Dynamic Relationships in the U.S. Lamb Marketing Channel

by

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Introduction

When sheep producers think about the price discovery and price transmission process, they are not usually concerned about the complex supply and demand relationships at each level of the system. Their concerns are more commonly focused on the observation that retail prices do not appear to come down in a prompt response to price changes at the farm level, even when live lamb prices fall dramatically. Any long lag in the response to price changes for live lambs becomes important to producers. Changes in supply at the producer level, especially on a seasonal basis, bring significant changes in live lamb prices. In order to move any additional supply through the system, retail lamb prices must decline so that consumption will increase. If there is no decrease in price at the retail level, the system is loaded with product with no increase in movement into consumption. The product must eventually be sold under distress conditions to secondary outlets.

Producers and consumers thus need to receive price signals quickly and accurately so their decisions will lead to optimal allocation of resources. The cost effectiveness of the entire system can be influenced by unwarranted price signal time lags. These time-related aspects of the pricing system also have important implications for market efficiency in terms of how quickly the market registers the price impact of new information.

In this study, the speed of price transmission between levels of the lamb system is investigated. The results are compared to previous studies in the beef and pork marketing channels and are then used as a base for suggested policy changes.

Past Research

The dynamics of lamb price changes have been the subject of recent debate. There is a lack of agreement among market analysts regarding the specific lead/lag relationships among retail, wholesale, and live lamb prices. Several plausible theories have been offered regarding the price transmission dynamics across the live, wholesale, and retail levels in the U.S. meat industries broadly defined. One economic theory suggests that farm level prices will be discovered by transmissions down through the system from the retail level in a derived demand framework. Recent work by Owen et al., for example, found that three fabricated beef cuts statistically dominated as leading indicators of fed cattle prices. These results suggest a derived movement of prices through the beef

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marketing system with the direction of flow from retail down to the fed cattle market.

Other recent studies of price transmission in the red meat industries, however, suggest that prices more closely follow what might be called a markup pricing framework. Boyd and Brorsen are among analysts who argue that most price changes originate from a shift in farm level supply rather than from a shift in consumer demand. They also point out that retailers may be reluctant to initiate price changes for fear of driving consumers to competitors.

Analysts also suggest that the time required to move meat from the livestock feeder to the retail shelf, including time for processing and packaging, can contribute to lags in responsiveness (Schroeder and Hayenga). Heien suggests that even if retailers use formula pricing, when consumer demand shifts, the farm level prices will change first due to an increase or decrease in orders from retailers. Modeling in the markup pricing framework, Miller (1979) found that farm level beef price changes lead wholesale price changes by 1 week and that wholesale changes lead retail changes by 3 weeks. In a later study (1980), Miller found that farm level pork prices lead wholesale prices by 3 weeks and that wholesale price changes lead retail price changes by 3 weeks. Other studies have found farm level price changes leading wholesale price changes in pork by 1 to 2 weeks, and wholesale price changes leading retail price changes by as much as 3 to 5 weeks (Boyd and Brorsen, Schroeder and Hayenga).

Methodology

Theory would therefore suggest the need to consider both price changes originating from the consumer level, in a derived demand framework, and price changes throughout the system in response to supply changes at the producer level. When investigating dynamic causal relationships, economists are sometimes tempted to rely on the structural approach of specifying a particular model and estimating the model using ordinary least squares. A specific theory is imposed on the data, and the data are then analyzed to see if they support the theory. This approach may not always be practical in that the proper specification of the model may not be known a priori. Even in the event the structural model is a close approximation to reality, statistical problems can occur in time series data. Spurious correlation, multicollinearity among regressors, and serial correlation of the residuals are among possible problems, making the estimates inefficient and possibly inconsistent (Granger and Newbold).

One statistical technique used to characterize a dynamic system and to minimize these statistical problems and the problems of imposing a particular structure a priori is known as the vector autoregressive model (VAR). In these models, each variable in the system is allowed to influence each other variable with possible time lags. The method is designed to estimate the dynamic aspects of relationships over time without forcing patterns of interactions among a set of variables. This approach allows the regularities and patterns present in the data to reveal themselves. VAR models thus provide a basis for discriminating among competing views and theories. For example, is the price transmission process in lamb markets more closely represented by a derived demand type model, or by a markup pricing model? Alternatives can be compared to determine how closely their theoretical implications match the observed dynamics, possibly ruling out alternatives that initially appear plausible, while strengthening the case for others. At a minimum, the VAR technique can prove valuable at the early stages of inquiry into the dynamics of a system. It seems appropriate to examine the historical evidence to see which views are consistent with the observed dynamics before imposing a particular structural model (Bessler).

A Look at the Lamb Industry

The first part of this study involves a three equation reduced form system for farm level price, wholesale price, and retail price, and is specified as follows.

$$(1)\quad R_t=\alpha_1+\sum_{i=1}^{n}\beta_1 R_{t-i}+\sum_{i=1}^{n}\Gamma_1 W_{t-i}+\sum_{i=1}^{n}\delta_1 F_{t-i}+\varepsilon_{1t},$$

$$(2)\quad W_t=\alpha_2+\sum_{i=1}^{n}\beta_2 R_{t-i}+\sum_{i=1}^{n}\Gamma_2 W_{t-i}+\sum_{i=1}^{n}\delta_2 F_{t-i}+\varepsilon_{2t},$$

$$(3)\quad F_t=\alpha_3+\sum_{i=1}^{n}\beta_3 R_{t-i}+\sum_{i=1}^{n}\Gamma_3 W_{t-i}+\sum_{i=1}^{n}\delta_3 F_{t-i}+\varepsilon_{3t}.$$

where: t = time in weeks,
n = the number of lags,
R = the retail price,
W = the wholesale price,
F = the farm level price,

and β_j, Γ_j, and δ_j are parameters to be estimated with ϵ_j as an error term.

The number of lags in the system must be truncated to some finite number in order to obtain parameter estimates. A likelihood ratio test suggested by Sims is used to determine how many lags to include. Thus, the number of lags, or order of the system, is estimated using the data and the same number of lags is used for each variable in the system (Featherstone and Baker). For the reduced form system of price equations, it was determined that 2 lags on each of the price variables should be included in each autoregressive equation.

Several dynamic attributes of an economic system can be examined using the VAR methodology. First, reaction times for responses of one price series to another can be investigated. Second, patterns, directions, and durations of price responses can be investigated. In addition, similarities or dissimilarities of response patterns for related variables can be examined and the strengths of the interrelationships among prices at different levels of the system can be explored.

The first step is to perform Granger causality tests by regressing each variable in the lamb pricing system on lagged values of itself and all the other variables in the model. This reveals information regarding the lead/lag temporal relationships of the price changes in the system.

A variable X is said to "Granger cause" a variable Y if Y can be better predicted using past values of X along with past values of Y. If X Granger causes Y and Y does not Granger cause X, then X is said to unidirectionally cause Y. The causation is said to be bi-directional if X causes Y and Y causes X.

The next step in the analysis is to examine the decomposition of forecast error variance from various specifications of the VAR model. With the autoregressive model re-specified as a moving average model (by dividing through each equation by the appropriate polynomial lag operator), the uncertainty in forecasts of future values of all variables in the model can be divided into components due to uncertainty in each variable. A variable that is truly exogenous (unrelated to other variables in the system) would explain 100 percent of its own forecast error. Conversely, a variable that is highly correlated with other variables in the system would have large proportions of its forecast error variance attributed to variation in those other variables.

Statistical problems can occur in VAR models when two or more of the data series being studied are highly correlated. The presence of large correlations between two series at the same point in time (contemporaneous correlations) is an indication that the sectors being studied may not be distinct. The one step ahead prediction errors will be correlated when the variation in different variables is not independent. Thus the decomposition of forecast error variance will not be interpretable. A widely used solution to this problem is to choose a particular ordering of the variables and remove from the variability in each variable that portion that is explained by contemporaneous variability of variables earlier in the ordering. This is done through an orthogonal decomposition of the error variance-covariance matrix. Therefore, a check on appropriate variable ordering involves analysis of the magnitude of the contemporaneous correlations and a careful study of the forecast error decompositions associated with differing variable orderings. The results provide a guide to the ordering of the variables in the model. Changes in the ordering will result in different decompositions, especially when contemporaneous correlations are high. Differences in the decompositions attained from different variable orderings can provide information about direction of information flows between variables.

The final step in the analysis is to examine closely the impact over time of a one time "shock" to one of the price series in the system. Sims suggests this approach as one of the best descriptive devices to use in analyzing a system. This is accomplished by "shocking" the appropriate error term in the moving average representation of the model. Output from the statistical package[2] used generates plots known as impulse response functions which illustrate the effect of a shock in one series on itself and on all other series in the system. Typically, these shocks are a one standard deviation positive innovation to each price series. The technique reveals how future values of each variable will be affected by a shock today and provides a method of examining the magnitude and direction of the dynamic relationships in the model.

Results

Retail price data availability limits the analysis of price transmission in the lamb sector. Retail scanner data were obtained from a large retail food chain of over 40 stores in the Houston area. Weekly retail lamb prices from January 1987 through November 1988, a total of 98 observations, were compiled. When lamb prices were changed, they were changed in all of the stores. The wholesale price is the East Coast 55 to 65 lb. carcass price reported weekly by the USDA's Agricultural Marketing Service (AMS). The AMS Minnesota direct trade live lamb price series is used for live prices. Weekly lamb slaughter numbers reported by USDA are also used in the analysis.

Granger causality tests revealed that the retail lamb price is significantly influenced by lagged values of itself. Likewise, wholesale lamb carcass prices are influenced only by lagged wholesale prices. Live prices are significantly affected by lagged values of all of the prices in the model, including the retail prices. When taken alone, these results might suggest a derived demand framework is appropriate in explaining price information flows in the lamb market.

A high degree of contemporaneous correlation (coefficient = .49) was found between the live and wholesale price series. This correlation suggests that the price discovery process for these two series may be in large part based on the same information. As mentioned earlier, this also suggests the need to investigate different variable orderings to determine the most likely recursive system.

Decomposition of forecast error variance provides insight regarding the appropriateness of the first variable ordering investigated, retail-wholesale-live, a typical derived demand framework. In the very short run (1 to 4 weeks), nearly all of the forecast error variance in the retail price series is explained by variance in the retail price series itself. At longer forecast horizons (20 weeks), however, nearly half of the variation in the retail price series is explained by the variance in the live and

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[2]The empirical work reported in this paper was performed using Regression Analysis of Time Series (RATS).

wholesale price series. This is an initial indication that the market does not transmit prices in a strictly derived demand framework, suggesting that a different variable ordering may be more appropriate.

Similar decompositions were performed on the wholesale and live price series. In short, the results revealed that relatively little of the forecast error variance in either the wholesale price or the live lamb price could be attributed to variance in the retail price series. These results indicate that care should be employed in assuming that the price information in the lamb market is transmitted in a unidirectional derived demand framework from retail down to wholesale and live animal levels.

Perhaps a stronger argument can be made that the three price series follow a markup pricing scheme, similar to earlier findings in beef and pork (Miller, Boyd and Brorsen, Schroeder and Hayenga), but with the possibility of longer time lags. By switching the variable ordering to live-wholesale-retail, decomposition of forecast error variance yields insight into the validity of the markup pricing theory. Table 1 summarizes results. Notice that even with a long time horizon of 20 weeks, more than 70 percent of the variation in the live price series forecast is explained by variance in the live price series itself. This is an indication that the live price is nearly exogenous and confirms the appropriateness of placing the live price variable first in the ordering. Variance in the retail price contributes relatively little to forecast error variance in both the live price and the wholesale price at any time horizon.

Table 1.

Decomposition Of Forecast Error Variance For Lamb Prices, Markup Pricing Model.

Forecast Horizon	Variable	% of Variance Attributed To		
		Live	Wholesale	Retail
1	Live	100	0	0
5		71	22	7
10		72	14	14
15		71	12	17
20		71	11	18
1	Wholesale	24	76	0
5		43	53	4
10		54	34	12
15		57	28	15
20		59	25	16
1	Retail	2	2	96
5		22	4	74
10		39	5	56
15		45	5	50
20		48	4	48

This is an indication that the retail price should be placed last in the ordering. In addition, while little of the variation in the forecast retail price series is explained by variation in the live price series in the short run, as the horizon lengthens to 20 weeks, this proportion increases to nearly 50 percent in the markup model specification. This is an indication that price changes at the live level do eventually find their way to the retail level. The contribution of variance in live price to the variance in wholesale and vise versa cannot be analyzed with certainty due to the high contemporaneous correlation between the two.

The finding of pricing information flows from live to retail is confirmed by the impulse response functions for the markup pricing model, which show the response in all the price series to a one-time (1 standard deviation) shock to each of the variables in the model. The functions reported in this paper show percentage movements in prices of all the data series. The responses marked by stars show innovations that are significantly different from zero at the .05 level. Figure 1 demonstrates the dynamics of a shock to the live price series. The wholesale and retail prices tend to adjust to the shock at the live level, however the response is spread out over several weeks. The response function for retail prices, for example, takes 6 to 8 weeks to "peak" and show the strongest response to the shock in live prices. This figure shows a price response pattern that looks very similar to the findings in beef and pork when modelled in a markup pricing framework, however as suspected longer time lags are present.

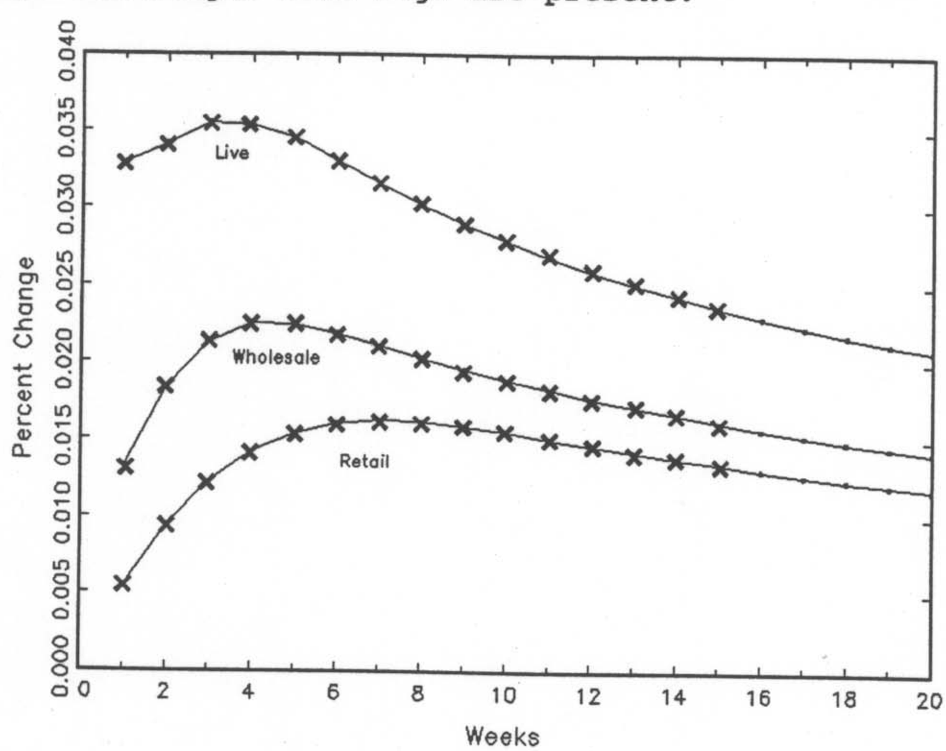

Figure 1. Impulse Response Functions Resulting From A Shock To The Live Price In A Markup Pricing Framework.

Figure 2 demonstrates the bi-directional flow of information apparently present in the system. A shock to the retail price series results in movement in the wholesale and live prices several weeks later, but the response is not as strong as the retail price responding to shocks at the live level, and the effects do not take as long to die out.

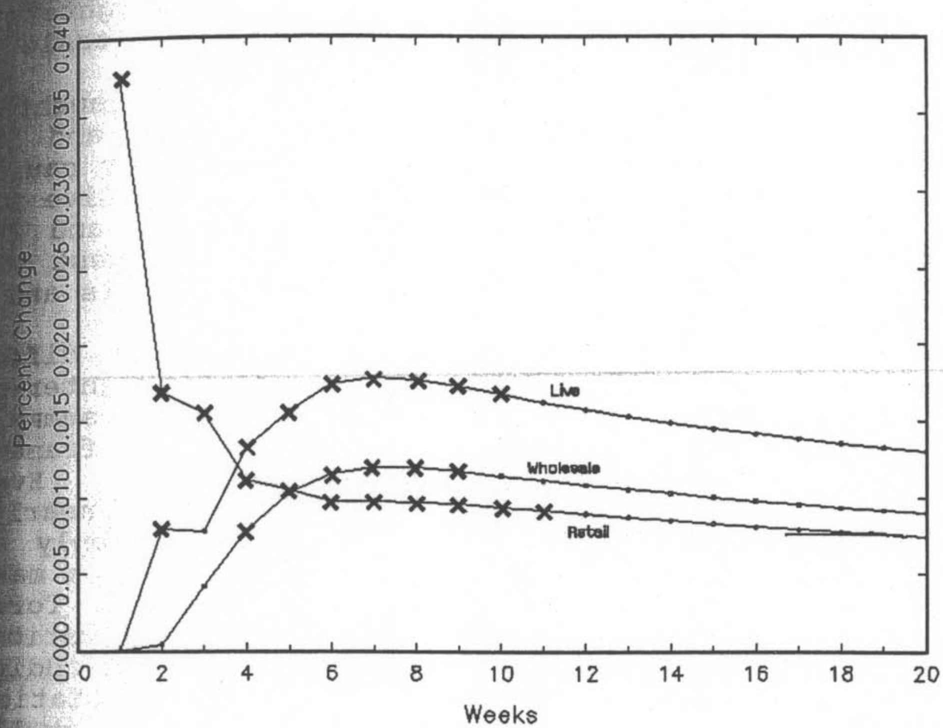

Figure 2. Impulse Response Functions Resulting From A Shock To The Retail Price In A Markup Pricing Framework.

The findings illustrated in Figures 1 and 2 lend general support to the markup pricing theory. Unlike previous results in the beef and pork markets, however, there is evidence of some bi-directional flow of information. In addition, these results support recent findings by the Texas Agricultural Market Research Center where a high degree of price transmission was found from the live level to the wholesale level. The Texas study found what they termed a "breakdown" in price transmissions from the live up to the retail level and from the wholesale to the retail level. The Texas study, however, did not directly analyze times of responses or the possibility of information flowing the other way in a derived demand framework. The analysis reported here finds significant time lags, with live price shocks taking up to 15 weeks to be fully reflected in the retail prices.

An Alternative Specification

Additional insights regarding the dynamics of the lamb marketing sector are provided when the wholesale price variable is dropped from the system, an adjustment justified by the high contemporaneous correlation between it and the live price series, and the apparent lack of any new information being incorporated into the wholesale price. Weekly slaughter is added as a proxy for quantity supplied in the market. The new three equation system thus includes live prices, retail prices, and slaughter numbers. The highest contemporaneous correlation present in this specification is .18 between live lamb prices and slaughter, much lower than the .49 found between the live price and wholesale price in the previous specification.

Granger causality test results suggest that slaughter is significantly influenced by lagged values of itself and lagged values of live lamb prices. Retail prices are Granger caused by lagged retail prices and lagged live animal prices. Live prices are Granger caused by lagged values of live prices and lagged slaughter levels. Thus, the causality tests suggest a bi-directional flow of information between slaughter levels and live prices.

Decomposition of forecast error variance under differing variable orderings reveals that an ordering of slaughter-live-retail is likely the most appropriate model. Table 2 summarizes the results of the forecast error decomposition in this framework. The slaughter variable appears to be nearly exogenous. Even at long forecast horizons, the slaughter variable explains nearly all of the forecast error variance in slaughter. The only added explanatory power comes from the live price series which makes a small contribution to explaining the variation in forecast slaughter levels. This result provides a strong justification for placing the slaughter variable first in the ordering. In addition, the live price series explains the majority of the variation in forecast error variance in the live price series, with very little explanation coming from the retail price series. This supports earlier findings indicating that changes in the prices at the retail lamb level are only partially and slowly transmitted down to the live level, and justifies placing the live price ahead of the retail price in the ordering. Variation in the forecast retail price is composed of mostly variation in the retail price series itself in the short run. However, over half of the variation in forecast retail prices can be attributed to the variation in the live price series at longer horizons (20 weeks), adding further support to the markup pricing theory.

Table 2.

Decomposition Of Forecast Error Variance With Slaughter Numbers Included In The Model.

Forecast Horizon	Variable	% of Variance Attributed To		
		Slaughter	Live	Retail
1	Slaughter	100	0	0
5		89	10	1
10		89	10	1
15		88	11	1
20		88	11	1
1	Live	3	97	0
5		4	92	4
10		4	86	10
15		4	84	12
20		5	83	12
1	Retail	0	0	100
5		2	14	84
10		2	42	56
15		2	52	46
20		3	56	41

Impulse response functions, with confidence intervals on the innovations, were generated in the same manner as described for the earlier model. The impact of a sudden (1 standard deviation) increase in slaughter level is illustrated in Figure 3 and reveals that the positive shock to slaughter level would result in a small increase in the live price the same week, with both price series (live and retail) and the slaughter level returning to pre-shock levels in a 2 to 3 weeks.

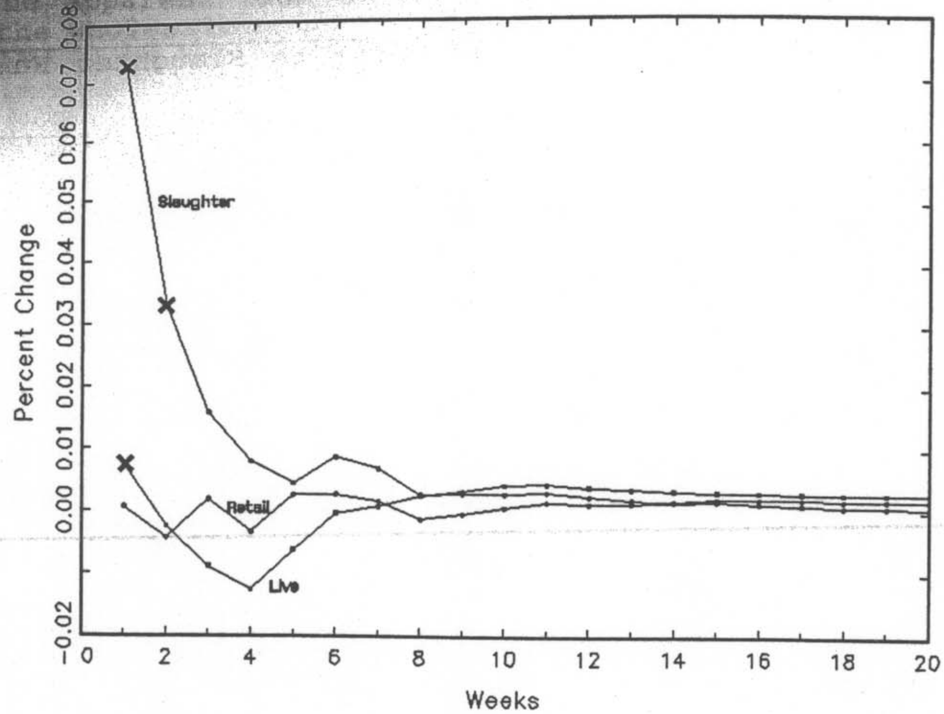

Figure 3. Impulse Response Functions Resulting From A Shock To The Slaughter Variable.

Figure 4 reveals that a positive shock to the live price would be followed by an increase in the slaughter level as well as an increase in the retail price the following week. The live price itself appears to take several weeks to come down from the shocked level. A shock to the retail price has no significant impact on future values of the live price or slaughter levels when modeled in this framework.

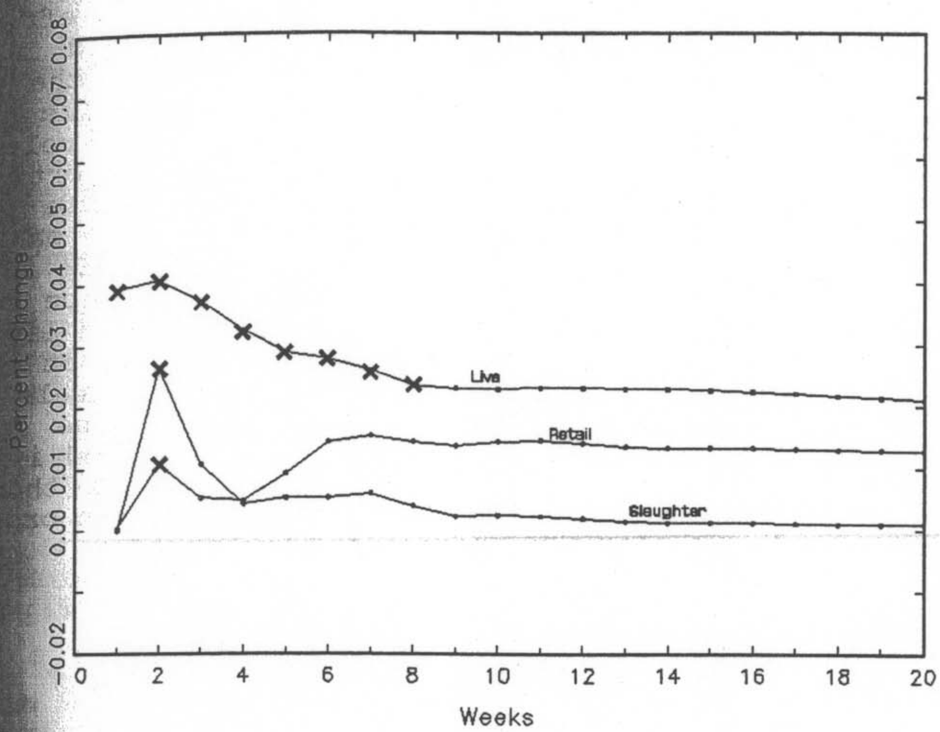

Figure 4. Impulse Response Functions Resulting From A Shock To The Live Price Series.

Summary

This analysis lends support to the theory that the lamb marketing sector follows a markup pricing scheme more closely than a derived demand pricing structure. This is consistent with the findings of Miller, of Boyd and Brorsen, and of Schroeder and Hayenga in the beef and pork marketing channels. It appears that changes in supply factors at the farm level initiate price changes and dominate the price transmission process. There are, however, clearly long time lags and evidence of incomplete price transmission from the live animal level up to retail in the lamb marketing system. The price discovery process for lambs, as the markets are presently structured, is therefore slow and relatively inefficient. Price signals that the producer receives and responds to are transmitted only partially and slowly through the system. The time lags are longer than the time it takes lamb products to pass through the marketing channel, suggesting the markup pricing theory can only partially explain the findings. Consistent with analyses in other meats, there seems to be a reluctance on the part of retailers and wholesalers to change prices until they are sure the price change at the live animal level is not short run in nature.

These shortcomings in the price discovery process may have helped cause the lamb sector to fall behind in the competitive struggle for the consumer's meat dollar. Better industry-wide understanding of the price transmission process in the lamb sector and broader recognition that it is both slower and less effective than the comparable processes in beef and pork should improve producers' knowledge base, improve the efficiency of the price discovery process, and contribute to more effective public policy and market reporting activities over time. Of particular relevance to policy decisions surrounding publicly supported reporting of prices is the need for a statistically valid and visible retail lamb price series. No publicly reported retail series has been available since the earlier series was dropped by the USDA in 1981 for budgetary reasons. A regularly reported retail price series would allow calculation and reporting of spreads between live and retail price levels and the monitoring of price changes at retail relative to price changes at wholesale and live animal levels. The effectiveness of the price discovery process and the timely transmission of price information might well be improved if this information were available. At the very least a more thorough analysis involving structural models would be possible in order to gain a better understanding of this market.

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