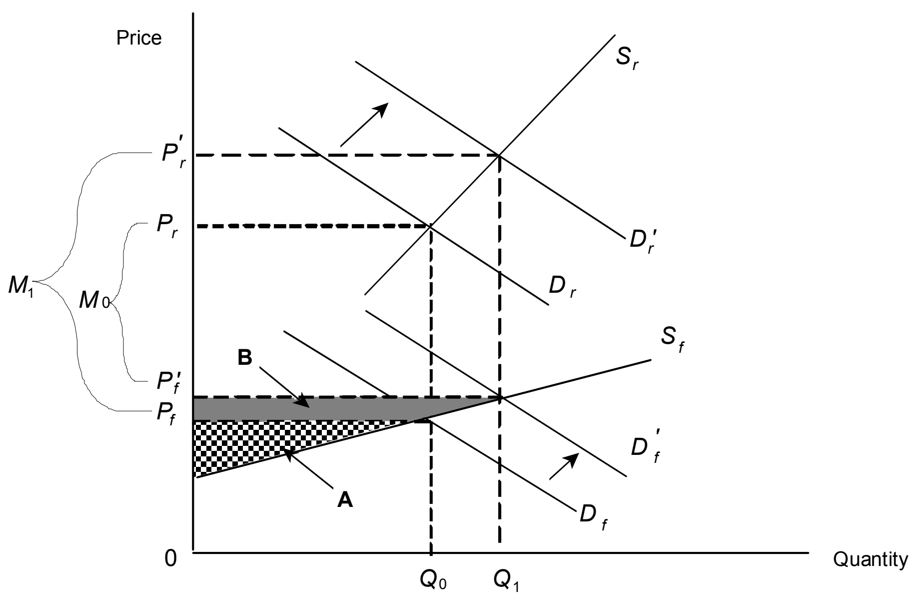

Figure 3. Effects on the marketing margin and producer surplus from an increase in retail demand

Research Strategy

In this study, the relationship between the FS statistics and producer surplus cannot be written as a closed-form solution. Therefore, we use simulation procedures to investigate the relationship between these two measures by empirically generating their joint distribution.

We first estimate the parameters of a dynamic specification of the beef and pork industries with data transformed by natural logarithms. The estimates represent short-run elasticities and price flexibilities. Using the covariance of these estimates, we generate 1,000 vectors of correlated short-run elasticities and flexibilities. Each vector is used to compute long-run (or steady-state) total response elasticities and flexibilities. The long-run estimates are used to compute 1,000 changes in long-run retail and farm prices, and 1,000 beef and pork FS statistics. Finally, 1,000 associated changes in producer surplus measures for beef and pork are calculated using linear approximations of farm-level supply functions.

A Structural Model of the Beef and Pork Sectors

A structural model is specified for the beef and pork sectors and consists of inverse demands at the retail (primary) and slaughter (derived) levels and ordinary supplies at the slaughter (primary) and retail (derived) levels. Consequently, the model is represented by eight equations (supply and demand functions for both beef and pork at the retail level, and supply and demand functions for both cattle and hogs at the slaughter level). The structural model considers vertical relationships based on farm-retail price spread theory (Gardner, 1975; Marsh and Brester, 2004; Tomek and Robinson, 1972; Wohlgenant, 1989). The maintained hypothesis includes competition and equilibrium conditions at the market levels and variable input proportions between farm output and marketing inputs (Azzam, 1992; Brester and Marsh, 2001; Holloway, 1991; Wohlgenant, 1989). Cross-equation symmetry restrictions are not imposed because the model encompasses different market levels (Marsh, 2007).

The following equations represent inverse demands and ordinary supplies at the retail and slaughter (farm) levels:

Retail Level

(2) $P_B^r = f_1(Q_B^r, P_K^r, P_Y^r, P_M^r, Y) + \mu_1$ (primary beef demand),

(3) $Q_B^r = f_2(P_B^r, FC, Q_C^s) + \mu_2$ (derived beef supply),

(4) $P_K^r = f_3(Q_K^r, P_B^r, P_Y^r, P_M^r, Y) + \mu_3$ (primary pork demand),

(5) $Q_K^r = f_4(P_K^r, FC, Q_H^s) + \mu_4$ (derived pork supply).

Slaughter Level

(6) $P_C^s = f_5(Q_C^s, P_B^r, W, BP_B, K_B) + \mu_5$ (derived slaughter cattle demand),

(7) $Q_C^s = f_6(P_C^s, P_C^f, P_{CN}, T_B, Q_C^f) + \mu_6$ (primary slaughter cattle supply),

(8) $P_H^s = f_7(Q_H^s, P_K^r, W, BP_K, K_K) + \mu_7$ (derived slaughter hog demand),

(9) $Q_H^s = f_8(P_H^s, P_{CN}, T_K) + \mu_8$ (primary slaughter hog supply).

Table 1 presents variable definitions and descriptive statistics. The disturbance terms μ_1–μ_8 are assumed to be contemporaneously correlated. Demand and supply prices and quantities are assumed to be in equilibrium at each market level. At the retail level, equations (2) and (4) represent inverse retail demand by consumers. The retail prices of beef (P_B^r) and pork (P_K^r) are specified as functions of per capita retail demand quantities (Q_B^r and Q_K^r), prices of meat substitutes including lamb (P_M^r) and poultry (P_Y^r), and real per capita disposable income (Y). Per capita retail supplies of beef (Q_B^r) and pork (Q_K^r) in equations (3) and (5) represent the behavior of retail firms that supply beef and pork products to consumers. The real retail supply prices of beef and pork (P_B^r, P_K^r) are specified as functions of food labor costs (FC) and slaughter supplies of cattle and hogs (Q_C^s and Q_H^s).

At the slaughter level, packing companies' inverse derived demands for cattle (P_C^s) and hogs (P_H^s) are represented by equations (6) and (8). Cattle and hog prices are specified as a function of slaughter demand quantities (Q_C^s, Q_H^s), real retail prices (P_B^r, P_K^r), real wages in the meat packing industry (W), real by-product values (BP_B, BP_K), and meat packer concentration (K_B, K_K). Cattle and hog feeding operations supply slaughter cattle (Q_C^s) and hogs (Q_H^s) to packing companies. Therefore, equations (7) and (9) are a function of real slaughter supply prices (P_C^s, P_H^s), the real price of feed corn (P_{CN}), and farm-level cattle and hog finishing technologies (T_B, T_K). Average dressed weights of steers and average dressed weights of barrows and gilts are used as proxies for technological change. In the slaughter cattle supply equation (7), the price of feeder cattle (P_C^f) represents feeder cattle costs in feedlot finishing and feeder cattle supply (Q_C^f) represents slaughter cattle numbers. Similar measures are not used in the slaughter hog supply equation because the high degree of vertical coordination in this sector results in a virtually nonexistent feeder pig market (Marsh, 2007). Packer concentration ratios (K_B, K_K) are included in the derived slaughter demand functions to represent the market structure in which meat processing firms operate (Marsh and Brester, 2004; Ward, 2002).

The structural model includes vertical marketing linkages. Retail prices are transmitted down the marketing chain to the slaughter level and, conversely, slaughter quantities feed up to the retail level. These specifications are consistent with vertical marketing linkages and relative price-spread theory (Brester, Marsh, and Atwood, 2004; Gardner, 1975; Wohlgenant, 1989).[2]

Long-Run Solutions, Total Response Elasticities, and FS Statistics

The structural model is used to obtain estimates of short-run elasticities and flexibilities and their correlations among vertical sectors. The long-run solution of the structural model represents market-clearing prices and quantities at the retail and slaughter levels of the beef and pork sectors. The parameters of the structural model's long-run solution represent total response elasticities and flexibilities. These total response measures are used to compute changes in FS statistics and associated changes in producer surplus.

To obtain long-run solutions caused by exogenous shocks in equations (2)–(9), the ARDL(1,1) structural model can be represented in matrix form as:

[2] A reviewer noted that the right-hand sides of the retail beef supply equation (3) and the cattle derived demand equation (6) should have identical specifications if they are derived from a single firm's profit-maximizing behavior [the same argument would also hold for the retail pork supply equation (5) and hog demand equation (8)]. In our model, however, equation (3) represents the supply of beef by retailers while equation (6) represents the derived demand by cattle slaughterers.

Table 1. Variable Definitions and Descriptive Statistics

Variable	Definition	Mean	Standard Deviation
Price of Retail Beef (P_B^r) [a]	Real retail beef price (¢/lb.)	226.62	40.58
Retail Beef Quantity (Q_B^r) [a]	Per capita beef consumption (lbs.)	74.82	8.57
Retail Pork Price (P_K^r) [a]	Real retail pork price (¢/lb.)	171.42	31.27
Retail Poultry Price (P_Y^r)	Real retail broiler price (¢/lb.)	77.95	20.44
Retail Lamb Price (P_M^r)	Real retail lamb price (¢/lb.)	271.65	54.51
Income (Y)	Real per capita disposable income ($)	12,470.81	1,904.64
Food Marketing Costs (FC)	Index of real food labor costs (1987 = 100)	324.10	26.22
Quantity of Slaughter Cattle (Q_C^s) [a]	Commercial cattle slaughter (billion lbs.)	40.24	2.59
Retail Pork Quantity (Q_K^r) [a]	Per capita pork consumption (lbs.)	51.42	3.26
Quantity of Slaughter Hogs (Q_H^s) [a]	Commercial hog slaughter (billion lbs.)	22.41	2.96
Price of Slaughter Cattle (P_C^s) [a]	Real price of choice slaughter cattle ($/cwt)	60.60	17.43
Packing Plant Wages (W)	Real wages in meat processing plants ($/hour)	8.05	1.88
Beef By-Product Value (BP_B)	Real beef farm by-product value (¢/lb.)	15.52	4.63
Beef Packer Concentration (K_B)	Four-firm beef packer concentration ratio	57.78	22.85
Price of Feeder Cattle (P_C^f)	Real price of 700–800 lb. feeder steers ($/cwt)	64.30	16.96
Price of Corn (P_{CN})	Real price of corn ($/bu.)	2.57	1.36
Technology in the Cattle Sector (T_B)	Average dressed weight of steers (lbs.)	737.08	45.96
Quantity of Feeder Cattle (Q_C^f)	Feeder cattle supply—calf crop (million head)	41.98	3.92
Price of Slaughter Hogs (P_H^s) [a]	Real price of slaughter hogs ($/cwt)	44.55	20.61
Pork By-product Value (BP_K)	Real pork farm by-product value (¢/lb.)	5.40	3.18
Pork Packer Concentration (K_K)	Four-firm pork packer concentration ratio	41.82	11.21
Technology in Hog Sector (T_K)	Average dressed weight of hogs (lbs.)	179.19	9.50

[a] Indicates an endogenous variable.

(10) $$\mathbf{B}_o \mathbf{y}_t = \mathbf{B}_1 \mathbf{y}_{t-1} + \mathbf{V}\mathbf{z}_{t-j} + \mathbf{u}_t \,,$$

where $\mathbf{y}_t = [P^r_{Bt}, Q^r_{Bt}, ..., Q^s_{Ht}]'$ is the 8×1 vector of the endogenous variables of (2)–(9), $\mathbf{z}_{t-j}$ is a K×1 vector of exogenous variables, $\mathbf{B}_o$ is an 8×8 nondiagonal matrix, $\mathbf{B}_1$ is an 8×8 diagonal matrix, and $\mathbf{V}$ is an 8×K matrix. The term $\mathbf{u}_t$ is an 8×1 vector of contemporaneously correlated error terms.

The parameter estimates are checked for dynamic stability by first solving (10) for the reduced form (ignoring the error term):[3]

(11) $$\mathbf{y}_t = \mathbf{B}_o^{-1}\mathbf{B}_1 \mathbf{y}_{t-1} + \mathbf{B}_o^{-1}\mathbf{V}\mathbf{z}_{t-j} \,.$$

If the modulus of each eigenvalue of $\mathbf{B}_o^{-1}\mathbf{B}_1$ is less than one, the model is stable in that the dynamic representation implies the long-run solution:

(12) $$\overline{\mathbf{y}} = [\mathbf{I} - \mathbf{B}_o^{-1}\mathbf{B}_1]^{-1}(\mathbf{B}_o^{-1}\mathbf{V})\overline{\mathbf{z}} \,.$$

The matrix $[\mathbf{I} - \mathbf{B}_o^{-1}\mathbf{B}_1]^{-1}(\mathbf{B}_o^{-1}\mathbf{V})$ represents long-run or total response elasticities (or flexibilities).

Calculating Changes in Producer Surplus

We use the long-run impacts of 10% changes in selected exogenous variables for each of the 1,000 sets of total response elasticities to calculate changes in producer surplus. For each total response supply elasticity estimate, a linear farm-level supply function is specified using 2000–2005 average prices and quantities. Estimated changes in cattle and hog prices are then used to calculate shifts away from the initial price and quantity equilibria. Depending upon the source of the shock, the movement away from the initial equilibria could be a change in quantity supplied or a change in supply. In either case, simple geometry is used to calculate changes in producer surplus for cattle and hog producers given various exogenous shocks.

For the beef sector, the exogenous shocks considered are changes in consumer income, poultry price (a consumption substitute), corn price, and the four-firm beef packing concentration ratio. For the pork sector, exogenous shocks include changes in consumer income, poultry price, corn price, and wages in the meat processing sector.[4] Figure 2 illustrates the case of a wage increase in the meat processing industry. The slopes and intercepts for the primary supply functions (S_f) for hogs are obtained using the estimated total response supply elasticity and average slaughter hog price and quantity data for the period 2000–2005.[5] An

[3] This process is used to determine if the estimated structural model is stable. However, even if the initial system is stable, this does not guarantee that all of the 1,000 sampled sets of total response elasticities will be dynamically stable. In fact, about 20% of the randomly sampled sets were not stable. Therefore, we follow Monte Carlo importance sampling procedures in which we report from the first 1,000 sets of total response elasticities that resulted in dynamically stable systems.

[4] A subset of exogenous shocks is presented because of space limitations. Those presented were selected because they are among the most discussed in the beef and pork industry. However, all other equilibrium multipliers are available from the authors upon request.

[5] For inelastic supply elasticities, the intercept term must be negative. Therefore, appropriate adjustments must be made for areas of producer surplus that occur in the fourth Euclidean quadrant.

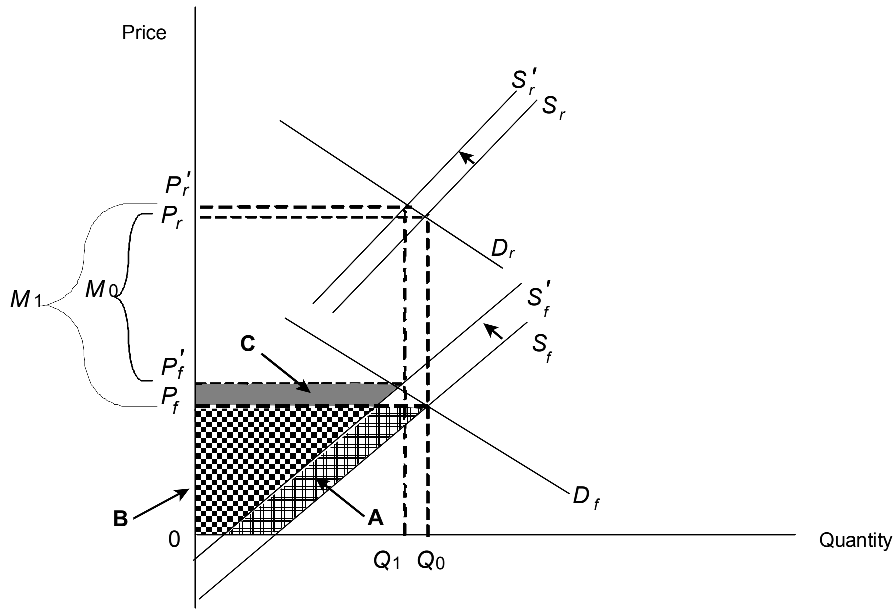

Figure 4. Effects on the marketing margin and producer surplus from increased farm-level costs

increase in wages in the meat processing industry results in a downward shift in the derived demand for hogs. Percentage changes in hog prices and quantities are obtained from the long-run solution, and used to calculate P_f' and Q_1. This procedure is repeated 1,000 times using a new set of randomly sampled short-run elasticities and their corresponding total response elasticities given a 10% increase in wages in the meat processing industry.

Our econometric results imply that increases in the four-firm concentration ratio in the beef packing industry negatively affect the derived demand for cattle. Therefore, a similar procedure is followed to obtain changes in producer surplus caused by a 10% shock in the four-firm concentration ratio.

The process is also used for estimating changes in producer surplus caused by exogenous shocks in per capita income and the price of poultry (i.e., primary demand shifters). As indicated by figure 3, changes in primary demand cause changes in derived demand for cattle and hogs. Again, we calculate changes in producer surplus that occur because of changes in farm-level prices and quantities supplied.

Changes in feed (corn) prices cause the farm-level cattle and hog primary supply curves to shift. For this shock, changes in producer surplus are illustrated in figure 4. Increases in farm-level costs shift the primary supply of slaughter cattle (and slaughter hogs) upward and to the left so that measures of changes in producer surplus must account for areas A, B, and C.

Developing Empirical Probability Distributions

We estimate empirical probability distributions of total response elasticities obtained from nonlinear transformations of estimated structural parameters. In addition, we maintain consistency between economic theory and parameter estimates when simulating the empirical probability distributions (Piggott, 2003). Our method is similar to Piggott's in that we use simulations to develop confidence intervals for the FS and producer surplus statistics while imposing economic theory on parameters. The primary difference between the two procedures is that we do not impose multivariate normality on the joint parameter distribution.

Our procedure also allows the imposition of parametric restrictions on the structural model and accounts for correlations among parameter estimates.[6] Such correlations generally exist within vertically coordinated marketing structures. The method maintains marginal distributions of individual parameter estimates without assuming a particular multivariate joint probability distribution. Furthermore, the technique does not require that marginal distributions be of the same family. This facilitates the imposition of inequality restrictions on simulated model parameters. The procedure is outlined in the appendix.

Empirical Results

This section reports the empirical results of the econometric estimation of the structural model and changes in FS statistics and producer surplus measures. Parameter estimates from the structural model are used to develop total response elasticities and flexibilities. The total response elasticities/flexibilities are then used to estimate percentage changes in equilibrium prices and quantities resulting from 10% shocks to various exogenous variables. The changes in equilibrium prices and quantities are used to calculate changes in FS statistics and producer surplus measures.

Data and Econometric Estimation of the Structural Model

Annual data from 1970 through 2005 are used to jointly estimate equations (2)–(9). Livestock data are obtained from the *Red Meats Yearbook* (USDA/ERS) and *Livestock, Dairy, and Poultry Situation and Outlook Reports* (USDA/ERS). Corn prices are derived from *Feed Outlook* (USDA/ERS) and *Agricultural Statistics* (USDA/NASS). Food labor costs are obtained from *Agricultural Outlook* (USDA/ERS), and meat packer wages are taken from the *Monthly Labor Review* (U.S. Department of Labor). All price/value data are deflated by the Consumer Price Index (CPI, 1982–84 = 100) obtained from the *Economic Report of the President* (Council of Economic Advisors, 2006).

Because of biological, technological, and expectations rigidities, the structural demands and supplies are assumed to be dynamic. A common modeling approach is to specify autoregressive distributed lags (ARDLs) with underlying rational distributed lags. Rational distributed lags specify dependent variables as infinite distributed lag functions of independent variables. Such models are generally estimated after specifying a finite set of lags on the dependent and independent variables using polynomial lag operators (Greene, 2003, pp. 571–576). One- or two-period lag lengths are often sufficient when using annual data. The Wald coefficient restriction test indicated that one-period lags were appropriate for all of the right-hand-side variables. Consequently, the polynomial numerators and denominators are specified as an ARDL (1,1) process. Own-prices and quantities are expected to be jointly determined, and contemporaneously correlated errors likely exist because of stochastic processes that may be common across a vertical marketing chain. The time-series properties

---

[6] Although not done in this paper, the procedures presented can also be easily modified to incorporate information from other studies or sources with respect to the possible range or other characteristics of the structural parameters' marginal distributions. Bayesian or other methods could be used to incorporate such information and generate posterior marginal distributions for use in the model.

of the model may also cause autoregressive (AR) error terms (Parks, 1967). Thus, the model was estimated with three-stage least squares (3SLS) using a nonlinear least squares algorithm in the *EViews 5.1* software program (Quantitative Micro Software, 2004).

Tables 2 and 3 present the 3SLS results of the structural model for beef and pork with all variables transformed by natural logarithms. All first-order lags on the dependent variables, except for the beef slaughter price equation, were significant at the $\alpha = 0.05$ level. Three equations (retail beef price, slaughter beef supply, and slaughter pork price) were corrected for first-order autoregressive [AR(1)] errors.[7]

The empirical results indicate the elasticity coefficients (signs) are generally consistent with theoretical reasoning; however, based on the asymptotic *t*-ratios, several of the variables were not statistically significant even at the $\alpha = 0.10$ level. All of the own-price/quantity relationships are negative, and the substitution and income effects are positive in the primary demands. In the derived demand equations, by-product and retail price effects are positive, while the packer wage effect is negative in the hog demand equation.[8]

On the supply side, quantity/own-price relationships are positive. Feed cost effects are negative in the primary supply equations, while the effects of technological change are positive. Note that meat packer concentration has a significant negative effect in the inverse slaughter cattle derived demand equation. The negative market concentration effect for beef could be interpreted as an indicator of oligopsony market power, although packer concentration effects in statistical analyses have been subject to various interpretations (Azzam and Anderson, 1996; Azzam and Schroeter, 1995; Marsh and Brester, 2004).

Farmer's Share Statistics and Producer Surplus Results

The partial adjustment elasticities obtained from the econometric model were used in equation (12) to generate 1,000 sets of total response elasticities and, subsequently, long-run percentage changes in the endogenous variables caused by exogenous shocks of 10%. Table 4 presents the mean results for selected exogenous variables. For example, a 10% increase in per capita income increases retail beef and slaughter cattle prices by 0.38% and 0.14%, respectively. These results are used in equation (1) to generate 1,000 FS statistics for slaughter cattle producers. The average slaughter cattle FS statistic decreases by 2.13%.

A 10% increase in the price of corn increases retail pork and slaughter hog prices by 0.15% and 0.19%, respectively. However, retail pork and slaughter hog quantities decline by 0.11% and 0.18%. The slaughter hog FS statistic increases by 0.53%.

Finally, the 1,000 sets of percentage changes in slaughter-level prices and quantities were used to generate 1,000 realizations of changes in producer surplus for the cattle and hog sectors. Table 5 indicates that, on average, a 10% increase in per capita income increases cattle producer surplus by 2.76%, but reduces the FS statistic of cattle producers by 0.0099 percentage points (or 2.13% of the mean). Therefore, the FS statistic declines merely because

[7] Unit root tests were conducted for each equation. Although unit roots existed, the residuals of the regression equations were stationary. Hence, the variables were cointegrated. Furthermore, Johnston and DiNardo (1997, p. 317) argue that econometric issues of unit roots in systems for which joint dependency exist are not serious. They note that "… conventional 2SLS inference properties are still valid." They also quote Hsiao (1994) who states, for models containing joint dependency, "For empirical structural model builders, the message is clear—one still needs to worry about the issue of identification and simultaneity bias, but one needs not to worry about the issues of nonstationarity and cointegration. All one needs to do in structural model building is to follow the conventional wisdom."

[8] The packer wage variable was omitted from the slaughter cattle demand equation because its estimated sign did not meet a priori expectations.

Table 2. Econometric Estimates for the Retail Beef and Pork Price and Quantity Equations (double logs)

	Dependent Variables			
Independent Variables	Retail Beef Price	Retail Beef Quantity	Retail Pork Price	Retail Pork Quantity
Constant	−1.14 (−0.38)	−1.91 (−4.58)	3.00 (2.63)	−0.77 (−1.09)
Beef Consumption	−1.14 (−7.40)			
Retail Pork Price	0.25 (3.66)			
Retail Poultry Price	0.02 (0.22)		0.35 (5.66)	
Retail Lamb Price	0.01 (1.73)		0.01 (0.81)	
Income	0.78 (2.74)		0.11 (1.33)	
Retail Beef Price$_{t-1}$	0.37 (3.58)	0.32 (8.57)		
Food Labor Costs				−0.04 (−0.40)
Food Labor Costs$_{t-1}$		−0.10 (−1.09)		
Retail Beef Quantity$_{t-1}$		0.70 (12.72)		
Cattle Quantity		0.55 (8.89)		
Pork Consumption			−0.76 (−8.92)	
Price of Retail Beef			0.27 (4.17)	
Price of Retail Pork$_{t-1}$			0.22 (3.69)	0.25 (4.20)
Retail Pork Quantity$_{t-1}$				0.61 (6.43)
Hog Quantity				0.40 (7.35)
AR(1)	0.97 (44.93)			
Adjusted R^2	0.95	0.95	0.96	0.55
Regression Std. Error	0.04	0.03	0.04	0.04

Note: Numbers in parentheses are *t*-values.

Table 3. Econometric Estimates for the Farm-Level Cattle and Hog Price and Quantity Equations (double logs)

	Dependent Variables			
Independent Variables	Cattle Price	Cattle Quantity	Hog Price	Hog Quantity
Constant	5.60 (5.51)	−0.62 (−0.94)	5.54 (9.87)	−2.29 (−1.29)
Cattle Quantity	−1.17 (−8.84)			
Beef By-product Price	0.20 (6.60)			
Retail Beef Price	0.57 (6.03)			
Beef Packing Concentration	−0.21 (−6.43)			
Slaughter Cattle Price$_{t-1}$		0.14 (4.37)		
Feeder Cattle Price		−0.23 (−14.29)		
Corn Price		−0.04 (−2.94)		
Cattle Dressed Weight		0.10 (1.35)		
Cattle Quantity$_{t-1}$		0.74 (16.15)		
Feeder Cattle Quantity		0.35 (6.47)		
Hog Quantity			−0.89 (−7.45)	
Meat Packing Wages			−0.19 (−1.91)	
Pork By-Product Price			0.56 (15.71)	
Retail Pork Price			0.15 (2.39)	
Pork Packing Concentration			−0.03 (−0.54)	
Hog Price$_{t-1}$			−0.001 (−2.66)	0.06 (0.91)
Corn Price$_{t-1}$				−0.09 (−2.20)
Hog Dressed Weight				0.66 (1.77)
Hog Quantity$_{t-1}$				0.60 (3.52)
AR(1)		−0.39 (−3.50)	0.65 (5.55)	
Adjusted R^2	0.98	0.91	0.99	0.81
Regression Std. Error	0.04	0.02	0.03	0.06

Note: Numbers in parentheses are *t*-values.

Table 4. Mean Percentage Changes of Retail Beef, Retail Pork, Slaughter Cattle, Slaughter Hog Prices and Quantities, and Farmer's-Share-of-the-Retail-Dollar Statistics Obtained from 1,000 Monte Carlo Simulations for 10% Changes in Selected Exogenous Variables

		Percentage Changes				
Changes in Prices, Quantities, and FS Statistics [a]	Means (2000–2005)	Per Capita Income	Poultry Price	Corn Price	Beef Packing Concentration	Meat Processing Wages
Retail Beef Price	\$3.61/lb.	0.38	0.09	0.11	0.0007	—
Retail Beef Quantity	19.22 bil. lbs.	0.50	0.12	−0.03[b]	0.0009	—
Slaughter Cattle Price	\$77.65/cwt	0.14	0.03	0.15	−0.11	—
Slaughter Cattle Quantity	42.86 bil. lbs.	0.06	0.01	−0.08	−0.05	—
Slaughter Cattle FS Statistic	0.464	−2.13	−0.52	0.60	−1.81	—
Retail Pork Price	\$2.69/lb.	0.16	0.28	0.15	—	0.04
Retail Pork Quantity	14.78 bil. lbs.	0.11	0.20	−0.11	—	−0.03
Slaughter Hog Price	\$44.57/cwt	0.02	0.03	0.19	—	−0.14
Slaughter Hog Quantity	26.74 bil. lbs.	0.01	0.01	−0.18	—	−0.05
Slaughter Hog FS Statistic	0.265	−1.36	−2.38	0.53	—	−1.81

[a] All estimates are statistically different from zero at the 5% level unless otherwise noted.
[b] Statistically different from zero at the 10% level.

Table 5. Changes in the Farmer's-Share-of-the-Retail-Dollar Statistic and Producer Surplus for Cattle and Hog Producers Given a 10% Change in Selected Exogenous Variables

		10% Increase in Each Exogenous Variable				
Change in PS and FS [a]	Means (2000–2005)	Per Capita Income	Poultry Price	Corn Price	Beef Packing Concentration	Meat Processing Wages
Slaughter Cattle Producer Surplus (million dollars)		\$91.911	\$21.479	\$12.400[b]	−\$73.691	
Change in Slaughter Cattle Producer Surplus as a Percent of Average Annual Total Revenue	\$3,328 million	2.76%	0.65%	0.37%	−2.21%	
Percentage Point Change in Slaughter Cattle Producer FS		−0.0099	−0.0024	0.0028	−0.0084	
Percent Change in Slaughter Cattle FS	0.464	−2.13%	−0.52%	0.60%	−1.81%	
Slaughter Hog Producer Surplus		\$3.111	\$5.558	−\$6.503		−\$23.917
Change in Slaughter Hog Producer Surplus as a Percent of Average Annual Total Revenue	\$1,192 million	0.26%	0.47%	−0.55%		−2.01%
Percentage Point Change in Slaughter Hog Producer FS		−0.0036	−0.0063	0.0014		−0.0048
Percent Change in Slaughter Hog FS	0.265	−1.36%	−2.38%	0.53%		−1.81%

[a] All estimates are statistically different from zero at the 5% level unless otherwise noted.
[b] Statistically different from zero at the 15% level.

the increase in slaughter cattle price is proportionally smaller than the increase in retail beef price. Nonetheless, cattle producers (in aggregate) are clearly better off from increases in per capita income. A similar (although smaller) result occurs for hog producers. A 10% increase in per capita income increases hog producer surplus by 0.26% and reduces the FS statistic for hog producers by 0.0036 percentage points. Similar relationships exist for increases in poultry price on cattle and hog producers.

A 10% increase in corn price causes a small (and statistically weak) increase in cattle producer surplus and a small increase in the FS statistic for cattle producers. However, the same increase in corn price significantly reduces hog producer surplus by 0.55%, while increasing the FS statistic for hog producers by 0.0014 percentage points (or 0.53% of the mean).

Finally, a 10% increase in beef packing concentration reduces both cattle producer surplus and the FS statistic. A 10% increase in wages in meat processing plants decreases both hog producer surplus and the FS statistic.

While tables 4 and 5 report the mean changes in FS statistics and producer surplus obtained from 1,000 Monte Carlo simulations, figures 5 and 6 present all of the 1,000 joint realizations of changes in FS statistics and changes in producer surplus given selected exogenous shocks in the beef and pork sectors. In addition, the number of joint realizations occurring in each quadrant is indicated in the figures. In the case of increases in per capita income and poultry price, the FS statistics and producer surplus in the cattle industry (figure 5) are clearly inversely related as 994 of the joint realizations reside in the fourth Euclidean quadrant (the results are similar for the hog industry, as shown in figure 6). Both the cattle FS statistic and producer surplus increase as corn price increases (902 realizations reside in the first quadrant), although this result is only statistically significant at about the 10% level. This somewhat counterintuitive result occurs because the impact of increases in corn price on changes in cattle producer surplus was small and statistically weak. Further, the result highlights the importance of simulating an entire system of demand and supply equations (and their correlations to other sectors) to appropriately model feedback effects. Conversely, the hog producer FS statistic increases and producer surplus declines in response to increases in corn price (at about the 10% level), as 891 joint realizations reside in the second quadrant (figure 6). Given that corn is a much more important feed input into hog production relative to cattle production, this result seems reasonable.

Figure 5 indicates that increases in beef packing concentration (holding other variables constant) cause reductions in both cattle producer surplus and FS statistics. However, beef packing concentration could have cost-saving benefits that are not captured by our structural model. For example, it is possible to find joint realizations (six in total) where increases in beef packing concentration increase producer surplus while the FS statistic declines. Increases in meat processing plant wages clearly reduce both hog producer surplus and the FS statistic (figure 6).

A final simulation was conducted to evaluate the impact of simultaneous shocks in all of the exogenous variables. Percentage changes in each exogenous variable were calculated from the data used in the econometric model. Five-year averages from the beginning and end of the sample (1970–1974 and 2001–2005) were used to smooth single-year aberrations. Some of the percentage changes were quite large—e.g., beef packing concentration increased 185% between these two periods. Given that the total response elasticities are only relevant for small shocks, we normalized these shocks based on the change in beef packing concentration. Changes in cattle and hog producer surplus and FS statistics were then simulated based on simultaneous 10% shocks to each of the normalized percentage changes.

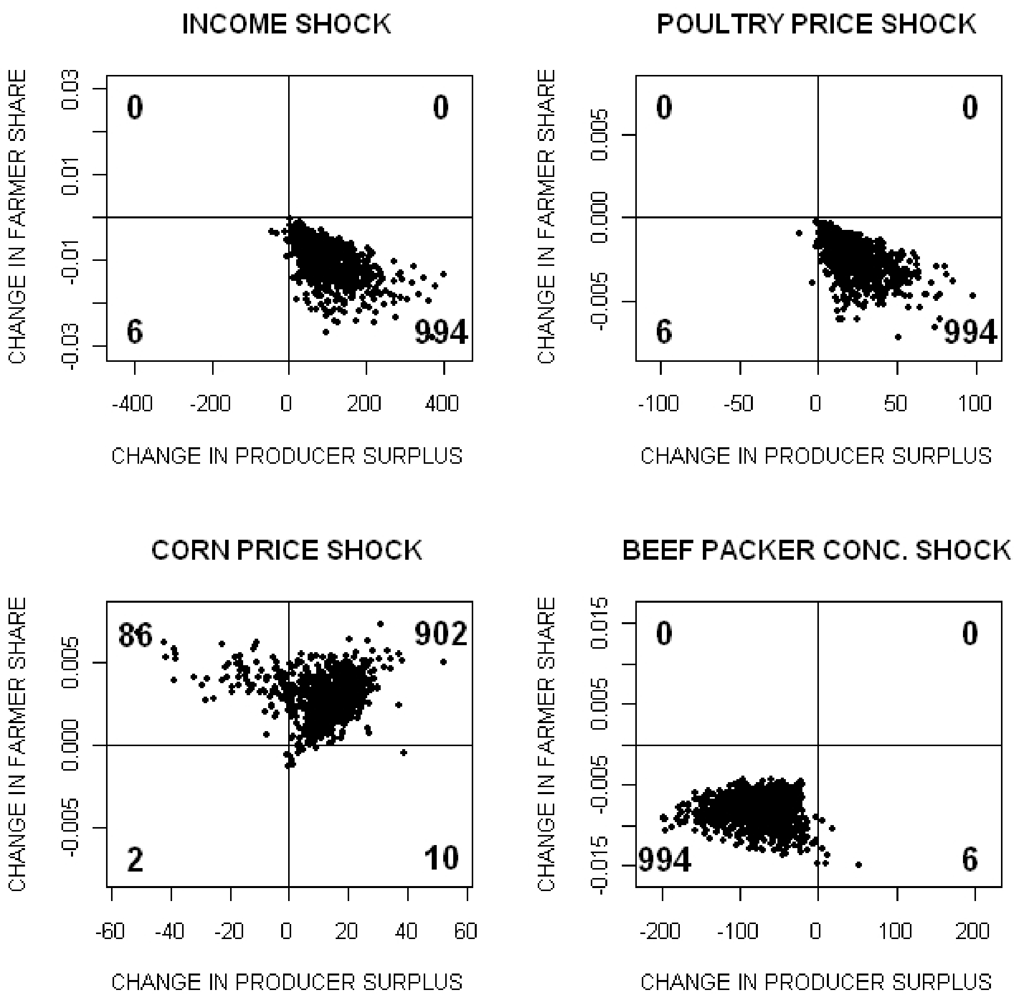

Figure 5. Scatter plots and quadrant counts of simulated joint realizations of cattle producer surplus and farmer's-share-of-the-retail-dollar statistics for selected exogenous shocks

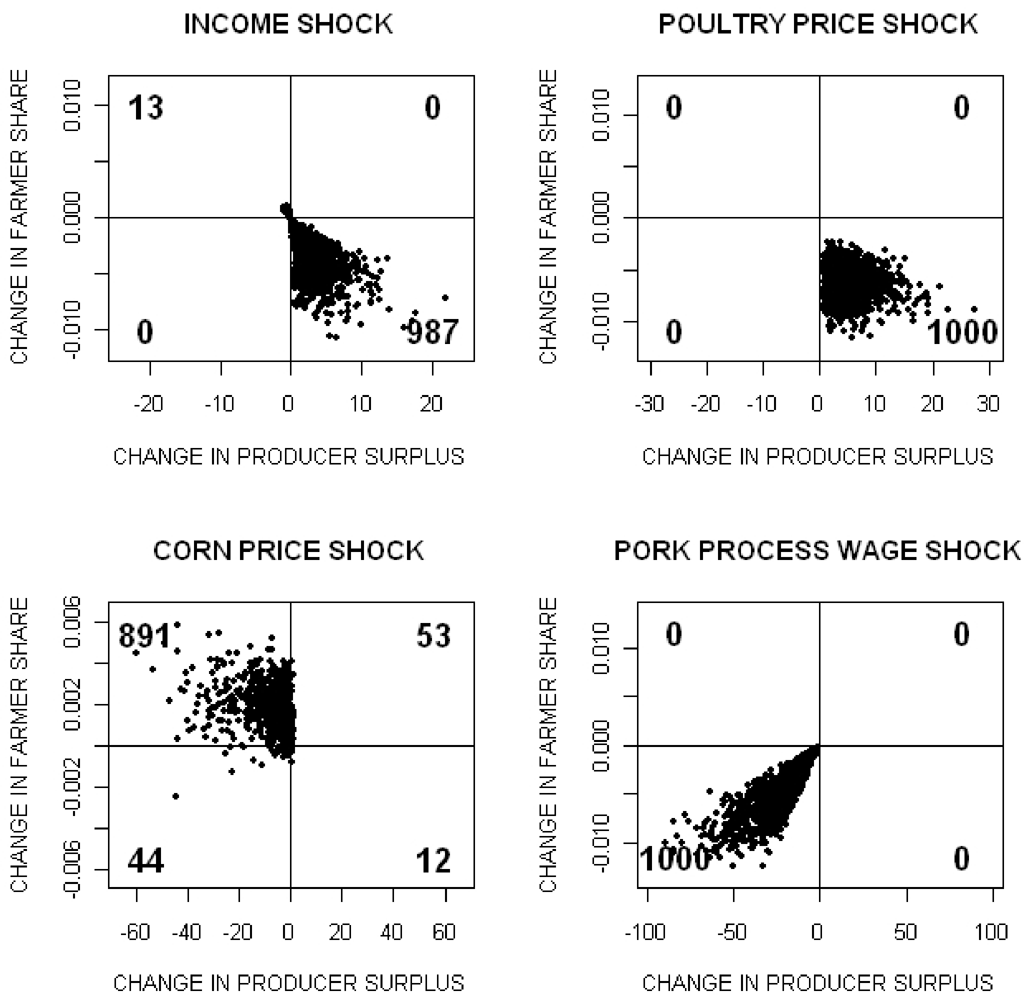

Figure 6. Scatter plots and quadrant counts of simulated joint realizations of hog producer surplus and farmer's-share-of-the-retail-dollar statistics for selected exogenous shocks

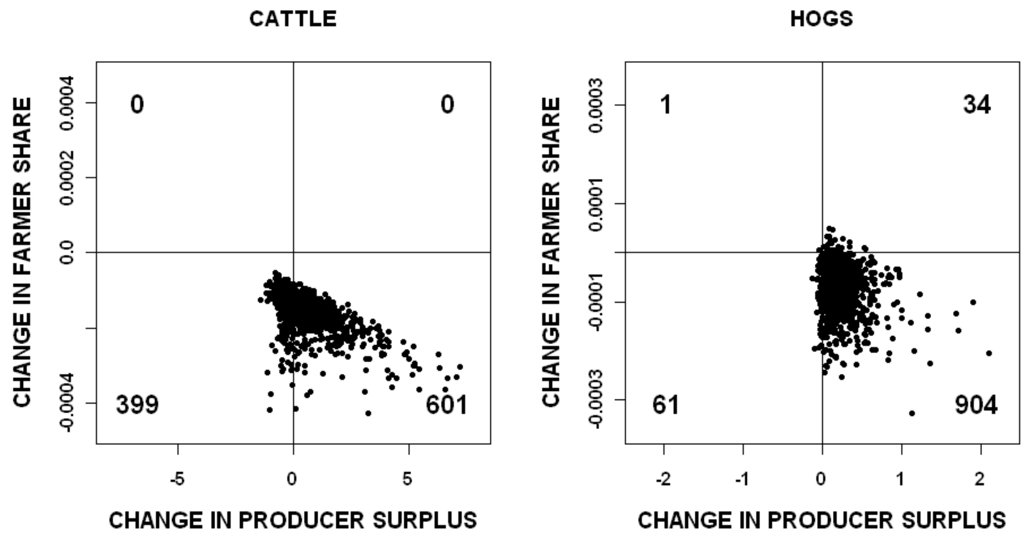

Figure 7. Scatter plots and quadrant counts of simulated joint realizations of cattle and hog producer surplus and farmer's-share-of-the-retail-dollar statistics for simultaneous shocks in all exogenous variables

Figure 7 illustrates that the joint shocks did not produce a statistically significant change in cattle producer surplus, as about 40% of the joint realizations reside in quadrant three and 60% in quadrant four. However, the shocks generated a change in the cattle producer FS statistic that was negative and statistically significant. On the other hand, these shocks had a statistically significant positive effect on hog producer surplus but a statistically significant negative effect on the FS statistic, as 904 joint realizations reside in quadrant four.

Conclusions

We have empirically demonstrated that FS statistics and, by construction, farm-to-retail marketing margins, are not reliable measures of changes in producer surplus (welfare) given exogenous shocks to various economic factors. In the cattle and hog sectors, FS statistics and producer surplus are directly related for some exogenous shocks. For other shocks, they are inversely related. The relationship between FS statistics and producer surplus depends upon structural dynamics, the source of exogenous shocks, and relative demand and supply elasticities. In fact, little or no accurate information is conveyed by FS statistics. We expect that our empirical results can be generalized to other agricultural commodities. Consequently, these data should not be used for policy purposes.

In addition, our simulation approach is applicable to a broad set of policy research issues. Our procedures for estimating marginal and joint confidence intervals for industry performance and/or policy effects can be easily incorporated into other methodologies such as the equilibrium displacement models of Muth (1964), Gardner (1975), and numerous other authors. Our procedures are also consistent with the unified approach to sensitivity analysis recommended by Davis and Espinoza (1998). Specifically, we have demonstrated the mechanism for maintaining modeling flexibility while incorporating a priori information into (potentially) bounded marginal parametric distributions. Moreover, the ability to maintain dependence among parameter realizations is especially important for modeling vertically related market structures. In many cases, the imposition of inequality constraints onto parametric realizations is more easily accomplished with the above procedures relative to bootstrapping methods. Finally, our procedures can be implemented using readily available software such as MS-Excel and R.[9]

Our research has several limitations. For example, we have focused on only two commodities (beef and pork). It would be interesting to examine relationships between FS statistics and producer surplus for other commodities. In addition, we have developed a technique for imposing inequality restrictions on short- and long-run elasticities. However, one can envision imposing other economically motivated restrictions on such models (e.g., symmetry or constant returns to scale). Finally, an interesting extension of this research would be to apply cointegration econometrics as a means for imposing long-run restrictions on our short-run model (Phillips, 1991).

In conclusion, our empirical results support Atchley's (1956) anecdotal comment:

> I think we can say that the farmer's best interests are not always served by increasing the farmer's share of the consumer's dollar. If they were, then farmers would sell directly to consumers. But the marketing system which we have developed does the job cheaper than farmers can do it. If an added marketing service increases the market or the value of the final product more than the costs, farmers stand to benefit for the added service even though it may lower the farmer's share (pp. 1578–1579).

We have empirically shown that this theoretic argument, advanced in 1956, remains relevant today.

[*Received May 2008; final revision received April 2009.*]

References

Atchley, F. M. "Alternative Approaches to the Marketing Margin: Farmer's Share Concept." *J. Farm Econ.* 38(1956):1573–1585.

Azzam, A. M. "Testing the Competitiveness of Food Price Spreads." *J. Agr. Econ.* 43(1992):248–256.

Azzam, A. M., and D. G. Anderson. "Assessing Competition in Meatpacking: Economic History, Theory, and Evidence." Pub. No. GIPSA-RR96-6, USDA, Packers and Stockyards Programs/Grain Inspection, Packers and Stockyards Administration, Washington, DC, May 1996.

Azzam, A. M., and J. R. Schroeter. "The Tradeoff Between Oligopsony Power and Cost Efficiency in Horizontal Consolidation: An Example from Beef Packing." *Amer. J. Agr. Econ.* 77(1995):825–836.

Been, R. O. U.S. Bureau of Agricultural Economics. "Price Spreads Between the Farmer and Consumer." Agr. Info. Bull. No. 4. Washington, DC, 1949. Online. Available at http://naldr.nal.usda.gov/.

Brester, G. W. "Research and Publishing: Relevance and Irreverence." *J. Agr. And Resour. Econ.* 31(2006): 455–470.

Brester, G. W., and M. A. Boland. "The Rocky Mountain Sugar Growers Cooperative: 'Sweet' or 'Sugar-Coated' Visions of the Future?" *Rev. Agr. Econ.* 26(2004):287–302.

[9] The MS-Excel spreadsheets and R code used in this study are available from the authors upon request.

Brester, G. W., and J. M. Marsh. "The Effects of U.S. Meat Packing and Livestock Production Technologies on Marketing Margins and Prices." *J. Agr. and Resour. Econ.* 26(2001):445–462.

Brester, G. W, J. M. Marsh, and J. A. Atwood. "Distributional Impacts of Country-of-Origin Labeling in the U.S. Meat Industry." *J. Agr. and Resour. Econ.* 29(2004):206–227.

Council of Economic Advisors. *Economic Report of the President*. Washington, DC: Government Printing Office, February 2006.

Davis, G. C., and M. C. Espinoza. "A Unified Approach to Sensitivity Analysis in Equilibrium Displacement Models." *Amer. J. Agr. Econ.* 80(1998):868–879.

Elitzak, H. "Food Cost Review, 1950–1997." Agr. Econ. Rep. No. 7890, USDA/Economic Research Service, Washington, DC, June 1999.

Food Systems Insider. "What Do We Want from the New Farm Bill?" 2007. Online. Available at http://ase.tufts.edu/gdae/policy_research/WiseInsider.PDF. [Accessed March 6, 2007.]

Gardner, B. L. "The Farm-Retail Price Spread in a Competitive Food Industry." *Amer. J. Agr. Econ.* 57(1975):399–409.

Greene, W. H. *Econometric Analysis*, 5th ed. Upper Saddle River, NJ: Prentice-Hall, Inc., 2003.

Harkin, T. "Opening Statement for the Senate Agriculture Committee." Washington, DC, 10 June 1998. Online. Available at http://agriculture.senate.gov/Hearings/Hearings_1998/har98610.htm. [Accessed November 2007.]

Holloway, G. J. "The Farm-Retail Price Spread in an Imperfectly Competitive Food Industry." *Amer. J. Agr. Econ.* 73(November 1991):979–989.

Hsiao, C. "Statistical Properties of the Two-Stage Least Squares Estimator Under Cointegration." Work. paper, University of Southern California, Los Angeles, 1994.

Iman, R. L., and W. J. Conover. "A Distribution-Free Approach to Inducing Rank Correlation Among Input Variables." *Communications in Statistics: Simulation and Computation* 11(1982):311–334.

Johnston, J., and J. DiNardo. *Econometric Methods*, 4th ed. New York: McGraw-Hill, 1997.

Marsh, J. M. "Cross-Sector Relationships Between the Corn Feed Grains and Livestock and Poultry Economies." *J. Agr. and Resour. Econ.* 32(2007):93–114.

Marsh, J. M., and G. W. Brester. "Wholesale-Retail Marketing Margin Behavior in the Beef and Pork Industries." *J. Agr. and Resour. Econ.* 29(2004):45–64.

Muth, R. F. "The Derived Demand Curve for a Productive Factor and the Industry Supply Curve." *Oxford Econ. Papers* 16(1964):221–234.

Nelson, E. "Economic Challenges and Opportunities Facing American Agricultural Producers Today." U.S. Senate Committee on Agriculture, Nutrition, and Forestry Hearing on Livestock, Poultry, and Competition Issues in the 2007 Farm Bill. Washington, DC, 18 April 2007.

Parks, R. "Efficient Estimation of a System of Regression Equations When Disturbances Are Both Serially Correlated and Contemporaneously Correlated." *J. Amer. Statist. Assoc.* 62(1967):500–509.

Phillips, P. C. B. "Optimal Inference in Cointegrated Systems." *Econometrica* 59,2(1991):283–306.

Pickett et al. v. Tyson Fresh Meats, Inc. U.S. District Court, Civil Action No. 96-A-1103-N, Vol. XI: 1576–1800. Montgomery, AL, 27 January 2004.

Piggott, N. E. "Measures of Precision for Estimated Welfare Effects for Producers from Generic Advertising." *Agribus.: An Internat. J.* 19(2003):379–391.

Quantitative Micro Software. *Eviews 5.1 Users Guide*. Irvine, CA, 1994–2004.

Taylor, C. R. "Where's the Beef? Monopoly and Monopsony Power in the Beef Industry." Agricultural and Resource Policy Forum, College of Agriculture, Auburn University, 2002.

Tomek, W. G., and K. L. Robinson. *Agricultural Product Prices*. Ithaca, NY: Cornell University Press, 1972.

U.S. Department of Agriculture, Economic Research Service. Food Marketing System price spreads. Online. Available at http://www.ers.usda.gov/Briefing/FoodMarketingSystem/pricespreads.htm. [Accessed May 2008.]

———. *Agricultural Outlook*. USDA/ERS, Washington, DC. Various issues, 1972–2006.

———. "Consolidation in Meatpacking: Causes and Concerns" *Agricultural Outlook*. AGO 272 (June/July 2000):23–26.

———. *Agricultural Outlook: Statistical Indicators*. USDA/ERS, Washington, DC, 2007. Online. Available at http://www.ers.usda.gov/publications/AgOutlook/AOTables.

———. *Feed Outlook*. USDA/ERS, Washington, DC. Various issues, 1972–2006.

———. *Livestock, Dairy, and Poultry Situation and Outlook Report*. USDA/ERS, Washington, DC. Various issues, 2004–2006.

———. *Red Meats Yearbook Statistical Series*. USDA/ERS, Washington, DC, 1970–2005. Online. Available at http//usda.mannlib.Cornell.edu/data-sets/livestock;94006.

U.S. Department of Agriculture, National Agricultural Statistics Service. *Agricultural Statistics*. USDA/NASS, Washington, DC, 2006.

U.S. Department of Labor, Bureau of Labor Statistics. *Monthly Labor Review: Wages in Animal Slaughtering and Processing*. Washington, DC. Various issues, 1972–2006.

U.S. Senate. Committee on Agriculture, Nutrition, and Forestry. "Economic Concentration and Structural Change in the Food and Agriculture Sector: Trends, Consequences, and Policy Options." Washington, DC, 29 October 2004.

Ward, C. E. "A Review of Causes for and Consequences of Economic Concentration in the U.S. Meatpacking Industry." *Current Agriculture, Food, and Resource Issues* [a journal of the Canadian Agricultural Economics Society] 3(2002):1–28.

Wohlgenant, M. K. "Demand for Farm Output in a Complete System of Demand Functions." *Amer. J. Agr. Econ.* 71(1989):241–252.

Zalesky, D. "Colorado Views on Federal Agriculture and Rural Policy: The 2007 Farm Bill." U.S. Senate Committee on Agriculture, Nutrition, and Forestry Field Hearing. Brighton, CO, 12 March 2007. Online. Available at http://agriculture.senate.gov/Hearings/hearings.cfm. [Accessed November 2007.]

Appendix: Simulating Joint Realizations of Total Response Elasticities, Producer Surplus, and Farmer Share Statistics

Assume a set of estimated structural parameters [from the **B** and **V** matrices in text equation (10)] with estimated covariance matrix $\hat{\boldsymbol{\Sigma}}_b$ and correlation matrix $\mathbf{R}_b$. The point estimates are then used to calculate a set of total response elasticities $m = m(\mathbf{b})$, producer surplus $PS = PS(\mathbf{b}, m)$, and farmer share $FS = FS(\mathbf{b}, m)$ statistics. In each case, the functionals m, PS, and FS involve nonlinear transformations of the initial structural parameter estimates **b**.

Although point estimates of m, PS, and FS are useful, we wish to estimate both confidence intervals and joint FS-PS realizations while maintaining appropriate signs on elasticities. One potential approach would be to bootstrap the entire system J times and record the joint $\mathbf{b}_j$, m_j, PS_j, and FS_j realizations for $j = 1, 2, \ldots, J$. However, accurately bootstrapping a system such as text equations (2)–(9) can be quite complex and sensitive to outliers. In addition, bootstrap procedures can result in some realizations of estimated elasticities being inappropriately signed in the absence of parametric inequality restrictions.

The following procedures obviate the need to impose such inequalities which are often intractable in many econometric applications. We use nonstandardized Beta distributions to model the marginal distributions of each structural parameter in **b**. Although we use Beta marginals in this study, other marginals can be used (including those formed with Bayesian approaches) and do not need to be limited to members of the same distributional family. For each element i in **b**, the nonstandardized Beta distribution can be written as:

(A1) $$f(b_i) = \frac{1}{K_2^i - K_1^i} \frac{\Gamma(\alpha_i + \beta_i)}{\Gamma(\alpha_i)\Gamma(\beta_i)} \left(\frac{b_i - K_1^i}{K_2^i - K_1^i} \right)^{\alpha_i - 1} \left(\frac{K_2^i - b_i}{K_2^i - K_1^i} \right)^{\beta_i - 1}$$

for $K_1^i \leq b_i \leq K_2^i$ and $\alpha_i, \beta_i > 0$. For each of the structural parameters, b_i, the econometric estimates of $\hat{b}_i$ and its standard error $\hat{\sigma}_i$ were used to set $K_1^i = \hat{b}_i - 4\hat{\sigma}_i$ and $K_2^i = \hat{b}_i + 4\hat{\sigma}_i$. K_1^i was bounded at zero if $\hat{b}_i$ represented a supply elasticity and if $\hat{b}_i - 4\hat{\sigma}_i < 0$. K_2^i was bounded at zero if $\hat{b}_i$ represented a demand elasticity and if $\hat{b}_i + 4\hat{\sigma}_i > 0$. Given K_1^i, K_2^i, the parameters α_i and β_i were solved to obtain a mean of $\hat{b}_i$ and a standard deviation of $\hat{\sigma}_i$ for the distribution given in (A1). It can be shown that setting

$$\alpha = \left(\frac{\theta_1}{\theta_1 + \theta_2}\right)(\theta_1\theta_2 - 1) \text{ and } \beta = \left(\frac{\theta_2}{\theta_1 + \theta_2}\right)(\theta_1\theta_2 - 1),$$

where

$$\theta_1 = \frac{\hat{b} - K_1}{\hat{\sigma}} \text{ and } \theta_2 = \frac{K_2 - \hat{b}}{\hat{\sigma}},$$

results in a mean of $\hat{b}$ and a standard deviation of $\hat{\sigma}$. If K_1^i and K_2^i are both four standard deviations from the mean, the marginal distribution is symmetric with $\alpha_i = \beta_i = 7.5$.

Given $(K_1^i, K_2^i, \alpha_i, \beta_i)$, the *Betainv* function in MS-Excel was used to generate 1,000 b_i stable realizations corresponding to the quantiles (0.001, 0.002, …, 1) for each of the model's 62 structural parameters. The resulting marginal b_i realizations were stacked or pooled into a 1,000 × 62 matrix **Y**. Parametric correlations were introduced using the Iman-Conover process. The Iman-Conover process re-orders the elements in **Y** to obtain $\mathbf{Y}_C$, where each column in $\mathbf{Y}_C$ has the same rank order as the corresponding column in a 1,000 × 62 multivariate normal sample $\mathbf{N}_C$ generated with covariance matrix $\hat{\mathbf{\Sigma}}_b$. The Iman-Conover process used here is equivalent to introducing marginal dependence using copula procedures with a 62-dimension normal or elliptical copula.

By construct, the re-ordered matrix $\mathbf{Y}_C$ will have the same Spearman rank correlation matrix as $\mathbf{N}_C$. The Pearson correlations of $\mathbf{Y}_C$ obtained using re-ordered Beta distributions were very similar to the model's estimated correlation matrix $\mathbf{R}_b$.

For each of the $j = 1, …, 1{,}000$ correlated $\mathbf{b}_j$ parameter realizations in $\mathbf{Y}_C$, the resulting multiplier (m_j), producer surplus (PS_j), and FS statistics (FS_j) joint realizations were generated for specific exogenous shocks.