



A dynamic price and supply model of the U.S. pork industry
by Cecil Dee Black

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in
Applied Economics
Montana State University
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Abstract:

A rational distributed lag model of prices and supplies is estimated for the farm, slaughter, and retail levels of the U.S. pork industry. The rational lags are estimated for estimation of nonstochastic difference equations. Estimation of nonstochastic difference equations allows for precision of the disturbance process from the systematic portion of the regression equations. Short, intermediate, and long term supply elasticities and price flexibilities are calculated to measure dynamic responsiveness within the industry. Interpretations and implications of the regression results are given in the body of the thesis.

The flexibility of the rational generating function permitted the measurement of biological and economic factors in the market. On the supply side, the ratio of hog prices to corn prices had a significant influence on farrowing and slaughtering decisions. However, the supply elasticities were relatively small, reflecting high investment costs in confinement technology. On the price side, the dynamics were less pronounced since pricing decisions are closely tied to short term wholesale pricing.

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Bozeman, Montana

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of a thesis submitted by

Cecil Dee Black

This thesis has been read by each member of the thesis committee and has been found to be satisfactory regarding content, English usage, format, citation, bibliographic style, and consistency, and is ready for submission to the College of Graduate Studies.

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Date June 6, 1984

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ABSTRACT

A rational distributed lag model of prices and supplies is estimated for the farm, slaughter, and retail levels of the U.S. pork industry. The rational lags are estimated for estimation of nonstochastic difference equations. Estimation of nonstochastic difference equations allows for preclusion of the disturbance process from the systematic portion of the regression equations. Short, intermediate, and long term supply elasticities and price flexibilities are calculated to measure dynamic responsiveness within the industry. Interpretations and implications of the regression results are given in the body of the thesis.

The flexibility of the rational generating function permitted the measurement of biological and economic factors in the market. On the supply side, the ratio of hog prices to corn prices had a significant influence on farrowing and slaughtering decisions. However, the supply elasticities were relatively small, reflecting high investment costs in confinement technology. On the price side, the dynamics were less pronounced since pricing decisions are closely tied to short term wholesale pricing.

CHAPTER 1

INTRODUCTION

The U.S. pork economy has been characterized by change, much of it credited to technological advancements and market reorganization. The resultant system is a complex network of markets, whereby consumers, retailers, agribusiness firms, and producers interact to establish market prices and quantities. Some of the important technical and economic changes that have occurred within the production and marketing sectors of pork include¹:

Enabling Factors:

1. The enlargement of grain farms associated with crop technology, thus, increasing domestic feed supplies,
2. Animal technology—antibiotics, genetics (leaner hogs), and specialized buildings and equipment.
3. Changed producer perceptions toward hog production enterprises,
4. Economics of size in farming operations.
5. Credit availability for needed financing.

Motivating Factors:

1. On the average, hog-corn ratios over the 1970-1982 time period have been favorable to expand sow herds. However, they have also demonstrated considerable variation.
2. Incentives from income tax rules have promoted fast growth of larger operations.

¹ U.S., Congress, Senate, Committee on Agriculture, Nutrition, and Forestry, Farm Structure, Committee Print, 96th Cong., 2nd Session, April 1980.

3. Anticipated further inflation as a motivator of growth now.
4. Improvement in consumer demand as attitudes towards pork products have improved.

Much of the structural change in the hog industry was a mere reflection of overall changes in postwar U.S. agriculture. Hog enterprises kept pace with the general increase in the size of farms and the substitution of capital for labor to reduce unit costs of production. Thus came the growth of large commercial farrowing and finishing operations. Within the realm of hog production, confinement buildings, mechanized handling of feed, water and wastes, and ventilation have become standard practices. Within the realm of hog marketing, more efficiency has been gained through increased direct sales to packers, horizontal specialization in packing plants, selling hogs on a carcass grade and weight basis, and advertising and promotion of pork products.

The importance of marketing hog and pork products is revealed in dollars generated. In 1982, farm sales were 136.2 billion dollars, of which 70.2 billion dollars was based directly on livestock production.² Revenues generated by individual livestock production species were: beef and dairy 48.2 billion dollars, pork 10.6 billion dollars, poultry 9.2 billion dollars, sheep and lamb .4 billion dollars, and other livestock 1.5 billion dollars.³

Statement of the Problem

Dynamic behavior in production, marketing, and consumption characterizes the total pork industry. Each level of the market independently exhibits its own characteristics and also interacts with other market levels in the industry (i.e., packers interacting with producers and retailers). These interactions significantly influence the variation in pork

² Addition of individual totals will not equal sector total due to rounding.

³ U.S. Department of Agriculture. Economic Research Service. "Indicators of the Farm Sector: Income and Balance Sheet Statistics." Statistical Bulletin ECIFS 2-2. Washington, D.C.: Government Printing Office. 1982.

demand, supply, and prices. Quantification of such demand and supply behavior in the pork industry would give a better understanding of the industry's economic forces and would also aid in forecasting important variables in the industry. Such information can lead to a more efficient allocation of resources in both hog production and marketing decisions.

Objectives

The major objectives of this research are:

1. To formulate a dynamic econometric model depicting the production, processing, and retail structure of the hog-pork economy. Emphasis is on specifying market price and supply equations.
2. To statistically estimate the parameters of the conditional probability distributions above by an appropriate regression method.
3. To assess the distributed lag effects (short, intermediate, and long term impacts) on the dependent variables from changes in economic and technical variables in the pork industry.

Procedures

The hog-pork market structure is represented by behavioral supply and price equations, formulated by economic theory, a priori knowledge of the livestock industry, and previous research. The model includes supply and price equations at the market levels of the producer, processor, and retailer. The sample period includes the years 1969 through 1982. The units of observation are defined on a semiannual period, which is consistent with the semiannual production period of market hogs. The structural parameters of the model are estimated by a nonlinear least squares algorithm, incorporating both nonstochastic difference equations and serial correlation in the error structure.

The distributed lag patterns of the endogenous variables assist in assessing the time path behavior of market price and supplies. They are calculated from a mathematical algorithm that estimates the partial derivatives of the equations both period by period and cumulatively, jointly using the parameters of the exogenous regressors and difference equations.

The following is a discussion of market structure and practices in the pork industry. This information is an important input in formulating the economic model to be presented in Chapter 2.

Dynamics of the Pork Industry

Many factors, individually and collectively, determine the supply and demand for pork at the farm, processor and retailer levels. Overall, the social, economic and technical factors that affect primary and derived demand and primary and derived supply interact to determine equilibrium consumption, production, prices and marketing margins.

Over time, changes in consumer preferences have led to more consumption of lean pork with a marked decrease in lard consumption. Pork production in 1960 yielded 10,863 million pounds of meat and 2,419 million pounds of lard, while 15,719 million pounds of meat and 1,155 million pounds of lard were produced in 1981.⁴ Per capita consumption of all meats in the United States increased by 25.76 pounds from 1960 to 1981, with the bulk of the change attributed to increased beef and poultry consumption. Poultry itself has experienced a 34 percent increase in per capita consumption since 1967. Pork and mutton and lamb consumption levels have remained relatively constant. Per capita pork consumption in 1969 was 65 pounds and decreased to 62.7 pounds in 1982.⁵

⁴ National Pork Producers Council. Pork Industry Statistics. Des Moines, Iowa, 1982.

⁵ U.S. Department of Agriculture. Economic Research Service. Livestock and Meat Statistics. Bulletin No. 522. Supp., 1982.

Because of increased consumer demand for lean meat, pork production trends have been toward hogs that consist of a higher lean to fat ratio. These hogs are being produced on fewer farms with increased technological and production capabilities (i.e., confinement operations). During the 1970 to 1982 period the average dressed weight of hogs decreased 7.6 percent, the number of hogs slaughtered increased 12.2 percent, and meat produced increased 21.3 percent.⁶ Therefore, the increased pork production (i.e., meat) is due more to hog type than animal size or number slaughtered.

Based on time series data, hog prices received by farmers have been characterized by large fluctuations (shown in Table 1). These price fluctuations reflect changes in market supply and demand conditions. The demand side changes include: (1) population size, (2) the level of inflation, (3) the level of consumer income and income distribution, (4) prices and availability of substitutes, and (5) consumer habits and preferences. Supply side changes include: (1) technology, (2) product substitutes, and (3) production and marketing factor costs (including interest).

Marketing margins change over time as a result of changes in the determinants of the demand for and the supply of marketing services. Changes in marketing margins shift either the primary or derived demand curves, depending upon the nature of the change (i.e., introduction of a new service or a cost change for existing services). A change in the cost of existing marketing services impacts both the retail and producer levels. For example, a wage increase in meat packing industry has the effect of decreasing both derived demand (downward shift) and derived supply (backward shift). All other factors held constant, the result is an increase in retail price and a decrease in farm price. The magnitude of change at each level is dependent upon the relative slopes of the primary supply and demand curves (Tomek and Robinson).

⁶ Ibid.

Table 1. Summary Statistics of Pork Prices and Supplies, 1969 through 1982.*

Year	Barrow & Gilt Slaughter Price (\$/hundred wt.)	Barrow & Gilt Slaughter Supply (thous. of head)	Sow Slaughter Price (\$/hundred wt.)	Sow Slaughter Supply (thous. of head)	Retail Price (\$/hundred wt.)	Retail Supply (mil. of lbs.)
1969	23.21	70342	20.14	5010	73.26	7433.8
1970	46.88	71086	19.51	4937	78.94	7609.95
1971	36.25	81026	15.11	5354	69.94	8605.0
1972	26.04	74685	22.44	4704	81.36	7961.2
1973	39.86	67586	35.03	4272	106.94	7220.3
1974	35.51	70723	29.63	5256	98.33	7784.9
1975	48.42	61327	42.89	3708	131.73	6537.8
1976	44.69	65540	38.14	3359	136.55	6909.7
1977	40.80	69542	38.44	4056	124.22	6719.2
1978	48.00	69581	42.80	3911	141.88	6755.1
1979	43.42	78776	37.60	4648	145.30	7676.5
1980	39.51	85654	35.27	5214	138.05	8317.9
1981	44.85	82072	40.68	4608	152.10	8066.3
1982	54.20	74412	46.93	3959	173.21	7305.4

*U.S. Averages, taken from monthly U.S.D.A. data.

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General Market Structure

The U.S. pork industry can be separated into several sectors: (1) production of breeding stock, (2) production of market hogs, (3) slaughter and processing, and (4) retailing of the final product. The majority of hog production occurs within the Midwest, close to the major source of feed (i.e., corn). Oftentimes the production of breeding stock and the production of market hogs are pursued simultaneously. These are referred to as farrow to finish operations. In some cases the functions are performed separately (i.e., strictly feeder pig production and strictly finishing operations). Within recent years technological advances have made confinement operations more prominent. The result has been a decrease in the number of producers with increases in average size and productivity of those remaining. Confinement operations are more capital intensive because of reduced labor requirements, and since there has been a growing market for lean pork, the result has been efficient production of the slaughter hog.

Slaughtering and processing are the next stages in the pork marketing channel. Their principal function is to slaughter, process and package fresh and cured meats. Hog slaughtering and processing plants are located throughout the U.S., but the volume of slaughter is largest in the North-Central states. This location coincides with greatest concentration of hog production.

Since the early 1920s, the market concentration of meat packing firms has declined. This has been reflected by changes in firm size in the national market. On a regional level, the market may indeed be classified as imperfect competition. Size structure refers to the volume of slaughter held by one firm or several firms relative to total slaughter. The factors that account for declining concentration include: (1) new firms have entered and are slaughtering increasing portions of livestock produced, (2) small firms that remained in the industry have experienced more rapid growth than the remaining larger firms, (3) increased

species specialization by slaughtering and processing firms (attributed to technical efficiency), and (4) federal inspection and grading of carcasses have enabled small firms to compete more effectively with larger firms. The combination of increased farm size and structural changes at the slaughter levels has been to reduce the importance of terminal markets and, to a certain extent, local auctions. This has led to a greater percentage of direct producer to packer sales rather than local auction market transactions. Currently, direct sales constitute more than 70 percent of total national hog sales (Sheperd and Futress, 1982).

Processors sell pork to retailers in a more highly processed form compared to beef, lamb and mutton, and poultry. On a regional basis, the structure of most retail markets is classified as monopolistic competition (Holdren, 1964). Retailers sell in local markets where the market is delimited by time and space, producing a certain amount of isolation from direct price competition and, thus, relying more upon non-price competition.

Many market participants in the livestock-meat economy have voiced concern over the structure and conduct within the food industry. Small retailers argue that large processors have undue market power, while small processors maintain they are at the mercy of large retailers. Consumers feel they are being exploited and are impotent in implementing corrective measures. Farmers feel that since they are the smallest and least organized institution in the food industry, they lack bargaining power and have limited marketing alternatives. Both consumers and producers have expressed concern over middlemen functions due to the increasing size of marketing margins. However, Tomek and Robinson indicate that the size of the margin itself does not automatically imply inefficiencies or profiteering in the marketing sector.

The next chapter presents a review of the literature relevant to the estimation of supply and prices in the pork industry. Also, a discussion of distributed lag models and the formulation of the hog-pork model for this thesis will be presented. The empirical results

are presented in Chapter 3. The final chapter summarizes the accomplishments of this work and directives for further study. Appendix A presents the raw data used in estimating the models.

