ANALYSIS OF THE EFFECT OF PACKING CAPACITY ON PORK PRICES

A Senior Honors Thesis

By

SARAH ELIZABETH SPIVEY

Submitted to the Office of Honors Programs
& Academic Scholarships
Texas A&M University
In partial fulfillment of the requirements of the

UNIVERSITY UNDERGRADUATE

RESEARCH FELLOWS

April 2000

Group:

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ABSTRACT

Analysis of the Effect of Packing Capacity on Pork Prices. (April 2000)

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In 1998, pork prices fell to an all time low. Across the industry concern was expressed for research as to what led to this price crash. Capacity constraints at the packer level have been a key area of concern. This study is an analysis of the effect of capacity constraints on pork prices. Ordinary least squares (OLS) models were run for both live and cutout prices. Capacity constraints were measured three ways: using a binary variable (0,1 dummy) and two continuous variables. One continuous variable was for the number of head slaughtered on the weekend, and the second continuous variable was found by using a ratio of slaughter during the weekends to slaughter during the 5-day work week ("over-flow" ratio). The continuous variables used to measure capacity constraints were statistically significant explanatory factors in the regressions for hog and pork prices. The capacity constraints were estimated to have a different relationship with the prices at the farm level as compared with packer prices. Increasing capacity constraints is associated with a negative relationship to farm prices, and a positive relationship to packer prices. The measurement used for over-flow ratio, the ratio of weekend slaughter to slaughter during the 5-day workweek, did not generate different

results than the continuous variable of weekend slaughter. The estimated coefficients for both continuous variables were more statistically significant than a dummy variable approach for the capacity constraint.

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To Lee, Stephanie, and Jimmy, thank-you for keeping me in line. I think the world of you, and I appreciate your friendship greatly.

To my family, thank-you for smiling and nodding. I know this has been a long, rough road, but May is almost here. Whoop! I appreciate your support, and love you dearly.

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CHAPTER I

INTRODUCTION

Currently, pork is the third most consumed meat, on a per capita basis, in the United States. The goal of the National Pork Producers Council (NPPC) for the past decade has been to surpass beef in consumption by the year 2000, and make "U.S. pork the consumer's meat of choice" (NPPC, 2000). In 1999, domestic per capita pork consumption is estimated to be 54.2 pounds (retail weight), surpassing previous years ("Livestock, Dairy and Poultry Situation and Outlook, 2000). Pork exports exceeded $1 billion dollars in 1998 (NPPC, 2000).

The pork farming industry has had a facelift. In the last five years, there has been an 84% increase in the number of large hog operations (defined as those with more than 5,000 hogs), and there has been a 50% decrease in the number of small farms, those with less than 2,000 hogs. The number of contracted hogs going to market also increased 29% from 1994 to 1997 and is steadily rising (Luby, 1999).

But, this expansion revealed another issue in the industry, that of production exceeding packing capacity. Shackle space (packing capacity) had decreased over time as plant closing outstripped the capacity of new plants coming on line. Last year alone, packing capacity fell 4% with the closing of Thornapple Valley's plant in Detroit (Luby, 1999). Packing plants were forced to run at more than full capacity for extended periods of time. Some observers feel that this capacity constraint has caused pork producers to experience the lowest hog prices ($8/cwt) in any relevant historical period (Lucas, 1998).

The price crunch felt by the hog industry resulted in many questions as to what led to the problems, and how to prevent a repeat of last year's devastation. In order to understand why the prices fell, all aspects of the market must be reviewed. Capacity constraints at the packer level have been a major topic of concern for both the farmer and the packer. These constraints are thought to be a major factor leading to lower prices.

Concern for research on the effects of capacity constraints on pork prices has been voiced by many, but little research has been done. In this light, we analyze the effect of capacity constraints on pork prices. Prices at two different levels of the farm-to-consumer market channel are of interest. Farmers are concerned about the price they receive (live price). Government policy makers who are considering possible questions of market power exertion by processing firms also focus strongly on trends in live hog prices. Processing companies pay live price to their suppliers, but their revenue depends on the price of slaughtered animals. This price is termed the "cutout" price. We separated live and cutout prices into two models, in order to analyze the effects capacity had at each end of the market, farmer and packer. This study makes a contribution to the following areas of concern within the industry: 1) little information currently exists pertaining to the analysis of capacity constraints and pork prices; and 2) no study has been conducted using separate models for live and cutout prices.

Objectives

The objective of this paper is to evaluate the effect of packing capacity constraints on hog and pork prices. There are two main objectives of this research.

The first objective is to analyze the effect of capacity constraints on live and cutout prices separately. Live prices are representative of the prices received at the producer level, whereas cutout prices are representative of prices received at the packer level. Separation of the two prices allows for a comparative analysis of the impact of capacity constraints on each price. The results may be useful for understanding the relative position of farmers and processors in the hog-pork market channel.

The second objective is to analyze the usefulness of various capacity constraint measurements. At the present time, various capacity constraint measurements have been suggested by the pork industry, but no definite measurement has been created. Analysis of three capacity constraint measurements, in this study, allows for more comprehensive analysis. The exploration of relevant variables conducted here will be valuable to future applied researchers in this field.

Literature Review

This study is unique in its kind. Very little work has previously been done on measuring the effects of capacity constraints on pork prices, and no other study has distinguished live price from cutout price when modeled. Existing literature on linear regression and modeling, asymmetric price transmission and the effects of capacity constraints on the price spread between live and cutout prices are available. The literature that is available contributes to pork pricing research, and aids in this research, but is not a direct guide to the models used here.

This study employed the use of linear regression models. For a linear model, the slope is constant (Studenmund and Cassidy, 1987). An equation is linear in the *variable* if plotting the function in terms of X and Y generates a straight line. An equation is linear in the *coefficients* if the coefficients appear in their simplest form-they are not raised to any powers, are not multiplied or divided by other coefficients, and do not themselves include some sort of function. A linear function is a function of the form:

$$Y = \beta_0 X + \beta_1 b$$

where a and b are constants. The regression model is assumed to be linear in the coefficients:

$$Y_i = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \ldots + \beta_{ki} X_{Ki} + \varepsilon_i$$

where the βs are linear coefficients, i = 1,2,…n (sample size), k = 1,2,…k (number of explanatory variables), and ε is the stochastic error term. The stochastic error term is a variable that is added to a regression equation to introduce into the model all the variation in Y that cannot be explained by the included Xs. The use of linear regression models is basic and common in economic studies. It is generally considered that this is a good starting point when beginning a new research project.

Existing literature on asymmetric price transmissions on a variety of agricultural commodities are available. Price transmission elasticities refer to the percent change in a price in a given system divided by a percent change in the price (Ferris, 1998). Asymmetric price transmission as described by Hahn is nonlinear phenomenons (Hahn, 1989). In his study, endogenous switching regressions were used to model which coefficients change, when endogenous variables change. In this model all prices were simultaneously determined, and asymmetry was found to be an important part of meat price transmission. Hahn stressed the importance of realizing that price transmission asymmetry could be a result of market power. Hahn speculated that because of a lack of competition in the short run, meat marketers may be able to keep their prices high even though their costs have fallen.

Many facets of the pork industry have voiced concern for research on the effects of capacity constraints on pork prices, but little research has been done. The only research to date on the effects of capacity constraints was conducted by the Food and Agricultural Policy Research Institute (FAPRI) (Brown). In the report by Brown, a dummy variable for capacity constraint was used to explain the effects of capacity constraints on the price spread between live and cutout prices. The dummy variable represented when slaughter exceeded 160,000 head for three consecutive weekends. This measurement was used to estimate the impact of capacity constraints for the last three months of 1998 (Brown, 1999). The last three months of the year generally have the highest number of hogs slaughtered, and this dummy was included in the equations used in this research. The use of this dummy helps explain the capacity constraints over a longer period of time. When capacity constraints are felt for only one week, the market is able to adjust. When above capacity levels are being met for more than three weeks, the market is not able to adjust and prices are affected. Brown's results suggested capacity constraints have a significant effect on pork prices, and prices may have been as much as $5.85 higher in 1998 had capacity constraints not been a factor.

In this paper, we use a similar version of Brown's model, following his lead of making weekly slaughter and a capacity constraint measurement explanatory variables. We chose to model live and cutout prices separately rather than a spread. This method has not been done previously to our knowledge.

Chapter Summary

To review, the available information on the effect of capacity constraints on pork prices is limited. Across the industry, from both the packer and producer sides, capacity constraints are mentioned as a major contributing factor during times of depressed pork prices. The main objective of this study is to measure the effects of capacity constraints on pork prices. Since capacity constraint has been blamed for the problems, a good measurement will allow researchers to test this hypothesis.

In this study linear regression models were used to explain the effects of capacity constraints on pork prices. Linear regressions are the simplest models, and are a good starting point for research in a new area. If capacity constraints are not found to have a significant effect on prices, due to an actual lack of significance or due to an inappropriate measurement, researchers are left at square one. Due to the lack of research on this topic, this study is timely.

The unique questions asked in this study are what effect does capacity constraint have on live and cutout prices when modeled separately, and can an accurate capacity constraint measurement be determined.

CHAPTER II

THE PORK INDUSTRY

Introduction

Many Americans do not know what a profound effect the pork industry has had on our lives. Wall Street, "Uncle Sam", and "living high on the hog" are examples of terms we use daily, that stem from the pork industry (NPPC, 2000). Yes, Wall Street was aptly named for a wall that was erected in colonial New York City to prevent wild hogs from running through the streets of Lower Manhattan. "Uncle Sam" was a packer, Uncle Sam Wilson, who shipped crates of pork to the soldiers in the War of 1812. The crates were stamped with US. Shortly thereafter, the soldiers began referring to US as Uncle Sam, and our national symbol was born. "Living high on the hog", is a phrase soldiers used because officers received top loin cuts that are located higher on the hog than the leg and shoulder cuts that enlisted soldiers received. In addition to inspiring various adages and symbols that we have come to recognize, Americans eat pork.

Currently pork is the third most consumed meat in the US, more than 50 pounds per capita are eaten annually ("Livestock, Dairy and Poultry Situation and Outlook, 2000). The U.S. pork industry is responsible for over $64 billion in total domestic economic activity (NPPC, 2000). In 1997 alone, over 17 billion pounds of pork were processed from approximately 93 million head of hogs. The annual farm sales in the United States exceeded $11 billion, and the retail value of pork sold to consumers exceeded $30 billion. The pork industry also provides over 600,000 jobs throughout the

U.S. annually. These staggering statistics add up to one important point – the pork industry has a profound effect on the American economy.

This chapter explains the past and present make up of the industry. A detailed description of the producer sector and how hogs are raised is discussed. The way hogs are marketed and the changes the industry is currently undergoing are also explained.

Industrialization of Hog Farms

The pork industry is currently undergoing a major reconstruction period. From the way hogs are produced to the way they are marketed, changes are occurring. New technology from the production side has resulted in a shift from traditional farming to industrialized, mass producing farms.

Traditionally, hogs have been produced on small (those farms controlling less than 1,000 head of hogs) Midwestern farms. Grain is a key source of food for hogs, and is relatively inexpensive and readily available in the Midwest states. Generally, hogs were produced on farrow-to-finish farms with less than 1,000 hogs (Espinoza, 1998). Farrow-to-finish farms are typically managed by a single household and involve all stages of production from breeding through finishing to market weights of averaging 262 lbs, the typical market weight of a hog ("Livestock Monitor," 2000). Farrowing is the process of the sow or gilt giving birth to their pigs. Baby pig management, weaning, and feeding are intermediate steps before finishing. Finishing is the final step, in which the market hog is fed until it reaches its market weight (Taylor, 1995).

Recent advances in the areas of production systems and technology have moved the hog industry in a new direction. Technological advances, such as artificial insemination improvements, computerized housing systems, and industry wide selective breeding for specific genetic qualities have enabled producers to produce larger litters of leaner and higher yielding pigs. One example of increased productivity can be seen with the increase of average litter size. In 1995, the average number of pigs weaned per litter was 8.5, a 1.25 head increase over the average litter size in 1980 (Espinoza, 1998). Advancements like these have made it economically feasible for the pork industry to expand.

Basic economic principles teach us that technology is a determinant of supply. As technological advancements lower production costs, an increase in supply occurs (Figure 1). The shift in the supply curve from S_1 to S_2 results in a shift in the equilibrium, and a lower equilibrium price. This lowered price changes the producers' revenue.

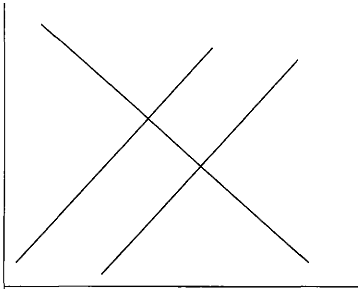

Figure 1. Supply Shifts

Technological advancements in the pork industry have resulted in a rapid growth of larger more specialized production and processing operations across the country. These systems utilize repeatable methods and specialization at each level of production (NPPC, 2000). Production systems separate each level of production (breeding, farrowing, weaning, feeding and finishing) (Espinoza, 1998). Often, each level is intensely managed by separate owners or managers.

Each level may or may not be located on the same farm. The hogs that are managed at each level generally are on contract with larger companies. These large companies typically have contracts with packing plants.

Consolidation of the pork industry into these more specialized production systems has only been a recent advancement. The most dramatic change was during the time period of 1993 through 1998. Large farms, those with over 5,000 hogs, rose 84% from 990 in 1993, to 1,825 in 1998 (Luby, 1999). Medium sized farms, those controlling 2,000-5,000 hogs, grew 41% from 3,390 to 4,770 during the same time period. Small farms, however, declined 50% from 213,680 to 107,695 over the five-year period. The reduction in the number of small farms could be a result of two things occurring in the industry. One, small farmers may not be able to return a profit with the lowered equilibrium price, and as a result close their operation. Secondly, small farmers may be investing in technological advancements and may have become a part of the larger farm sector.

Whether or not this rapid expansion of the pork industry has been an improvement is still not clear. The majority of this growth has occurred in the southeastern states, specifically North Carolina. Presently there is limited legislation on the pork industry in these states, and an increase in "mega-producers" continues. Farmers in states such Iowa, Kansas, and Illinois, where traditional hog farms have been a way of life, are desperately trying to prevent mega-producers from overtaking the independent family farms. But many of the states' governments are torn. There is the realization that the industry is headed into a new "high tech," mass-producing industrialization age, where small and inefficient farmers will flounder, while those who are willing to convert will prosper. David Topel, of Iowa State University, believes it is possible for both the corporate farms and the traditional family farms to work simultaneously to develop a stronger industry in the Midwest (Warrick and Smith, 1995). He, as well as many state officials, believes that excluding the corporate farms will result in a detrimental loss of capital and innovations that the big companies bring.

Changes in the Pork Industry

Industrialization in agriculture refers to the use of modern methods of manufacturing, production, and distributions (Martinez, Smith, and Zering, 1997). Efforts to industrialize the pork industry have been in response to the changes in consumer preference and a growing market for pork.

Terms that are commonly associated with industrialization include vertical integration, vertical coordination, and contracting. Heavy investment in specialized facilities may be a leading factor for the association of industrialization with these business factors. Vertical coordination, as defined by Martinez, includes all the ways of synchronizing vertical stages of a marketing system (Martinez, 1999). Open market prices, contracting, and vertical integration are examples of coordination. Vertical integration, as defined by Martinez, is the method of vertical coordination representing the greatest degree of control that a firm can gain over another stage of production; coordination of two or more stages occurs under common ownership via management directive. This can be seen through production operations of many of the "mega-producers."

Economic advancement of this integration occurs by ownership. Linking each level of production provides a faster means of responding to a changing market because each level is able to specialize (breeding, farrowing, etc). This allows each level to respond to changes faster and more efficiently. For example, managers of a breeding farm spend all their resources selecting and breeding for specific characteristics, whereas a farrow-to finish producer must allocate resources to each level of production. The breeder can adjust more quickly to demands in quality than the farrow-to-finish producer because the breeder is only breeding. These pigs are then passed through the integrated chain of producers. The farrow-to-finish producer must work with the genetics that has been put into the current finishing hogs as well as the newly bred sows.

Part of the trend of industrializing the pork industry has been a revolution in how hogs are marketed. Contracts are now an integral part of the marketing of hogs. There are two major types of contracts being used in the pork industry-production and marketing contracts.

Production contracts are contracts made with producers at the farrowing or the finishing level of production by a larger producer or company. In 1997, an estimated 40% of hogs farrowed and 44% of hogs finished were produced on production contracts (Lawrence, Grimes, and Hayenga, 1998). This was an estimated 29% increase from 1994. Not surprisingly, the increase in contracts was most noticeable in the large farm sector.

Marketing contracts are contracts that are directly between producers and packers. There are two types of marketing contracts that are commonly employed. The most common type of market contracts is a formula price contract (Lawrence, Grimes, and Hayenga, 1998). These contracts are ongoing agreements between the producer and the packer in which the selling price is based on an observable market (Lawrence, Grimes, and Hayenga, 1998). In 1997, approximately 39% of all hogs were marketed on formula price system contracts, and approximately 75% of all producers producing more than 50,000 head of hogs were on this form of contractual agreement. Another form of market contract is a risk share window contract, which is a contract of fixed length in which the packer and the producer share the gain and losses above or below the predetermined upper and lower price boundaries. Medium sized producers are the main group of producers involved in these contracts. From the breeding to the finishing stage, many producers are opting for contracts rather than selling at market prices.

When surveyed, producers who were on contract rated increased prices and the ability to participate in the hog industry as incentives for continuing the use of contracts (Lawrence, Grimes, and Hayenga, 1998). Many producers are willing to sign contracts in order to enjoy the security that the contracts somewhat provide, and hope the contracts will help protect them from disastrous prices such as those of 1998. In a study released in March 2000, over 70% of all hogs sold in January 2000 were on some form of contractual agreement, which is up 23% from just three years ago (Grimes and Meyers, 2000). With the increase of production systems and specialized farming, the number of contracted hogs is also expected to rise.

Regardless of the type of production or marketing system used, profit is ultimately the incentive for producing hogs. Traditionally the price paid for a hog was negotiated on the basis of the live weight of the hog. The pricing system began in the open markets during the 1800's and has only recently been changed (NPPC, 2000). This system often benefited producers of lower quality hogs, and penalized those producers of high quality hogs (Espinoza, 1998). Lower quality hogs may meet weight requirements thus receiving higher prices than their lighter weight counterparts, but may require more fat trimming. This costs the packer additional time for trimming, and money due to less lean meat. On this system, leaner, lighter hogs would receive a lower price at market, but generate more dollars per pound for the packer.

The producers that were being penalized sought a system that would increase the rewards for quality. Packers also sought a system that would promote leaner carcasses that would result in less trimming and lowered labor costs; thus the carcass merit pricing system was developed. Under this system, premiums and discounts are offered based on carcass weight, size, muscling, back fat measurements, quality of the sellers previous loads, and number of head in the load (Espinoza, 1998). Carcass merit pricing is increasingly being used for those producers that sell at market as well as those producers who are on contract.

Impacts on the Consumer

Not only must producers meet the demands of the carcass merit system, they must meet the demands of the consumer. Recent trends of a health conscious society have pushed the pork industry to produce lean, high quality pork. In addition to taste preferences, the consumer market is seasonal and pork producers must adjust their production accordingly.

There are no government subsidies to support low prices, so producers must adjust to the ever-changing market. Prices vary from month to month and year to year within the pork industry, and it is up to the pork producer to meet the demands of the continuous fluctuations from both the packer and the consumer.

Chapter Summary

The pork industry is a multi-billion dollar industry that has had and will continue to have a large impact on the lives and lifestyles of Americans. Although the pork industry has experienced hard times, it has proved to be an industry that can adjust to time and to the demands required for change. In order to understand why and how this industry has prevailed, we must understand its make-up and the changes it has endured in order to meet the tests of time.

Understanding and adjusting to the changes in the core structure of how hogs are raised and marketed are key to the pork industry. The shift from small Midwestern farms to large, specialized farms has been anything but easy. The trends in industrialization, vertical coordination and vertical integration may be key aspects for studying and understanding the problems the facing the future of the pork industry.

CHAPTER III

EFFECTS OF CAPACITY CONSTRAINT ON PORK PRICES

Introduction

The effects of capacity constraint on pork prices are evaluated in this chapter. While efforts have been made through other studies to measure the effects of capacity constraint, none has measured its effects on live and cutout prices separately. Careful examination of the effects of three different capacity constraint measurements on live and cutout price are reviewed in this chapter.

This chapter reviews the methods employed in this study in the analysis of the effects of the various capacity constraint measurements. The data used and the results found are described in this chapter.

Methods

This study utilized the method of linear regressions. Ordinary least squares (OLS) models were run for both live and cutout prices. The basic equation for each model was set up according to the following:

$$Y = \text{Constant} + \beta_1\text{WKLS} + \beta_2\text{Capacity Measurement} + \varepsilon$$

In this equation Y equals price, live or cutout. WKLS equals the number of head slaughtered per week. The next explanatory variable is a measurement of capacity constraints. Capacity constraints are measured by a continuous and/or a dummy variable. Three alternative measures of capacity constraints were examined.

An ideal explanatory variable to represent capacity limitations would be the percentage of capacity utilized. Information on total capacity for the pork packing industry is not available for an extended time series. Preliminary research has revealed at least 40 plant closings and estimates a net decrease in slaughter capacity of 8,300 head between 1986 and 1992, approximately 15 of which closed during the time period used in this study ("Estimated January 1986 Pork Industry Capacity Versus August 1992," November 1999). The National Pork Producers Council reported 14 plants to be closed or mothballed from 1990 to 1994, and 12 plants, with an estimated slaughtering capacity of 88,000 head, closed from 1995 to 1998 (NPPC, 1995). From 1986 to 1998, approximately 15 plants came on line, at least 3 plants were reopened, and at least 24 plants increased their slaughter capacity by at least 1,000 head. A reported 4% decrease in hog slaughtering capacity occurred in 1998 with the closing of a single plant (Thornapple Valley, Detroit) (Luby, 1999). This information suggests that there has been a decline in the capacity for slaughtering hogs throughout the industry, but a detailed study of plants going off and coming on line has not been conducted to generate a variable that can be used in econometric research at this time.

In this study capacity constraints were measured three ways: using a binary variable (0,1 dummy) and two continuous variables. The dummy variable indicator of full capacity utilization was defined as $D_1=1$ when slaughter exceeded 160,000 head for three consecutive weekends (D3WK160K). This is the same dummy variable used by Brown. The second measurement of capacity constraints was a continuous variable for the number of head slaughtered on the weekend. Typically, pork-processing facilities operate with fewer lines and limited operating staff on Saturdays. Larger numbers slaughtered on Saturday or Sunday are hypothesized to represent weeks in which capacity was fully utilized. The third measurement of capacity constraints was also a continuous variable. It was found by using a ratio of slaughter during the weekends to slaughter during the 5-day workweek ("over-flow" ratio). Slaughter during the 5-day workweek is not an exact measure of total capacity, but, particularly when weekend slaughter is large, slaughter during the week is believed to be fairly close to total packing capacity.

After running the regression models, autocorrelation was found within the data. Econometric estimation and inference using OLS is based on the requirement that the unexplained component of the model can be represented by an error term that is independently distributed, with constant variance. It is fully random and does not retain any predictable pattern that could have been included in the model. This property is written as:

$$E(\varepsilon\varepsilon') = \sigma^2 I$$

When this condition is violated by the presence of autocorrelation among the errors, OLS is inefficient. This means it is not the minimum-variance estimator. There is little information available on how much inefficiency OLS has when there is positive autocorrelation (Greene, p. 420-422).

The major problem with autocorrelation is that inference is affected. OLS under-estimates the standard errors. This will lead to misleading t statistics (Greene, p.

435). OLS estimates are unbiased and are consistent in models having no lagged dependent variables such as those used in this study.

Shazam software was used to estimate ρ, then correct for autocorrelation using the Cochrane-Orcutt iterative procedure. The program is attached in Appendix B.

Data

Our data set is of weekly prices (in dollars per hundred weight or cwt) and quantity (number of hogs slaughtered) from January 6, 1990 through July 31, 1999 (Table 1). This information comes from the Livestock Marketing Information Center (LMIC). LMIC collects information on a weekly basis from the USDA, and compiles the data into a readable format. The IA/MN reported live prices and US #2 cutout prices were used. The number of head slaughtered weekly is reported by the USDA for Monday through Saturday. In this data set the number of hogs slaughtered weekly was found by subtracting the number of head slaughtered Saturday for the number of head slaughtered per week.

Table 1: Descriptive Statistics of the Variables in the Models

Variable	Mean	Standard Deviation
Live Price ($/cwt.)	45.198	9.5025
Cut-out Price ($/cwt.)	63.085	9.3721
Weekly Slaughter in Head (Monday-Friday)	1,656,000	152,510
Weekend Slaughter in Head	98203	61391
Over-flow Variable (Weekend/Week)	0.059854	0.038312

*Prices were observed from January 6, 1990 through July 31, 1999
*Data obtained from LMIC based on IA/MN reports
*Cut-out Price based on US # 2
*Federally Inspected Hogs

A total of 500 observations were used in this analysis, and one observation was dropped due to missing data for live price.

Dummy variables were generated to represent capacity constraints. One measurement of capacity was a dummy that was based on whether slaughter exceeded 160,000 head for three consecutive weekends (D3WK160K). If slaughter exceeded 160,000 head for three consecutive weekends, the dummy was designated as 1. If slaughter did not exceed 160,000 head for three consecutive weeks, then the dummy was designated as 0. This variable was found to equal 1 in 42 weeks out of the 499 weeks in the sample. It equaled 1 for 13 consecutive weeks beginning September 24, 1994, and for 10 consecutive weeks beginning October 17, 1998.

A correlation matrix was estimated for all variables (Table 2). The dummy variable was highly correlated with the capacity constraint variables of weekend slaughter. Also, overflow was correlated with weekend. This suggest that either measurement effectively can represent capacity constraints, but more than one should not be used in the same model. Weekly slaughter was not strongly correlated with any of the capacity constraint measurements. Thus one would expect no severe

Table 2: Correlation Matrix

Correlation Matrix of Variables – 499 Observations						
WKENDSL	1.0000					
WKSL	0.33859E-01	1.0000				
LIVE	-0.47749	-0.50812	1.0000			
CUTOUT	-0.41980	-0.45859	0.96546	1.0000		
D3WK160K	0.61789	0.10856	-0.34960	-0.26194	1.0000	
OVER	0.97528	-0.15662	-0.38448	-0.33696	0.57153	1.0000
	WKENDSL	WKSL	LIVE	CUTOUT	D3WK160K	OVER

Estimated in Shazam

problems from including both the quantity variable and one capacity variable in the models.

Results

OLS Estimation

Ordinary least squares regressions indicated that there was a negative relationship between quantity slaughtered during a week and the prices at both the farm and the packer levels (Appendix A). The variables that represented capacity constraints also had an estimated strong negative relationship to live and cutout hog prices. The estimated coefficients were statistically powerful, with all t-statistics greater than 5 in absolute value and many greater than 10 in absolute value. One exception to the statistical significance was found in the models that included both the dummy variable and the continuous variable for capacity constraints. In those models, the coefficient on the dummy variable was not statistically significant.

It must be noted, however, that the presence of autocorrelation in the residuals from the OLS models suggests that the initial results are misleading. OLS underestimates the standard errors when autocorrelation is not corrected. The evidence of autocorrelation is strong, as noted by the estimate of ρ (0.77231) and the Durbin-Watson statistic (0.4587).

The residuals from the OLS regressions were examined to determine the order of autocorrelation. The graphs of residuals from models with a continuous explanatory variable suggest either autocorrelation of order 1, with a large coefficient on the lag variable, or perhaps cycling, indicating autocorrelation of order 2 or greater . Diagnostics using the ARIMA procedure in Shazam indicated autocorrelation functions exhibiting slowly dampening coefficients, suggesting AR(1) characteristics in the residuals (Table 3). The partial autocorrelation coefficient for the first lag was largest, again suggesting an AR(1) pattern of the residuals.

Estimates Corrected for Autocorrelation

Estimations were conducted using the correction for autocorrelation of order 1 in Shazam and TSP. Several alternative procedures are available to correct for autocorrelation, all of which provided similar results. Findings from the model corrected for autocorrelation are much different from the OLS results (Appendix A).

In nearly all models examined, the quantity slaughtered during the 5-day workweek does not have a significant relationship to the farm price of hogs. Quantity

Table 3: Autocorrelation functions and partial autocorrelation functions for residuals.

	Autocorrelation Function		Partial Autocorrelation Function	
Lag	Live	Cutout	Live	Cutout
1	0.77	0.80	0.77	0.80
2	0.67	0.71	0.21	0.19
3	0.63	0.65	0.16	0.13
4	0.67	0.68	0.28	0.27
5	0.66	0.66	0.12	0.07
6	0.61	0.62	0.00	0.01
7	0.57	0.58	0.01	0.00
8	0.58	0.58	0.10	0.09
9	0.56	0.56	-0.01	-0.01
10	0.49	0.51	-0.13	-0.11
11	0.46	0.47	-0.01	-0.01
12	0.46	0.46	0.03	0.04
13	0.45	0.44		
14	0.44	0.43		

ARIMA on residuals from OLS model with continuous capacity variable (WKENDSL).

slaughtered during the 5-day week was positively related to the cutout price. The estimated marginal effect is small (about 0.0002 cents per hundredweight cutout price for an additional head slaughtered).

Slaughter during weekends was significantly related to both live and cutout prices, but the direction of the effect was different. Increasing weekend slaughter had an estimated negative relationship with live hog prices and a positive relationship with cutout carcass prices. The positive effect on cutout price was unexpected. The estimated marginal effect of an additional head slaughtered on weekends was -.0007 cents on the farm level price per hundredweight, and a positive 0.0007 cents on the per hundredweight price received by packers.

The ratio of slaughter during weekends to slaughter during the 5-day work week ("over-flow" ratio), had similar effect to the weekend slaughter continuous variable. The over-flow ratio was significantly related to both live and cutout prices, but the sign of the effect was different. The over-flow ratio had an estimated negative relationship with live hog prices and a positive relationship with cutout carcass prices. The negative effect on live price was expected, but the positive effect on cutout price was unexpected. The estimated marginal effect of an additional percentage point in the over-flow ratio was negative $11.63 per hundredweight at the farm level, and positive $10.58 per hundredweight on the price received by packers.

The dummy variable designed to represent capacity constraints was not statistically different from zero in any of the models estimated after correction for autocorrelation.

Chapter Summary

Estimated coefficients for the various capacity constraint variables were determined by using a linear regression model. The estimated coefficients for the continuous capacity constraint variables are statistically significant. The estimated coefficients for live price had negative effects, whereas they had a positive effect on cutout price. The estimated coefficients on the dummy variables were not statistically significant, but moved in the same direction as the continuous variables' estimated coefficients. The unexpected positive sign on the coefficient for capacity constraints in the cutout price model occurs repeatedly. This may suggest that these models are incorrectly specified and that more research should be conducted on the effects of the capacity constraint variables identified and modeled in this study. The movement may be justified due to various unidentified factors in the market, such as market power.

The main emphasis of this study was to identify a working capacity constraint variable. Although there may be other variables that can be identified, the continuous variables identified and modeled in this study were easily generated and were found to have a statistically significant effect on prices.

CHAPTER IV

SUMMARY AND CONCLUSIONS

Summary

This paper evaluated various aspects of the pork industry. The effects of capacity constraints on pork prices, with live and cutout prices separately observed, were modeled and studied. In addition, the usefulness of various capacity constraint measurements was studied.

The pork industry is a multi-billion dollar contributor to the American economy. In the last decade, the industry has undergone drastic changes in structure, and it is becoming more industrialized each year. This has resulted in a shift from the traditional, small mid-western farm to more vertically integrated farming.

In the past decade pork prices fell dramatically more than once, but none as hard as in 1998. Prices dropped as low as $8/cwt, and resulted in a loss of income for many producers. Some pork producers were forced out of business. Across the industry, cries for help and questions arose as to why these price decreases were occurring.

This study evaluated one aspect that was named as a possible reason for the low prices. Capacity constraints are constraints at the packing level when there is an influx in the number of hogs being slaughtered, and not enough room at the packing plant to slaughter. An exact measurement of capacity constraint has previously not been agreed upon by researchers and industry experts. This study utilized three possible variations of a capacity constraint measurement.

The continuous variables used to measure capacity constraints were statistically significant explanatory factors in the regressions for hog and pork prices. Increasing capacity constraints is associated with a negative relationship to farm prices, and a positive relationship to packer prices.

The major contribution of this research was modeling the effects of various capacity constraint variables on pork prices. Linear regression models that were representative of both live and cutout prices were developed. After running the models in Shazam, the results were analyzed. This research presents findings of the analysis on the preliminary measures of capacity constraints and their relationship to hog and pork prices. The measure used here for over-flow ratio, the ratio of weekend slaughter to slaughter during the 5-day workweek, did not generate different results than the continuous variable of weekend slaughter. The estimated coefficients for both continuous variables were more statistically significant than a dummy variable approach for the capacity constraint. The presence of autocorrelation affects the estimation procedures used. Correction for autocorrelation, using the Cochrane-Orcutt iterative procedure, changed the results of the estimated coefficients when compared to the OLS results.

Conclusions

The implication that capacity negatively affects the live price, and positively affects cutout leaves room for much speculation. The difference in prices may indeed be justified by the extra costs incurred by the packers while running at full capacity for extended periods of time, but there is an implication of market power. Hahn stressed the importance of realizing that price transmission asymmetry could be a result of market power. Hahn speculated that because of a lack of competition in the short run, meat marketers may be able to keep their prices high even though their costs have fallen. Market power is a topic that should be considered. Although opposite effects on price were not expected from the estimated coefficients of the capacity constraint variables, it could be that the results are consistent with the theory that market power is the underlying problem.

Suggestions for improvement on this topic include looking at different pricing systems, including wholesale prices and retail prices. Cold storage and production quantity in pounds rather than head are also areas that may need to be addressed. Such areas may require looking at the data set on monthly or quarterly time periods. Weekly time periods were used in this study, in order to observe short run changes.

Future research on this topic should explore other measures of capacity constraints that more closely approximate a capacity utilization percentage. Another step for future research is to examine the performance of these models as predictors of price trends.

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APPENDIX A

Estimated Coefficients for Models

	WKSL	WKENDSL	OVER	D3WK160K	R^2
	ESTIMATED COEFFICIENT	ESTIMATED COEFFICIENT	ESTIMATED COEFFICIENT	ESTIMATED COEFFICIENT	
	T-RATIO	T-RATIO	T-RATIO	T-RATIO	
OLS					
LIVE = WKSL + D3WK160K	-3.00E-05			-10.18	0.3476
	(-13.07)			(-8.146)	
LIVE = WKSL + WKENDSL	-3.07E-05	-7.13E-05			0.4703
	(-15.06)	(-14.09)			
LIVE = WKSL + OVER	-3.63E-05		-118		0.4790
	(-17.75)		(-14.5)		
LIVE = WKSL + WKENDSL + D3WK160K	-3.09E-05	-6.97E-05		-0.60482	0.3476
	(-14.99)	(-10.83)		(-0.4228)	
LIVE = WKSL + OVER + D3WK160K	-3.64E-05		-115.04	-0.73591	0.4820
	(-17.16)		(-11.31)	(-0.5284)	
AUTO					
LIVE = WKSL + D3WK160K	8.82E-07			-0.1315	0.9741
	(1.879)			(-0.3805)	
LIVE = WKSL + WKENDSL + D3WK160K	1.07E-07	-7.59E-06		0.23117	0.9750
	(0.2151)	(-4.162)		(0.6586)	
LIVE = WKSL + OVER + D3WK160K	-6.29E-07		-12.209	0.2126	0.9750
	(-1.071)		(-4.167)	(0.6076)	
LIVE = WKSL + WKENDSL	1.89E-07	-7.22E-06			0.9750
	(0.3876)	(-4.106)			
LIVE = WKSL + OVER	-5.09E-07		-11.625		0.9750
	(-0.8941)		(-4.107)		

	WKSL	WKENDSL	OVER	D3WK160K	R^2
	ESTIMATED COEFFICIENT	ESTIMATED COEFFICIENT	ESTIMATED COEFFICIENT	ESTIMATED COEFFICIENT	
	T-RATIO	T-RATIO	T-RATIO	T-RATIO	
OLS					
CUTOUT = WKSL + D3WK160K	-2.71E-05			-7.2372	0.2585
	(-11.25)			(-5.506)	
CUTOUT = WKSL + WKENDSL	-2.73E-05	-6.18E-05			0.3739
	(-12.51)	(-11.39)			
CUTOUT = WKSL + OVER	3.22E-05		-102.51		0.3816
	(-14.66)		(-11.72)		
CUTOUT = WKSL + WKENDSL + D3WK160K	-2.81E-05	-6.76E-05		2.0464	0.3796
	(-12.71)	(-9.807)		(1.337)	
CUTOUT = WKSL + OVER + D3WK160K	3.34E-05		-111.1	• 1.8828	0.3873
	(-14.65)		(-10.18)	(1.269	
AUTO					
CUTOUT = WKSL + D3WK160K	1.01E-06			0.10423	0.9607
	(1.756)			(0.2473)	
CUTOUT = WKSL + WKENDSL + D3WK160K	1.71E-06	6.86E-06		-0.223	0.9614
	(2.789)	(3.059)		(-0.517)	
CUTOUT = WKSL + OVER + D3WK160K	2.33E-06		10.715	-0.19739	0.9614
	(3.231)		(2.974)	(-0.4588)	
CUTOUT = WKSL + WKENDSL	1.73E-06	6.71E-06			0.9612
	(2.883)	(3.098)			
CUTOUT = WKSL + OVER	2.35E-06		10.584		0.9612
	(3.357)		(3.037)		

APPENDIX B

Shazam Program

```
SAMPLE 1 499
FILE 11 GENERALI
READ(11)  WKENDSL WKSL LIVE CUTOUT D3WK160K DAVGWKE OVER

*WKENDSL: SATURDAY SLAUGHTER
*WKSL: SLAUGHTER WEEK (M-F)
*LIVE: LIVE PRICES $/CWT (BARROW AND GILT IA-MN)
*CUTOUT:  CUTOUT VALUES $/CWT (U S #2)
*D3WK160K: DUMMY 1= 3WK TOTAL OF 160,000 1=ABOVE 2=BELOW
*DAVGWKE:  DUMMY 1= AVERAGE WEEKEND SLAUGHTER 1=ABOVE
0=BELOW
*OVER: WEEKEND SLAUGHTER/WEEKLY SLAUGHTER
*PRINT    WKENDSL WKSL LIVE CUTOUT D3WK160K DAVGWKE OVER

SAMPLE 1-499
STAT WKENDSL WKSL LIVE CUTOUT D3WK160K DAVGWKE OVER / PCOR

SAMPLE 1 499
OLS LIVE WKSL WKENDSL / PCOR RSTAT
OLS CUTOUT WKSL WKENDSL / PCOR RSTAT
AUTO LIVE WKSL WKENDSL / PCOR RSTAT
AUTO CUTOUT WKSL WKENDSL / PCOR RSTAT

SAMPLE 1 499
OLS LIVE WKSL OVER / PCOR RSTAT
OLS CUTOUT WKSL OVER / PCOR RSTAT
AUTO LIVE WKSL OVER / PCOR RSTAT
AUTO CUTOUT WKSL OVER / PCOR RSTAT


SAMPLE 3 499
OLS LIVE WKSL WKENDSL D3WK160K / PCOR RSTAT
OLS CUTOUT WKSL WKENDSL D3WK160K / PCOR RSTAT
AUTO LIVE WKSL WKENDSL D3WK160K / RSTAT
AUTO CUTOUT WKSL WKENDSL D3WK160K / RSTAT

OLS LIVE WKSL OVER D3WK160K / PCOR RSTAT
OLS CUTOUT WKSL OVER D3WK160K / PCOR RSTAT
AUTO LIVE WKSL OVER D3WK160K / RSTAT
AUTO CUTOUT WKSL OVER D3WK160K / RSTAT
```

```
OLS LIVE WKSL D3WK160K / PCOR RSTAT
OLS CUTOUT WKSL D3WK160K / PCOR RSTAT
AUTO LIVE WKSL D3WK160K / RSTAT
AUTO CUTOUT WKSL D3WK160K / RSTAT
STOP
```

VITA

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