THE DEMAND AND SUPPLY OF CATFISH IN THE UNITED STATES: A SIMULTANEOUS EQUATION MODEL

BY

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EQUATION MODEL

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CHAPTER I

INTRODUCTION

Producing farm-raised channel catfish (Ictalulus punctatus) has became an important farming activity in rural areas of Mississippi, Alabama and Arkansas. Mississippi's Delta, responsible for producing more than two-thirds of total U.S. production, is the most favorable region for raising catfish (1).

In addition to Mississippi, Alabama, and Arkansas, other states with relatively smaller production, are Missouri, California, Texas, Louisiana, Georgia and Tennessee (14). This new farm enterprise not only offers farmers in the south an opportunity to more fully use resources, but also diversifies farm income sources.

A 1981 survey by the Crop Reporting Board indicated that 67,930 surface acres of water were used in catfish production by the major producing states (14). The major producing states' catfish sales, value of sales and acres of water surface used are shown in Table 1. Total live weight of catfish delivered for processing in 1981 amounted to 60,640,000 pounds. In 1986, the amount of catfish produced increased more than threefold to 211,748,000 pounds (14). The trend of these increases in quantity produced is depicted in Figure 1.

TABLE 1

MAJOR CATFISH PRODUCING STATES, SALES AND WATER SURFACE USED
JANUARY 1 - JUNE 30, 1981

States	Live Weight Sold* (1,000 lbs)	Value (1000$)	Water Surface (Acres)
Mississippi	31,808	22,516	46,240
Alabama	5,859	4,420	8,200
Arkansas	5,389	4,820	7,630
Missouri	971	1,230	1,070
California	371	574	1,300
Texas	353	700	1,400
Louisiana	209	221	760
Georgia	140	299	1,070
Tennessee	132	192	260
Total	45,232	34,972	67,930

*: Include Fry/Fingerling, Stocker and Food Size Sales.

Source : USDA, Catfish, Crop Reporting Board, Economics and Statistical Services, Washington D.C., August 1981.

Production and Processing

Channel catfish are commonly raised in ponds. Pond size ranges from one acre to forty acre water surfaces. Some producers use cages when seining or draining the pond is not a practical harvesting method.

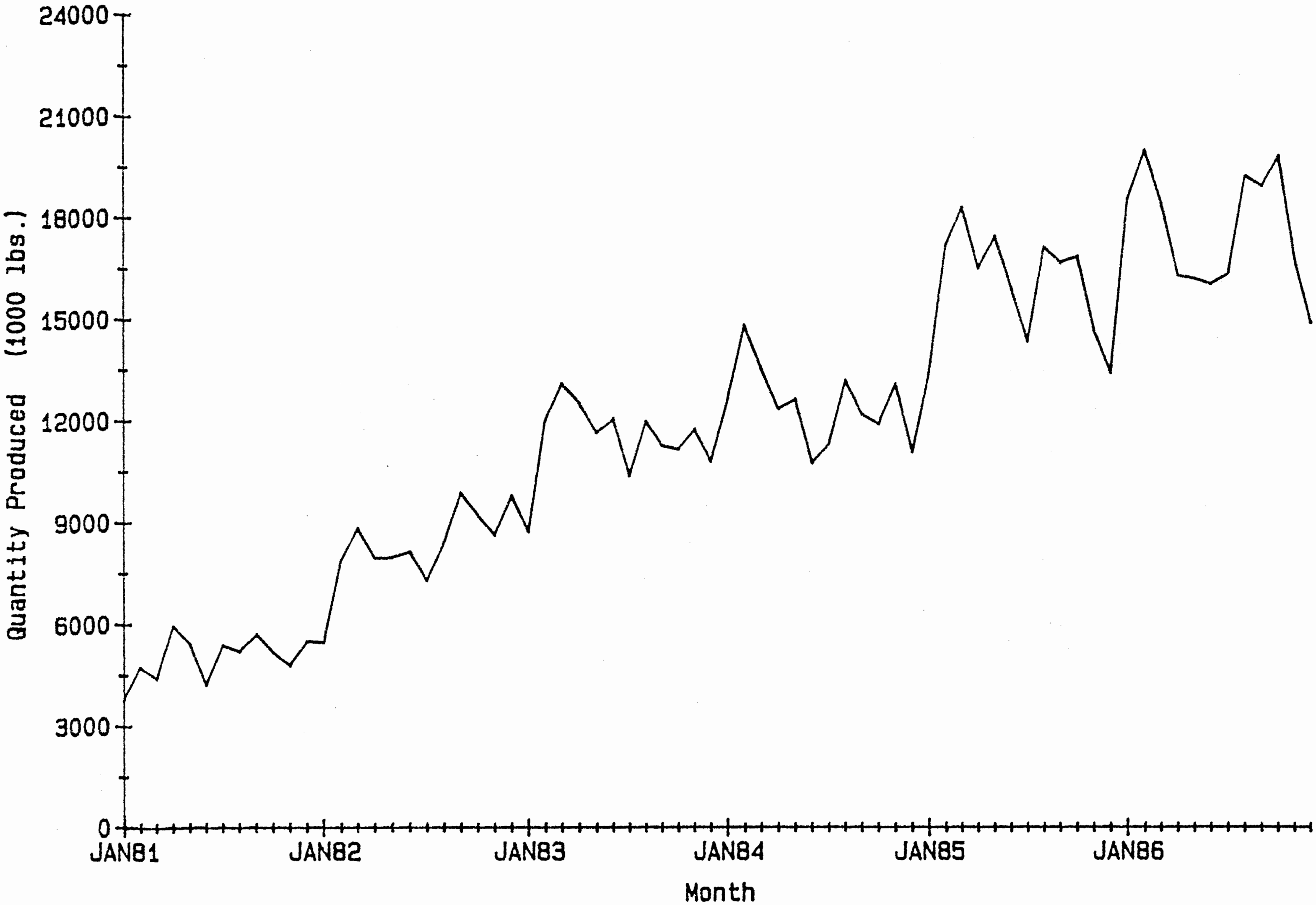

Figure 1. Monthly Quantity of Catfish Produced. Jan.1981 to Dec.1986

Producers stock their ponds in spring and harvest in late summer or early fall, allowing the catfish to grow quickly in the favorable summer months. In the south, this growth period takes an average of 150 days. The catfish grow from fingerlings to a suitable harvest size of 0.75 to 2.00 pounds (18).

During June and July, the quantities of catfish supplied by individual farmers are not adequate to meet demand. To maintain a more consistent supply to processing plants and to meet market demand, some major processors have their own production facilities with adjusted harvesting periods. Other processors contract with farmers to specifically produce in "off-season" months (7).

Sinking and floating pellet feed are the two most common feeds for farm-raised catfish. Sinking feed is used for open pond cultures and floating feed is more suited for cage cultured catfish. In Oklahoma, catfish fed a recommended feed containing 32% protein have an average conversion ratio of 1.7 pounds of feed to every pound of gain (18).

The catfish processing industry is highly concentrated. Miller et. al. reported in 1981 that there were only nine processors and that five of them handled 98% of the total pounds processed (7). Although the number of processors has since increased and quantity produced has expanded, the market power of the processors is still great. Possible reasons for the high concentration are the substantial capital investment for building a cost-efficient plant and keen competition from existing plants. There are currently about 18 commercial processors serving the industry's 1000 producers (14).

Approximately 72% of the catfish delivered for processing came from individual catfish producers, while the remaining 28% came from processing firm controlled production units. Three-fourths of the catfish delivered for processing weigh 0.75 to 2.00 pounds live weight. Catfish of this size dress out to be the size most demanded in the market in the form of whole dressed fish. In the processing plant, catfish are cleaned, decapitated and eviscerated. Further processing involves filleting and steaking (7).

Prices

For the past several years, wholesale prices of catfish have been fluctuating very mildly around $1.50 a pound (Figure 2). The situation for farm prices was quite similar to wholesale prices. Farmers received an average of 66.8 cents per pound (live weight) in 1986 for raising catfish. Figure 3 shows that from 1981 to 1986, prices farmer received for catfish have been relatively constant. Comparing Figure 2 and 3, farm prices appears to be closely correlated with wholesale prices.

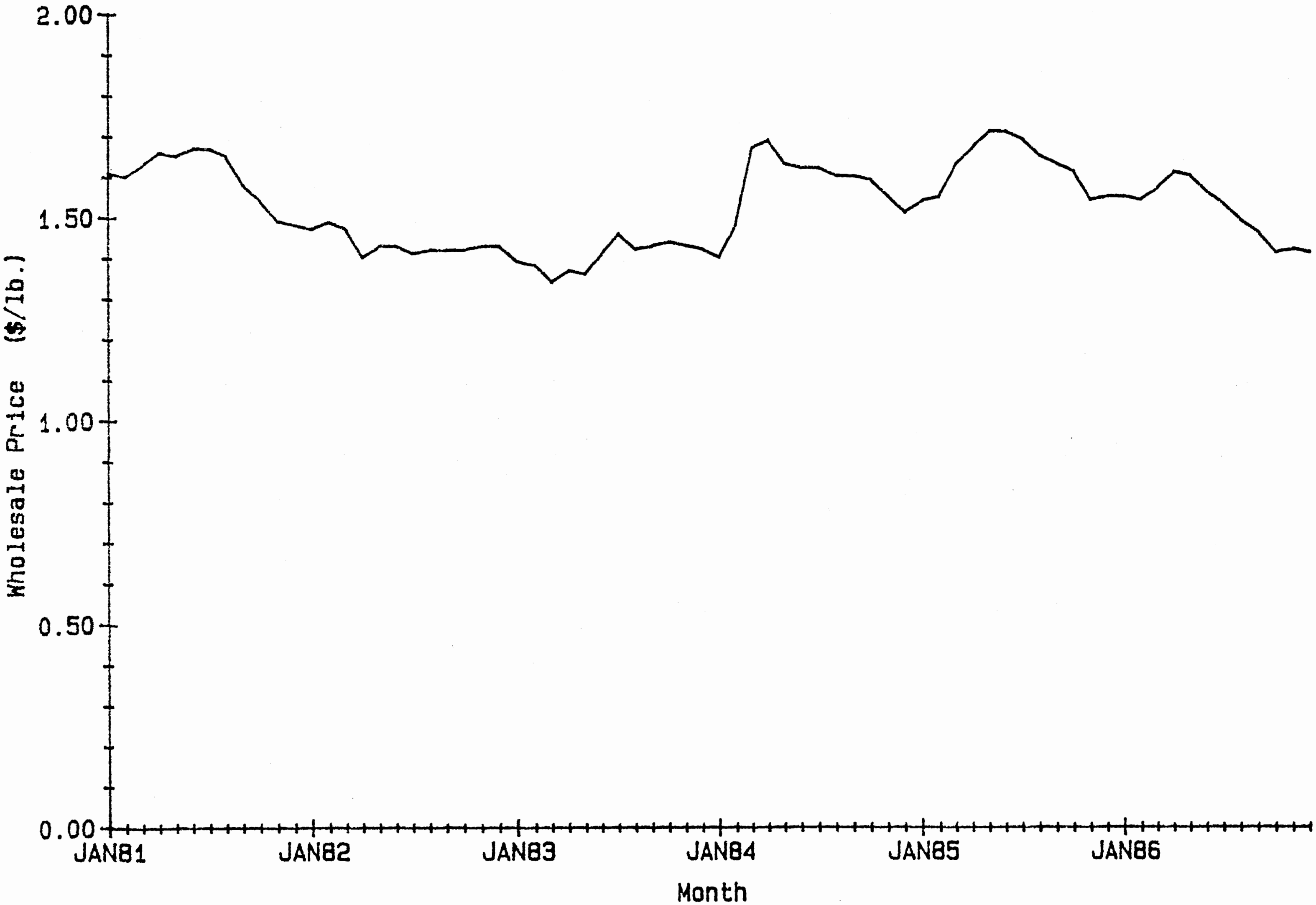

Figure 2. Monthly Wholesale Price of Catfish. Jan.1981 to Dec.1986

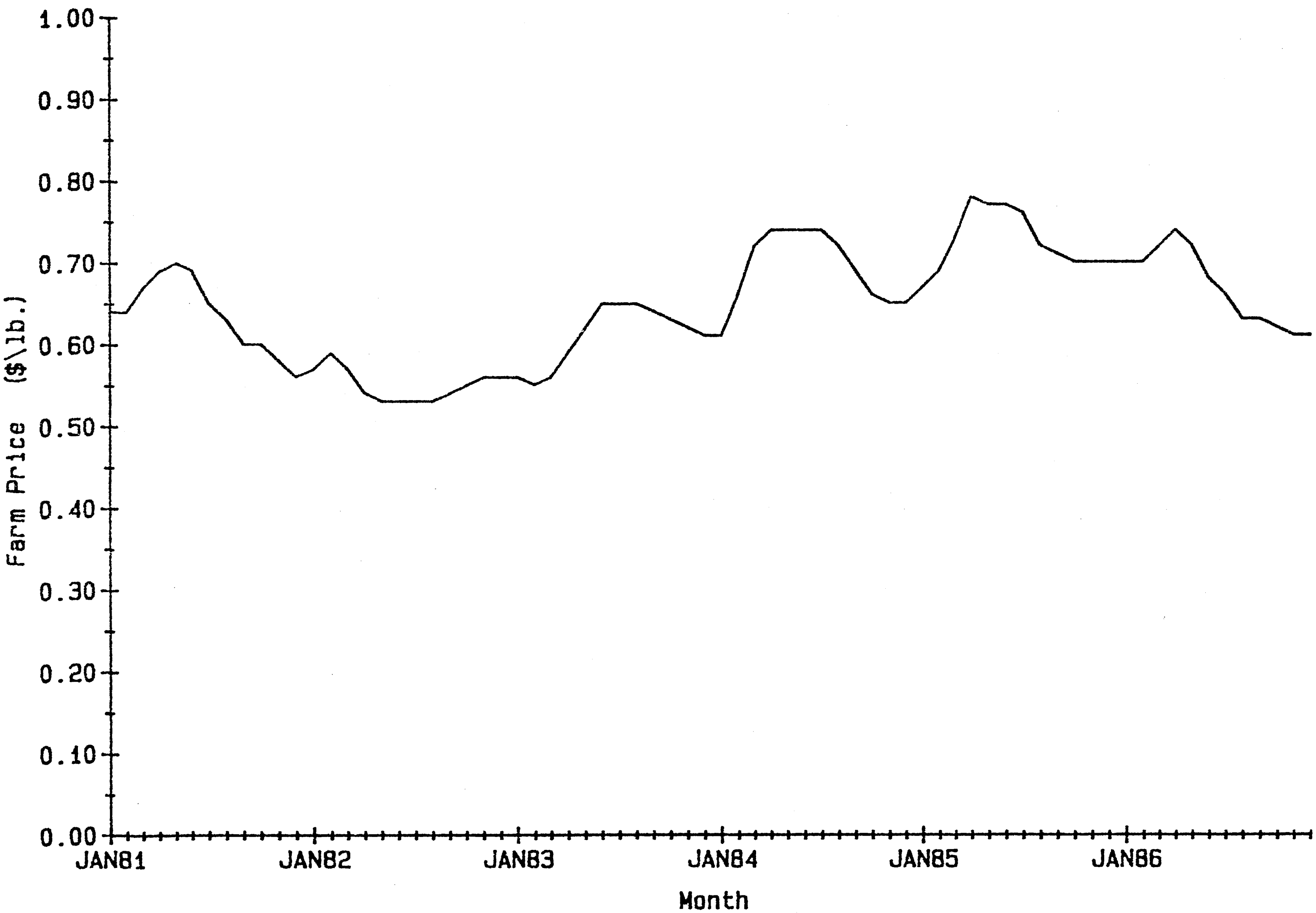

Figure 3. Monthly Catfish Price Farmer Receive. Jan.1981 to Dec.1986

Imports

In 1986, the U.S. imported 8,167,000 pounds of catfish; over 98% of the imports were from Brazil (14). For the last six years, quantity of catfish imported has varied greatly from year to year (Figure 4).

The prices of imported catfish from 1981 to 1986 are shown in Figure 5. These prices are for processed whole catfish (skinned and decapitated to marketable form). The lowest price for imported catfish was 65 cents per pound in November 1984; prices have fluctuated rapidly, with the highest price being $1.15 in October 1984. Average of these prices was about 85 cents per pound. The wholesale prices of imported catfish are substantially lower than prices of their domestically raised counterpart.

Problem Statement

Although the quantity of catfish produced in the U.S. has expanded to over 200 million pounds in 1986, per capita consumption is still very low. Compared to other meats in the average American family's diet, fish account's for only 5 percent of their meat intake, and catfish are a relatively small proportion of total fish consumption. The annual per capita consumption share of major meat groups is shown in Figure 6 (13). In view of the current controversy over the relationship between red meat intake and health problems associated with fat and cholesterol content, the potential to increase catfish sales may be great.

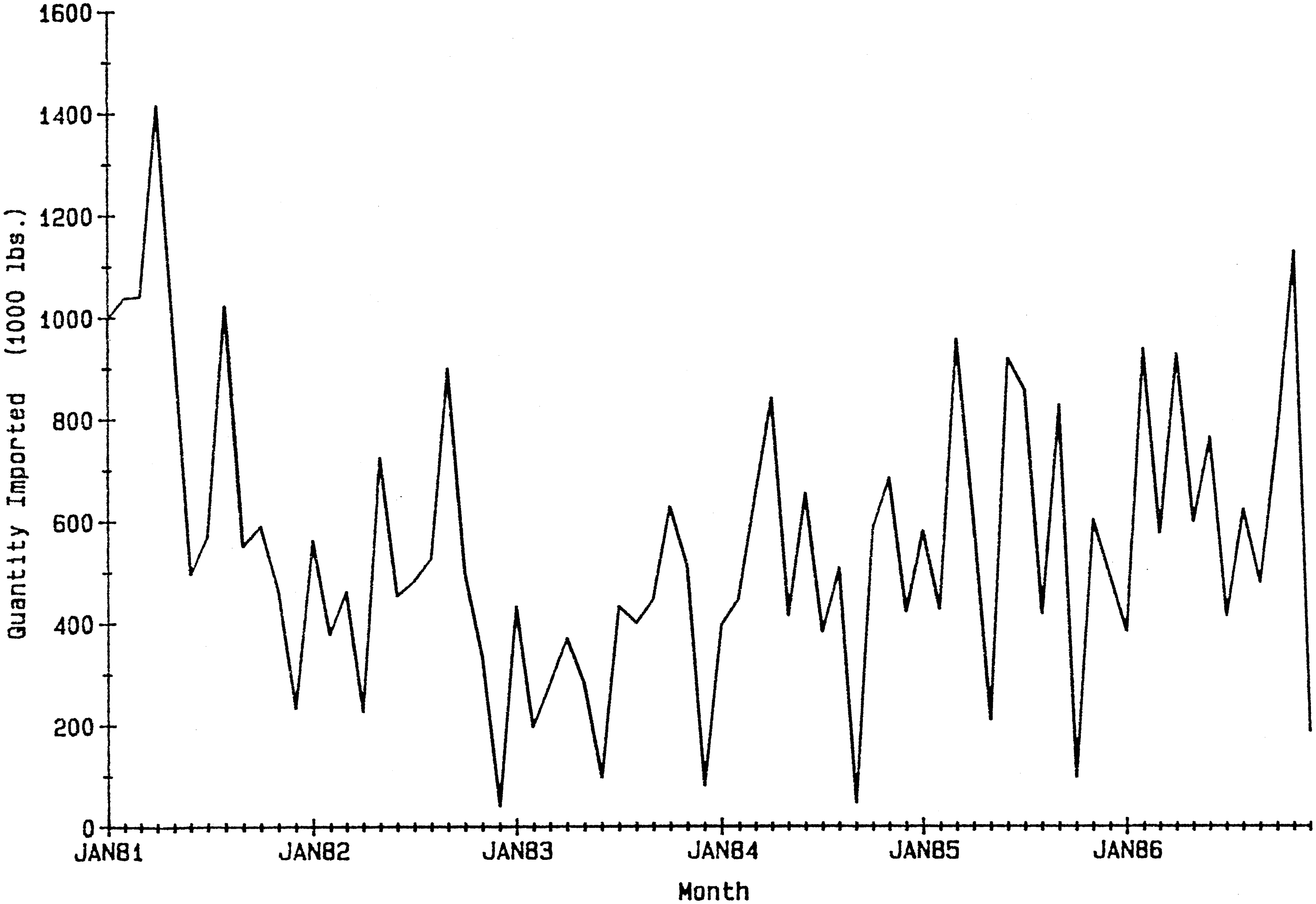

Figure 4. Monthly Catfish Imports. Jan.1981 to Dec.1986

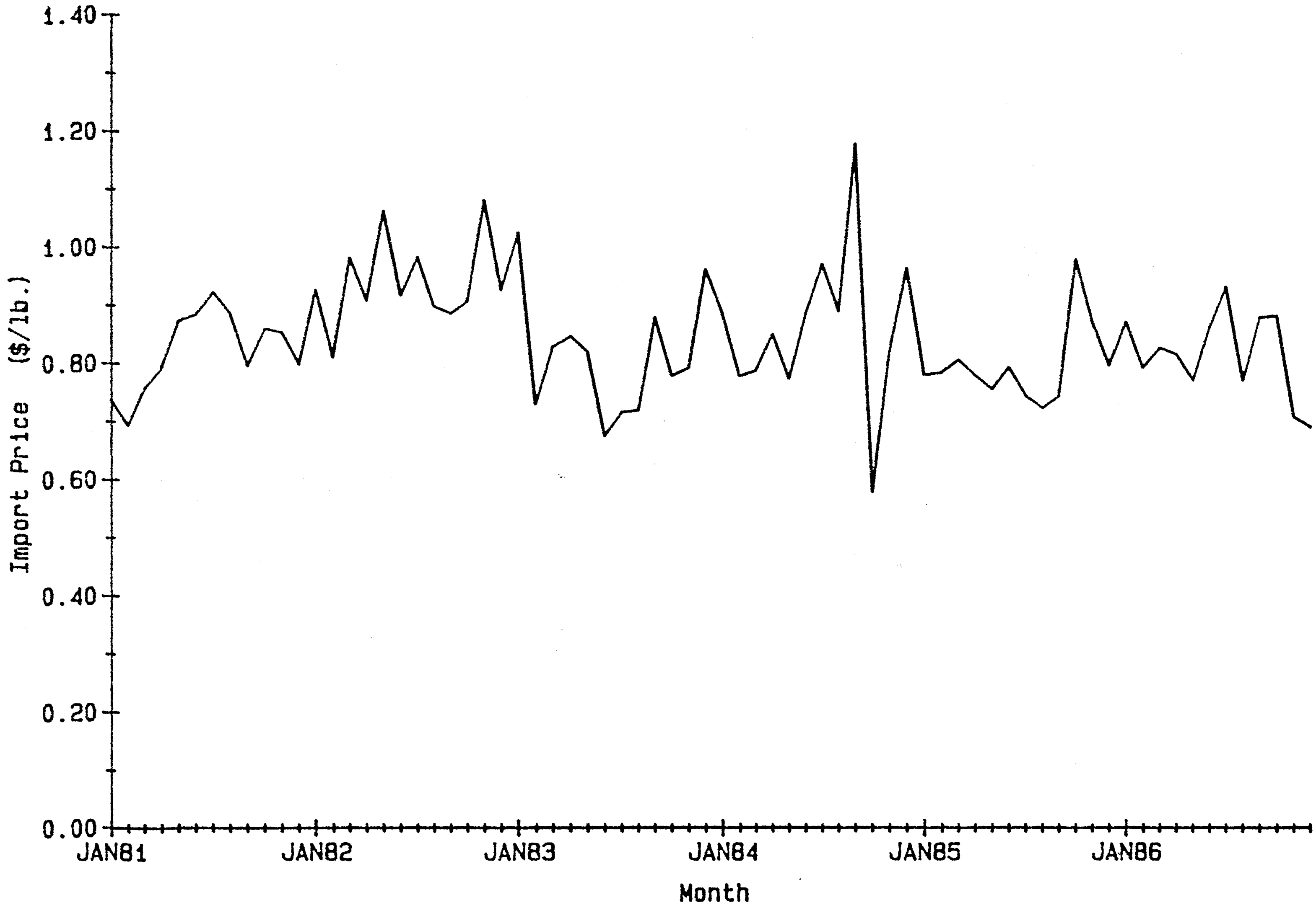

Figure 5. Monthly Wholesale Price of Imported Catfish. Jan.1981 to Dec.1986

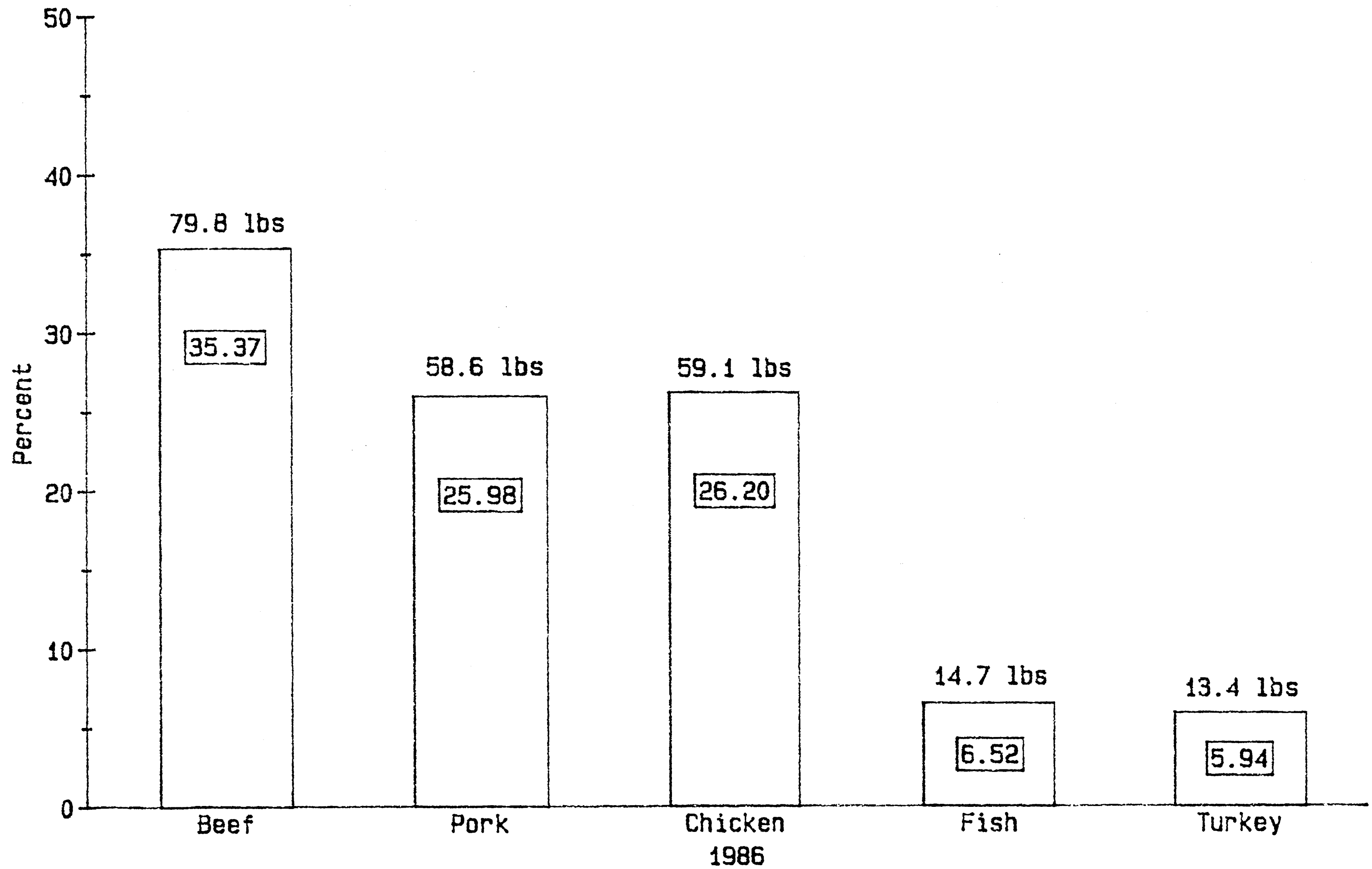

Figure 6. Per Capita Shares of Meat Consumption in the United States.

Since the conception of the industry in the 1960's, research geared towards solving production problems has been quite successful. From a technical standpoint, the prospects for production expansion, increasing yield per surface acre, and putting more resources into catfish farming are good. Catfish consume about 1.7 pounds of feed for every pound of weight gained. This is three to four times better than the feed conversion ratio of hogs and cattle, and is slightly better than chicken (18). Production efficiencies coupled with a relatively low cost of production will allow catfish to compete for a larger share of the U.S. meat market.

However, the industry is not free from every barrier to expansion. One barrier is little consumer awareness and hesitancy to accept catfish as food in the non-traditional catfish consuming regions of the Northern, New England and Western States (1).

Previous Research

Previous research related to catfish showed that most studies were reports of market surveys and production management practices (1) (2) (7) (8). One study attempted to measure the farm supply elasticity of catfish in Western Alabama (5). One other study presented as estimate of the demand elasticity of catfish at six Atlanta grocery stores in 1972 (10). No previous econometric model of the industry have been reported.

Objectives

The overall objective of this study is to provide information to the U.S. catfish industry to help in the decision making process. To accomplish this objective, this study will look at the market demand and supply conditions, the import situation, the prices farmers receive, feed costs, and the production and processing in the U.S. catfish industry.

Specifically, this study will attempt to:

a) determine the nature of the wholesale demand for catfish from processors;

b) determined the relationship between prices received by processors and the prices paid to farmers;

c) examine the extent to which catfish production responds to changes in prices and feeding costs;

d) evaluate the nature of the demand for catfish imports from Brazil; and

e) discover the price determination process and the effect of price changes on processors.

Organization of Study

Chapter II presents the conceptual model of the supply and demand dynamics of the catfish industry. Inter-relationship of variables affecting major components in the catfish market are explored. Empirical estimates of the structural and reduced form relationships are presented and discussed in chapter III. Chapter IV provides the implications of the results. The final chapter summarizes the study, draws conclusion, and gives recommendations for future research.

CHAPTER II

CONCEPTUAL FRAMEWORK

A conceptual model of the supply and demand dynamics of the U.S. catfish market is developed. Six structural equations plus one identity describe the interrelationships among variables that are hypothesized to affect the major sectors of the industry.

Overview of The Model

The model is diagramed in Figure 7. Endogenous variables, which are determined within the system, are shown in boxes; predetermined variables are enclosed in ovals. The variables used in the model are define in Table 2.

The simultaneously determined variables are wholesale quantity demanded, wholesale price, farm production, processor supply, farm price, import quantity, and changes in monthly inventory. The hypothesized relationships among sale prices, demand and supply, prices farmers receive, quantity of imports and inventory level of catfish in the U.S. catfish market are expressed using arrows and, plus and minus signs to indicate the positive and negative relationships.

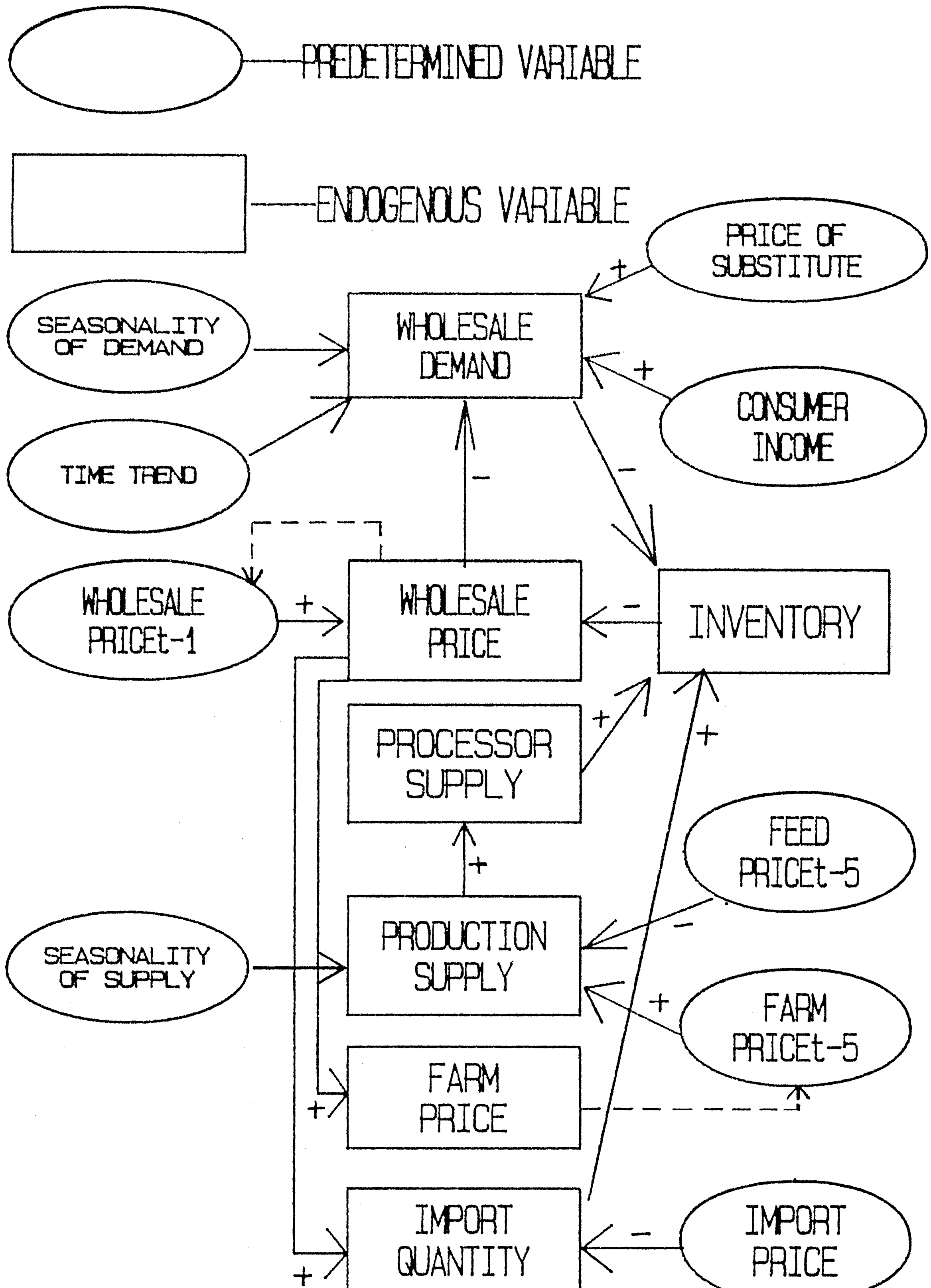

Figure 7. Interrelationships of Variables in the Catfish Model

TABLE 2

VARIABLE DESCRIPTION, SOURCE, MEAN AND STANDARD DEVIATION

Variable Notation	Description and Source	Mean Value	Standard Deviation
<u>Endogenous Variable</u>			
WD_t	Wholesale Demand Quantity pounds per capita (USDA Crop Reporting Board)	0.0268	0.0091
WP_t	Processor Wholesale Price dollars per pound (deflated) (USDA Crop Reporting Board)	0.5047	0.0338
DP_t	Farm Production Per Month pounds per capita (USDA Crop Reporting Board)	0.0497	0.0182
PS_t	Quantity Processed Per Month pounds per capita (USDA Crop Reporting Board)	0.0249	0.0089
FP_t	Farm Price dollars per pound (deflated) (USDA Crop Reporting Board)	0.2139	0.0209
$IMPQ_t$	Import Quantity Per Month pounds per capita (Commerce Dept. Bureau of Census)	0.0023	0.0011
$CHATI_t$	Change in Inventory Level pounds per capita (INV_t - INV_{t-1})	0.0002	0.0001
<u>Predetermined Variable</u>			
INC_t	Consumer Real Personal Income thousands of dollars per year (Survey of Current Business)	4.0653	0.2112
$CHICKP_t$	Wholesale Price of Chicken dollars per pound (deflated) (Livestock & Poultry Situation)	0.1668	0.0206
WP_{t-1}	Wholesale Price Lagged 1 Month	0.5052	0.0339

TABLE 2 (Continued)

Variable Notation	Description and Source	Mean Value	Standard Deviation
Predetermined Variable			
INV_t	Processor Monthly Inventory pounds per capita (USDA Crop Reporting Board)	0.0135	0.0044
FP_{t-5}	Farm Price Lagged 5 Months	0.2144	0.0215
PF_{t-5}	Price of Feed Lagged 5 Months dollars per pound (deflated) (USDA Agricultural Prices)	0.0451	0.0057
$IMPP_t$	Wholesale Import Price dollars per pound (deflated) (Commerce Dept. Bureau of Census)	0.2789	0.0342
OBS	Time Trend Variable Indicating Supply Shift (Jan 81=1 .... Dec 86=72)	36.500	20.928
OBSSQ	Time Trend Variable Indicating Demand Shift (Square of OBS)	1764.1	1576.5
POPLN	U.S. Population thousands people (Bureau of Census)	235843.9	3975.5
D1-D11 (S_t)	Monthly Dummy Variables (Seasonal Factor) When Month=January, D1=1 Zero Otherwise	0.0833	0.2783
CPI	Consumer Price Index 1967=100 (Survey of Current Business)	303.59	19.893
WPI	Wholesale Price Index 1967=100 (Survey of Current Business)	302.42	6.2902

Note: All prices are deflated by the Wholesale Price Index

Lagged relationships are shown with dashed lines. The hypothesized relationships are discussed for each of the endogenous variables in the following section.

Wholesale Demand

Wholesale quantity demanded is the amount of catfish purchased from the processors and represents the quantity of catfish demanded in the market for the current month. Economic theory suggests that demand is affected by the level of consumer disposable income, price of substitutes, own price of catfish and seasonal demand changes. Broiler chicken was selected to be used as a substitute because of its popular demand and because it has a closer nutritional value to catfish than does any other meat. Monthly quantity demanded of catfish varies by season. Higher quantities are demanded during the spring and fall months, average during summer, while relatively lower quantities are demanded during the winter seasons.

It is hypothesized that wholesale purchases of catfish are positively related to consumer disposable income and the price of substitutes, and negatively related to its own sales price. Purchases are expected to increase (decrease) when disposable income and price of chicken increases (decreases), and are expected to decrease (increase) when price of catfish increases (decreases).

The wholesale demand function can be expressed as:

$$WD_t = f(WP_t, INC_t, CHICKP_t, S_t) \qquad (2.1)$$

where:

WD_t = Wholesale quantity demanded

WP_t = Wholesale price

INC_t = Personal disposable income

$CHICKP_t$ = Price of chicken

S_t = Seasonal demand factor

There are reasons to believe that the wholesale demand curve for catfish is shifting to the right due to the preference towards leaner meat products and increases in the number of retailers selling catfish. A time trend variable squared (OBSSQ) is used in the empirical estimation to account for the demand shift over time.

Wholesale Price

Considering the high concentration and small number of processors and the oligopolistic nature of the catfish market reported by Miller et al. (7), wholesale price is assumed to be set by the processors. The wholesale price is expected to be negatively related to changes in inventory, positively related to previous month's price, and is expected to vary by season. Changes in processors' inventory give signals to the processors about the effect of the price set and wholesale buyers' willingness to purchase catfish at that price. It is hypothesized that when the current month's ending inventory is large relative to the previous month's inventory, processors will decrease the price.

The wholesale price function is written as:

$$WP_t = f(CHATI_t, WP_{t-1}, S_t) \tag{2.2}$$

where:

WP_t = Wholesale price of catfish

$CHATI_t$ = Change in processors' inventory

WP_{t-1} = Wholesale price lagged 1 month

S_t = Seasonal factor

Farm Production

Most of the catfish produced by farmers are sold to processing plants. Farmers are assumed to base their production on the price they expect to receive from processors and evaluate this against the expected costs of raising catfish. The quantity of catfish raised is therefore a function of expected prices received by farmers for their product and the expected cost of production. Other than the initial capital investment and cost of fingerlings, the cost of feed is the major outlay for catfish farming. Thus, the feed price is used to represent the variable cost of production. It is hypothesized that producers base their expectations of prices and costs on the prices and costs observed when they begin the five-month production process.

It is hypothesized that farmers increase (decrease) quantity produced when the expected price received for catfish increase (decrease) and decrease (increase) the quantity produced when expected feed cost increases (decreases).

Assuming that price and cost expectation are the only factors influencing the quantity of catfish produced simplifies the production process. Other variables that can affect production are labor and management efficiency, water quality, crop lose due to disease and adverse weather conditions, and other non-price factors. However, due to data limitations, the human factors and water quality factors are not included in this model.

The proposed production supply relationship is:

$$DP_t = f(FP_{t-5}, PF_{t-5}, S_t) \qquad (2.3)$$

where:

DP_t = Domestic farm production

FP_{t-5} = Farm price lagged five months

PF_{t-5} = Price of feed lagged five months

S_t = Seasonal supply factor

Processor Supply

The quantity of catfish supplied by the processor to the market is positively related to the quantity of farm production. It is hypothesized that the number of pounds of fish shipped by processors for any given level of farm production is declining because of a shift toward filets and away from whole fish.

The quantity of processed catfish is a direct function of the farm production. Therefore, processor supply of catfish is expected to increase (decrease) with respond to increase (decrease) in the quantity of farm production. The expected sign on the coefficient of the time trend variable is negative.

The processor supply function would be:

$$PS_t = f(DP_t, OBS_t) \qquad (2.4)$$

where:

PS_t = Processor supply quantity

DP_t = Farm production quantity

OBS_t = Time trend variable

Farm Price

Farm price or the price received by farmers is said to be a function of the wholesale price since the most important market outlet for catfish raised by farmers is processing plants. With only a small number of processors in the industry to buy their product, farmers receive whatever price the processors are willing to offer. The ability of processors to pay a higher price in turn depends on the wholesale price of processed fish they charge. A positive relationship between prices farmers receive and wholesale prices is expected. That is, if the processor's wholesale price is high, farmers receive a higher price for their product and if the wholesale price is low, the price farmers receive is expected to be lower.

The farm price equation will simply be:

$$FP_t = f(WP_t) \qquad (2.5)$$

where:

FP_t = Farm price of catfish

WP_t = Wholesale price of catfish

Import Quantity

Brazil is the country that is responsible for supplying almost all of the catfish imported to the U.S. The amount of catfish imported is hypothesized to be affected by the domestic price and the price of Brazilian imports. Assuming minimum trade barriers, quantity imported would be positively related to domestic price and negatively related to import price. It is expected that imports will increase (decrease) when the domestic price increases (decreases) or when the Brazilian import price decreases (increases).

The import quantity function can be written as:

$$IMPQ_t = f(WP_t, IMPP_t) \quad (2.6)$$

where:

$IMPQ_t$ = Imports from Brazil

WP_t = Wholesale price (U.S.)

$IMPP_t$ = Price of imported catfish

Inventory

A market clearing inventory identity is included to complete the model. Current month ending inventory is equal to inventory from the previous month plus processor supply, plus imports, minus sales in month t:

$$INV_t = INV_{t-1} + PS_t + IMPQ_t - WD_t \quad (2.7)$$

while the change in inventory is defined as the current period inventory minus the previous period's inventory:

$$CHATI_t = INV_t - INV_{t-1} \quad (2.8)$$

Therefore the inventory identity can be written as:

$$CHATI_t = PS_t + IMPQ_t - WD_t \quad (2.9)$$

where:

INV_t = Current month inventory

INV_{t-1} = Previous month inventory, and

all other variables are as previously defined.

CHAPTER III

EMPIRICAL MODEL AND RESULTS

In this chapter, structural form and reduced form coefficients based on a linear form of the conceptual model are shown. After discussing the data and estimation procedures, each of the structural form equations are discussed and the reduced form coefficients are presented.

Data and Estimation

Seventy-two monthly observations for the period January 1981 through December 1986 were used to estimate the structural coefficients. A list of variables, their sources, and the mean and standard deviation of the data are presented in Table 2 on page 17.

All quantities, which include wholesale, production and quantity processed, imports and inventory are divided by the U.S. population. All prices are deflated by the wholesale price index. The monthly consumer price index is used to deflate the consumer disposable income variable. The indices use 1967 as the base year.

In a system of simultaneous equations, a change in any disturbance term changes all the endogenous variables since they are determined simultaneously. That is, when an endogenous variable is used as a regressor, its association with the disturbance term causes the estimation to be not consistent (3).

For example, consider the wholesale demand equation:

$$WD_t = a_1WP_t + a_2INC_t + a_3CHICKP_t + a_4S_t + e_1 \quad (3.1)$$

in which one of the predictor variables WP_t is endogenous in the system that WP_t is correlated to the disturbance term e_2

$$WP_t = b_1WP_{t-1} + b_2CHATI_t + e_2 \quad (3.2)$$

Ordinary least squares (OLS) estimates of the coefficients are no longer consistent because of this simultaneity bias. Three stage least squares (3SLS) technique was applied to the simultaneous equation system to provide consistent estimates of the coefficients (4).

Wholesale Demand Equation

The statistically estimated coefficients for the wholesale demand equation are presented in Table 3. A time trend square (OBSSQ) variable is included to shift the demand curve outward. Eleven dummy variables were used to measure the monthly demand variations.

The signs of the coefficients are consistent with the hypothesized effects stated in the conceptual equation except for the coefficient for $CHICKP_t$. Nevertheless, the standard error for the coefficient of substitute price ($CHICKP_t$) variable is larger than the estimated parameter, suggesting that changes in the price of the substitute do not significantly affect demand.

The estimated inverse relationship between wholesale price of catfish and the wholesale demand was as expected. An increase (decrease) in wholesale price of catfish will result in a decrease (increase) in quantity demanded.

As hypothesized, the relationship between consumer disposable income and demand for catfish was found to be positive. Purchases of catfish increase when income of consumers rise and vice versa. The positive sign of the coefficient for the time trend variable OBSSQ indicates that the demand for catfish is expanding rapidly over time.

TABLE 3

ESTIMATED RESULTS FOR THE WHOLESALE DEMAND FOR CATFISH EQUATION (WD_t)

Explanatory Variable	Hypothesized Sign	Estimated Coefficient	Standard Error
Intercept		-0.0347	0.0355
WP_t	-	-0.0762	0.0200
INC_t	+	0.0222	0.0111
$CHICKP_t$	+	-0.0124	0.0184
OBSSQ	+	0.000002	0.0000014
D1		0.0046	0.0017
D2		0.0111	0.0017
D3		0.0131	0.0016
D4		0.0089	0.0016
D5		0.0093	0.0016
D6		0.0074	0.0017
D7		0.0070	0.0017
D8		0.0105	0.0017
D9		0.0078	0.0016
D10		0.0065	0.0016
D11		0.0034	0.0015

From the estimated structural coefficient, the own price elasticity of demand for catfish calculated at the mean price and quantity is -1.43. This suggests that one percent increase (decrease) in price leads to 1.43 percent decrease (increase) in quantity demanded. This elasticity may be high when compare with other meats, but because there are other kinds of fish in the market available to consumers which compete with catfish, an elasticity of 1.43 for catfish is considered reasonable.

A point estimate for income elasticity also was calculated at the mean income and quantity. An elasticity of 3.36 indicates that a one percent increase (decrease) in consumer disposable income results in a 3.36 percent increase (decrease) in the quantity of catfish demanded.

The magnitude of each dummy coefficient shows the intercept shift for each of the eleven months with December as the base intercept.

Wholesale Price Equation

The estimated coefficients and their standard errors for the wholesale price equation are presented in Table 4. Dummy variables were included in the statistical equation to show the relative intensity of price differences in each month.

The signs of the estimated coefficients did not deviate from expectations. The estimated parameter for the change in inventory variable ($CHATI_t$) is 1.5 times greater than its standard error.

Lagged price (WP_{t-1}) was found to be statistically significant in affecting the present period wholesale price. The lagged price coefficient estimated is large relative to its standard error.

The results show that wholesale price is negatively related to change in the inventory level and positively related to the previous month price.

TABLE 4

ESTIMATED RESULTS FOR THE WHOLESALE PRICE OF CATFISH EQUATION (WP_t)

Explanatory Variable	Hypothesized Sign	Estimated Coefficient	Standard Error
Intercept		0.0892	0.0346
$CHATI_t$	-	-9.6629	6.0949
WP_{t-1}	+	0.8287	0.0644
D1		-0.0116	0.0109
D2		-0.0043	0.0118
D3		0.0061	0.0118
D4		-0.0023	0.0110
D5		-0.0070	0.0108
D6		0.0007	0.0092
D7		-0.0034	0.0099
D8		-0.0132	0.0112
D9		0.0033	0.0085
D10		-0.0044	0.0084
D11		-0.0026	0.0084

Farm Supply Equation

The estimated results for the farm supply equation are presented in Table 5. The dummy variables were included to depict the relative differences in monthly quantity supplied of live catfish. All of the signs and hypothesized effects of the parameters are consistent with a priori expectations.

The results confirm that an increase (decrease) in the price farmers receive and a lower (higher) feed cost will lead to a higher (lower) quantity supplied.

The supply elasticity calculated at the mean of supply quantity and farm price is 0.90. That is, a one percent increase (decrease) in the farm price will lead to 0.90 percent increase (decrease) in farm supply of catfish.

The supply response with respect to changes in feed cost, calculated at the mean of supply quantity and feed price, was found to be -1.33. This suggests that a one percent increase (decrease) in feed price will result in 1.33 percent decrease (increase) in the quantity of catfish supplied, ceteris paribus.

The dummy variables indicate intercept shifts associated with month of the year. Lower quantity is supplied in the months of June, July, November, December and January. Lower quantity of catfish supplied in the winter may be attributed to the cold and wet weather making harvesting more difficult in some ponds, and reducing the weight gain on fish.

TABLE 5

ESTIMATED RESULTS FOR THE FARM SUPPLY OF CATFISH EQUATION (DP_t)

Explanatory Variable	Hypothesized Sign	Estimated Coefficient	Standard Error
Intercept		0.0651	0.0171
FP_{t-5}	+	0.2100	0.0559
PF_{t-5}	-	-1.4675	0.1816
D1		0.0063	0.0051
D2		0.0174	0.0051
D3		0.0181	0.0052
D4		0.0102	0.0052
D5		0.0101	0.0053
D6		0.0050	0.0050
D7		0.0036	0.0049
D8		0.0096	0.0049
D9		0.0082	0.0049
D10		0.0073	0.0048
D11		0.0031	0.0048

Processor Supply Equation

The estimated results for the processor supply equation are shown in Table 6. OBS is a time trend variable included in the equation to account for any structural change in the quantity processed of catfish.

TABLE 6

ESTIMATED RESULTS FOR THE PROCESSOR SUPPLY OF CATFISH EQUATION (PS_t)

Explanatory Variable	Hypothesized Sign	Estimated Coefficient	Standard Error
Intercept		-0.00045	0.00097
DP_t	+	0.5722	0.0607
OBS	-	-0.00007	0.00005

The signs of the estimated coefficients are as expected. The results confirmed that quantity processed is positively related to the farm production. The farm supply coefficient of 0.5722 indicates that 0.57 pounds of processed product is produced from the marginal pound of live fish processed.

The negative coefficient for the time trend variable indicates lower processed volume for any given volume of farm production over time because of the greater dressing lost in shifting from whole fish to more filets .

Farm Price Equation

Estimated results for the coefficients of the farm price equation are presented in Table 7. The sign for the estimated coefficient is positive and significant as expected. The small standard error relative to the coefficient suggests that wholesale price is significant in determining the farm price of catfish.

TABLE 7

ESTIMATED RESULTS FOR THE FARM PRICE OF CATFISH EQUATION (FP_t)

Explanatory Variable	Hypothesized Sign	Estimated Coefficient	Standard Error
Intercept		-0.0545	0.0263
WP_t	+	0.5340	0.0526

The positive relationship between farm price and wholesale price implies that farm price increases (decreases) as price received by processors increases (decreases).

Import Quantity Equation

The estimated coefficients and their standard errors for the import quantity equation are presented in Table 8. All the signs of the estimated parameters are as hypothesized. The coefficient estimates are large relative to standard errors indicating that wholesale price and import price significantly affect the quantity of catfish imported.

TABLE 8

ESTIMATED RESULTS FOR THE U.S. CATFISH IMPORTS EQUATION ($IMPQ_t$)

Explanatory Variable	Hypothesized Sign	Estimated Coefficient	Standard Error
Intercept		-0.0004	0.0021
WP_t	+	0.0071	0.0037
$IMPP_t$	-	-0.0034	0.0029

The positive relationship between wholesale price and import quantity indicates that as price of catfish in the U.S. increases (decreases), a higher (lower) amount of catfish will be imported. The inverse relationship between import price and import quantity suggests that more (less) catfish will be imported when the price of imported catfish is lower (higher).

The import price elasticity at the mean of import price and import quantity is -0.41, indicating that every one percent increase (decrease) in the import price will lead to a 0.41 percent decrease (increase) in quantity imported.

From the structural coefficient, the cross price elasticity of import demand calculated at the mean price and quantity was found to be 1.56. This means that every one percent increase (decrease) in the price of catfish in the U.S. lead to a 1.56 percent increase (decrease) in the quantity of catfish imported.

Reduced Form Equations

Seven reduced form equations are derived from the estimated structural coefficients. In the reduced form equations, all endogenous variables are functions of predetermined (exogenous and lagged endogenous) variables in the model. The reduced form coefficients, which are also called impact multipliers, measure the impact in the current period on each endogenous variables of a unit change in any predetermined variable (3).

The results for the estimated reduced form coefficients are presented in Table 9. The effect of several reduced form coefficients are significant to warrant further discussion.

In the wholesale demand function, income elasticity, calculated using the reduced form coefficient, suggest that a one percent increase in consumer income will lead to 1.98 percent increase in demand for catfish.

In the conceptual model, wholesale price is not directly impacted by feed cost changes. But because of the interdependencies of the supply variable with other endogenous variables, changes in feed prices exert an impact on the market through a multiplier effect. As a result, a unit increase (decrease) in feed price will increase (decrease) wholesale price by 4.49 units. The impact of feed price changes on wholesale price was the resulting chain effect of feed prices on farm production; farm production on processor supply; processor supply on inventory; and finally change in inventory on wholesale price.

TABLE 10

REDUCED FORM EQUATIONS

Endogenous Variables	Predetermined Variables							
	INC_t	$CHICKP_t$	$IMPP_t$	PF_{t-5}	WP_{t-1}	FP_{t-5}	OBSSQ	OBS
WD_t	.0131	-.0073	-.0014	-.3427	-.0350	.0490	1.21E-6	-2.86E-5
WP_t	.1189	-.0663	.0187	4.4936	.4589	-.6430	1.10E-5	3.74E-4
DP_t				-1.467		.2100		
PS_t				-0.839		.1201		-7.01E-5
$IMPQ_t$	.0008	-.0004	-.0033	.0319	.0032	-.0045	7.84E-8	2.66E-6
FP_t	.0635	-.0354	.0099	2.3996	.2450	-.3433	5.88E-6	.0002
$CHATI_t$	-.012	.0068	-.0019	-.4650	.0382	.0665	-1.14E-6	-3.8E-5

TABLE 10 (Continued)

Endogenous Variables	Predetermined Variables										
	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D11
WD_t	.0041	.0102	.0113	.0073	.0080	.0053	.0052	.0089	.0062	.0055	.0027
WP_t	.0067	.0111	.0225	.0209	.0171	.0271	.0235	.0201	.0200	.0139	.0049
DP_t	.0063	.0174	.0181	.0102	.0101	.0050	.0036	.0096	.0082	.0073	.0031
PS_t	.0021	.0085	.0095	.0048	.0054	.0024	.0022	.0053	.0044	.0035	.0014
$IMPQ_t$	4.E-5	7.E-5	.0001	.0001	.0001	.0001	.0001	.0001	.0001	9.E-5	6.E-5
FP_t	.0035	.0059	.0120	.0111	.0091	.0144	.0125	.0107	.0106	.0074	.0050
$CHATI_t$	-.001	-.001	-.001	-.002	-.002	-.002	-.002	-.003	-.001	-.001	-.001

The implications of the impact of a higher feed price is that it will result in a higher wholesale price, while a higher wholesale price will result in a lower quantity being demanded. A higher wholesale price will bring a higher farm price for catfish. Conversely, if the feed price was lower, wholesale price would be lower and would result in a higher quantity demanded. But, prices farmers receive for the catfish they produced would be lower.

Prediction and Actual Data

To understand how well the model predicts the actual data, predicted values of the endogenous equations are generated and plotted on the same graph with the actual data.

The performance of the predicted values compared to the actual values of the deflated values of wholesale demand, wholesale price, farm supply, processed supply, import and farm price equations is shown in Figures 8 through 13.

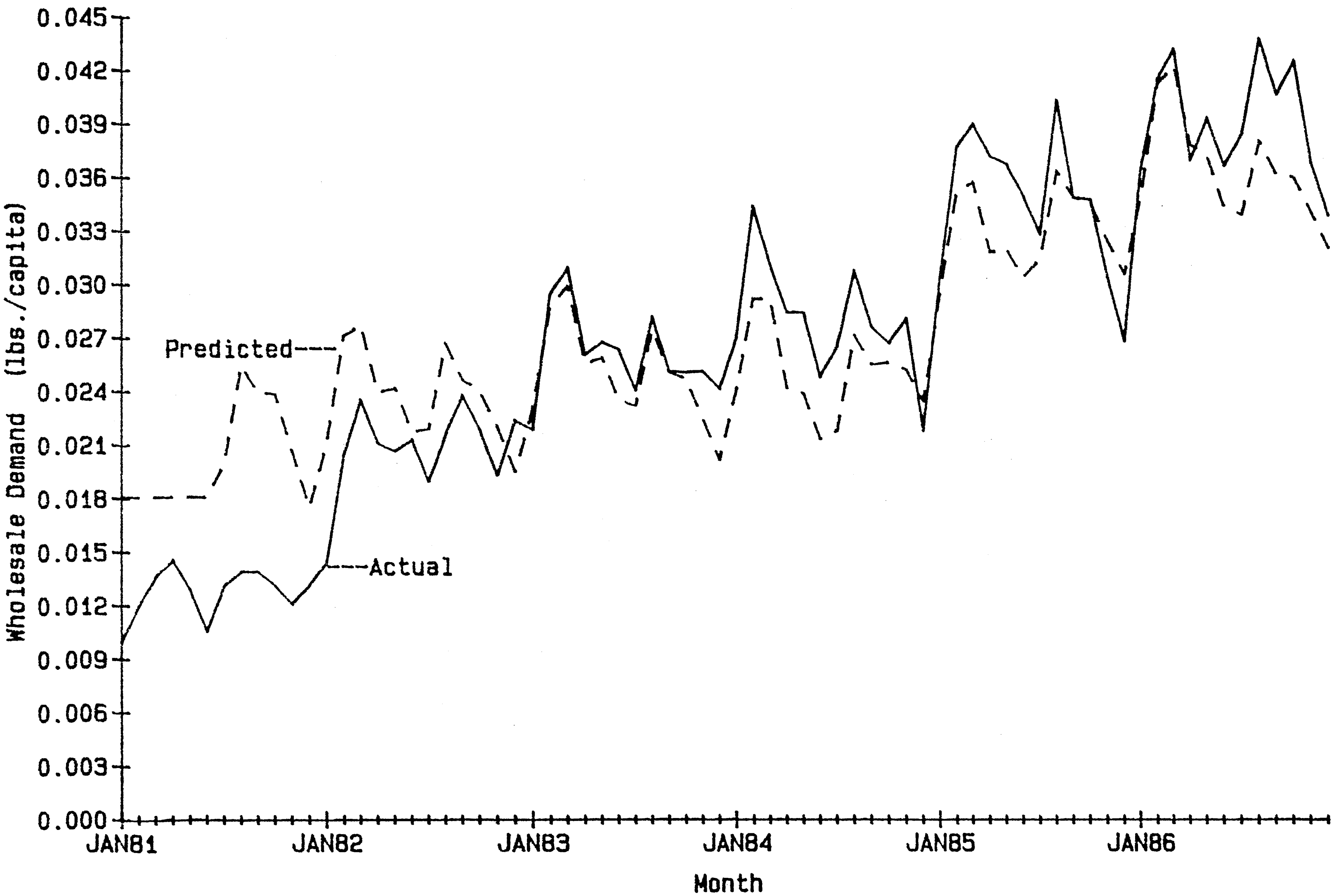

Figure 8. Wholesale Demand For Catfish: Actual and Predicted.

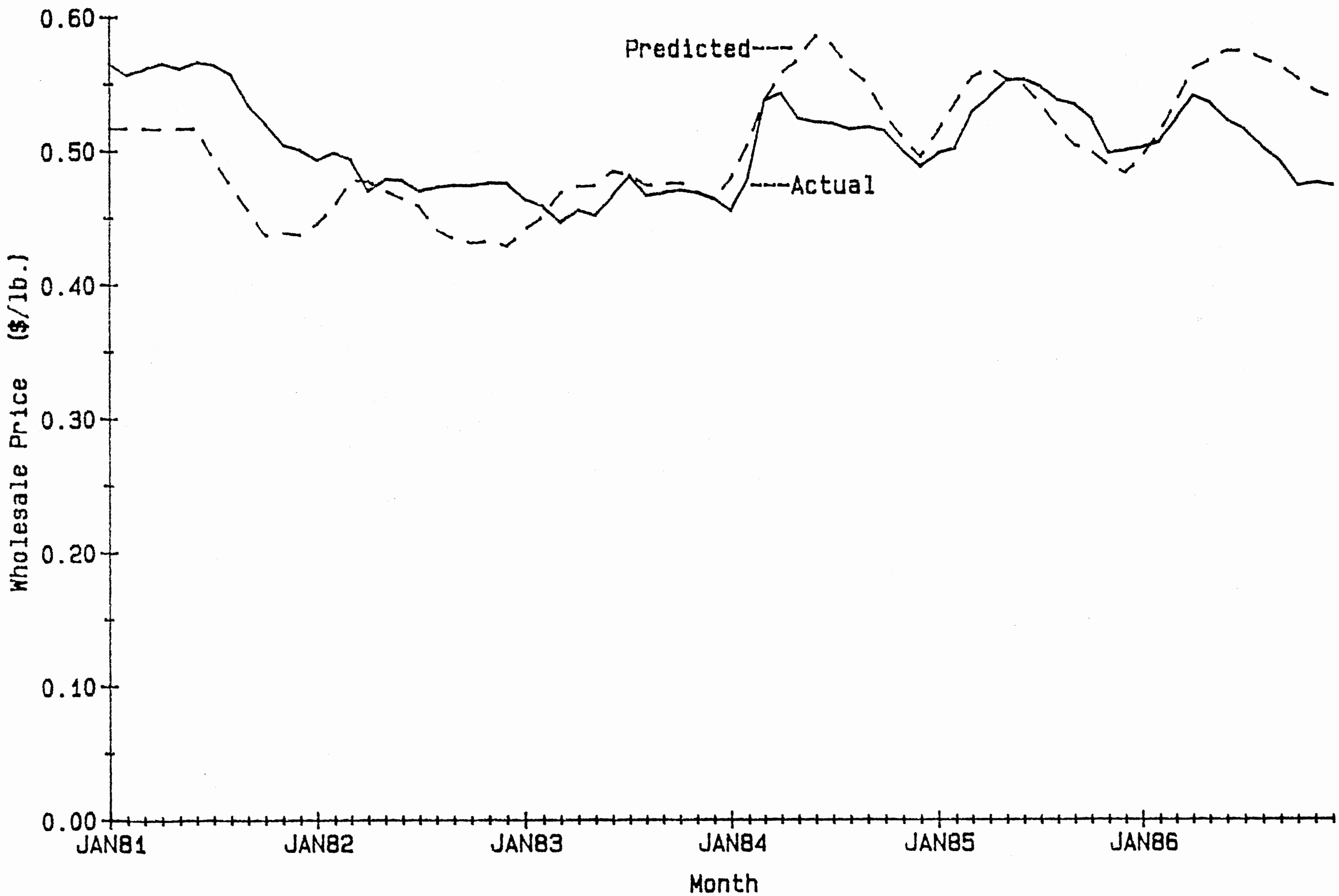

Figure 9. Wholesale Price Of Catfish: Actual and Predicted.

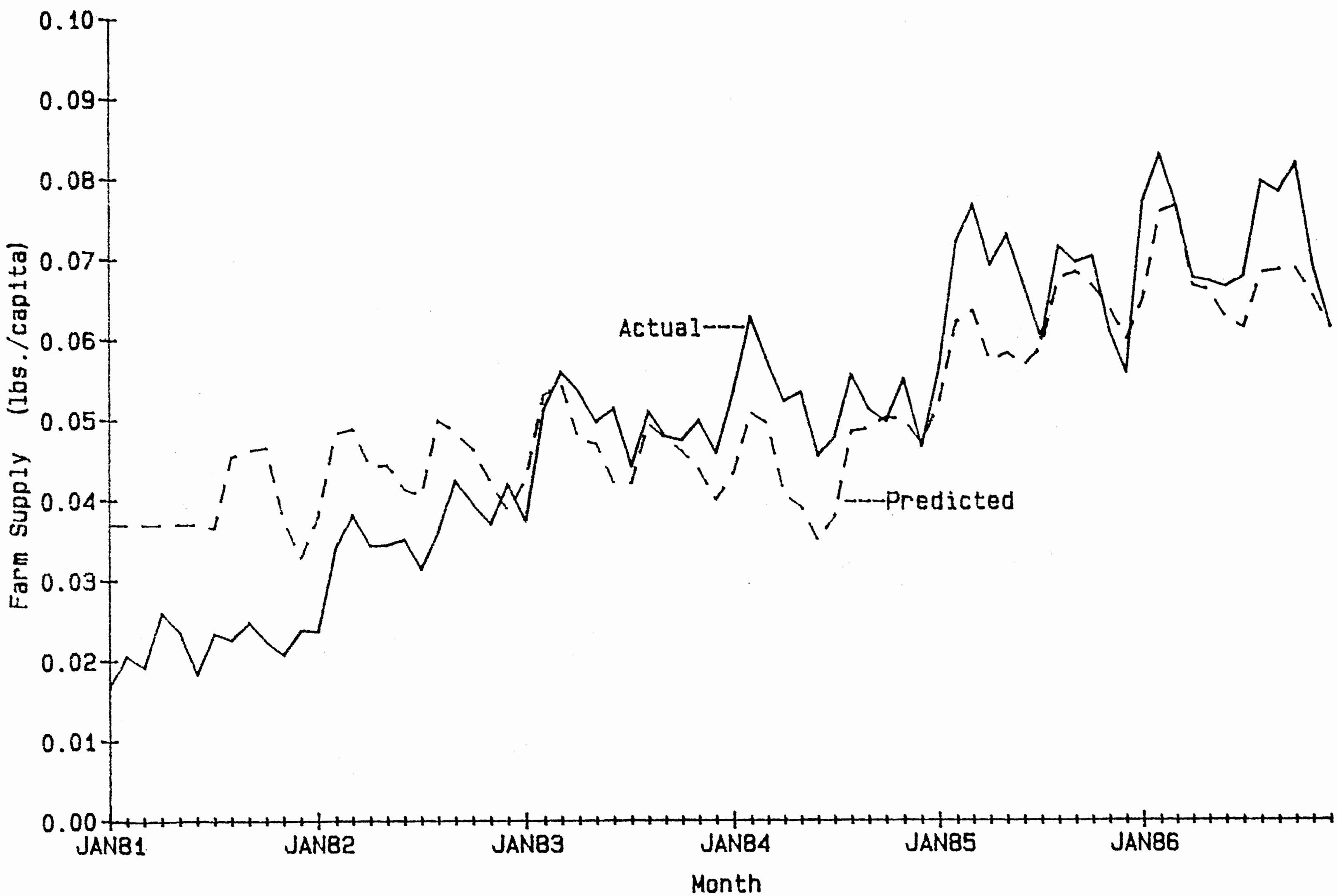

Figure 10. Farm Supply Of Catfish: Actual and Predicted.

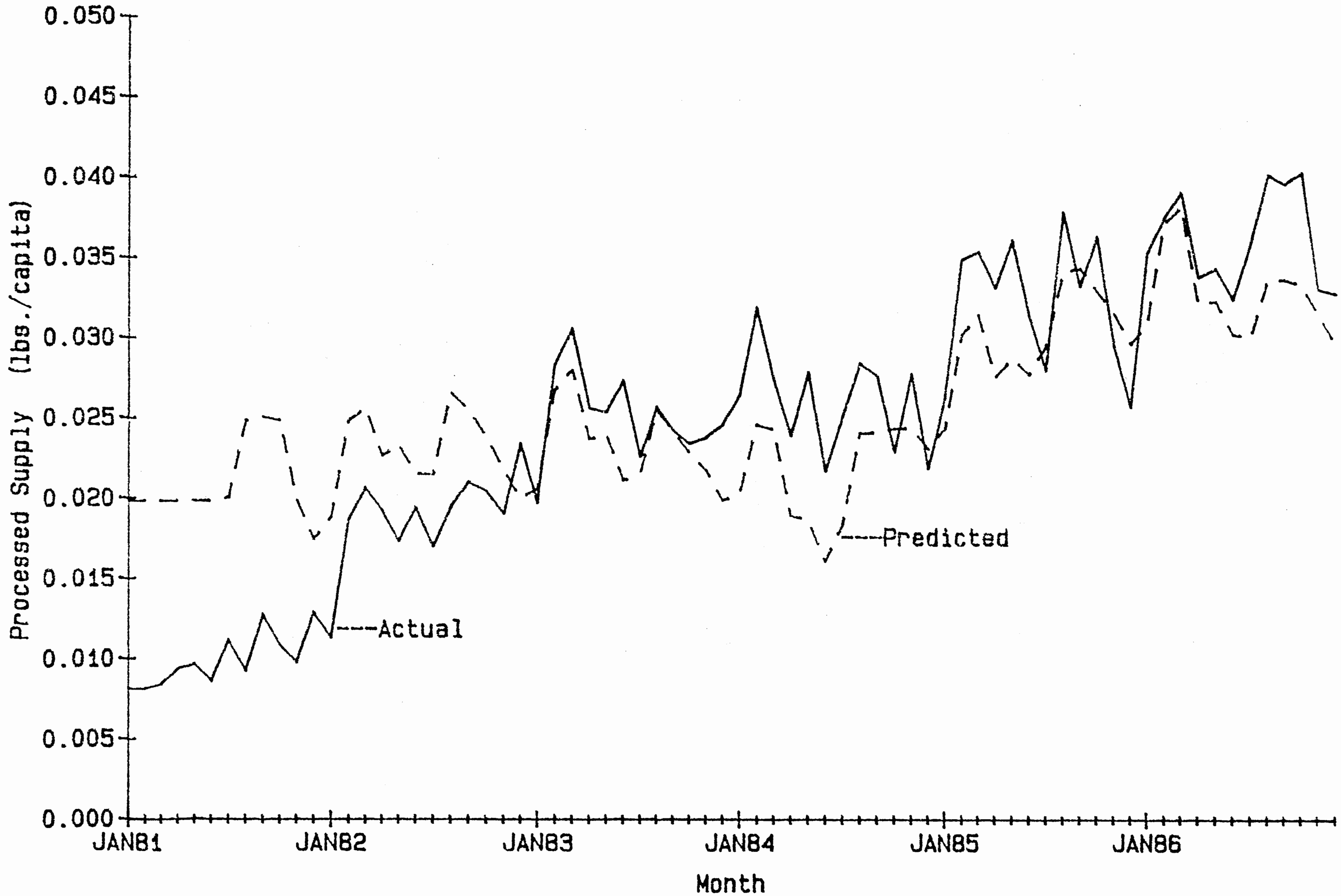

Figure 11. Processed Catfish Supply: Actual and Predicted.

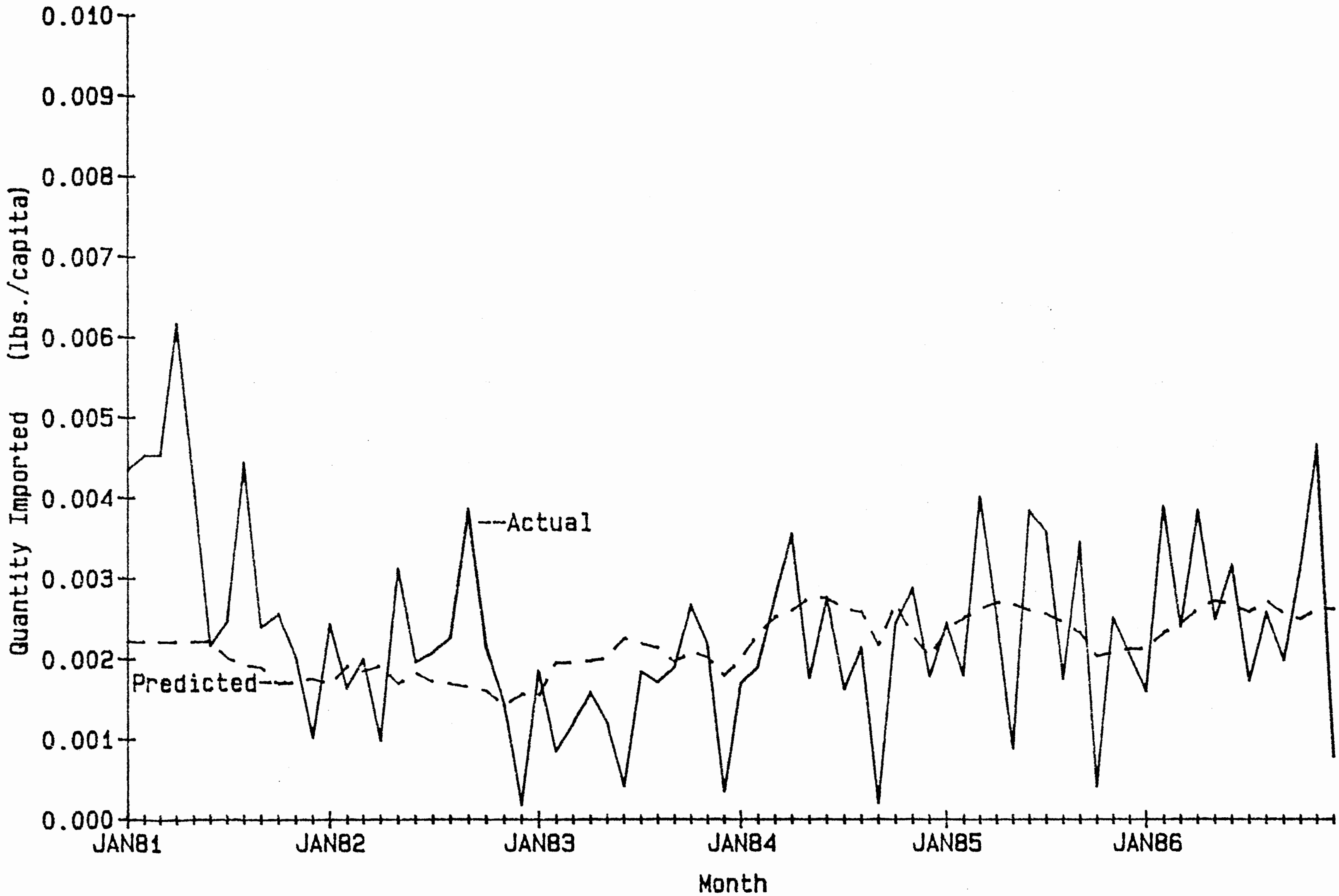

Figure 12. Imports Of Catfish: Actual and Predicted.

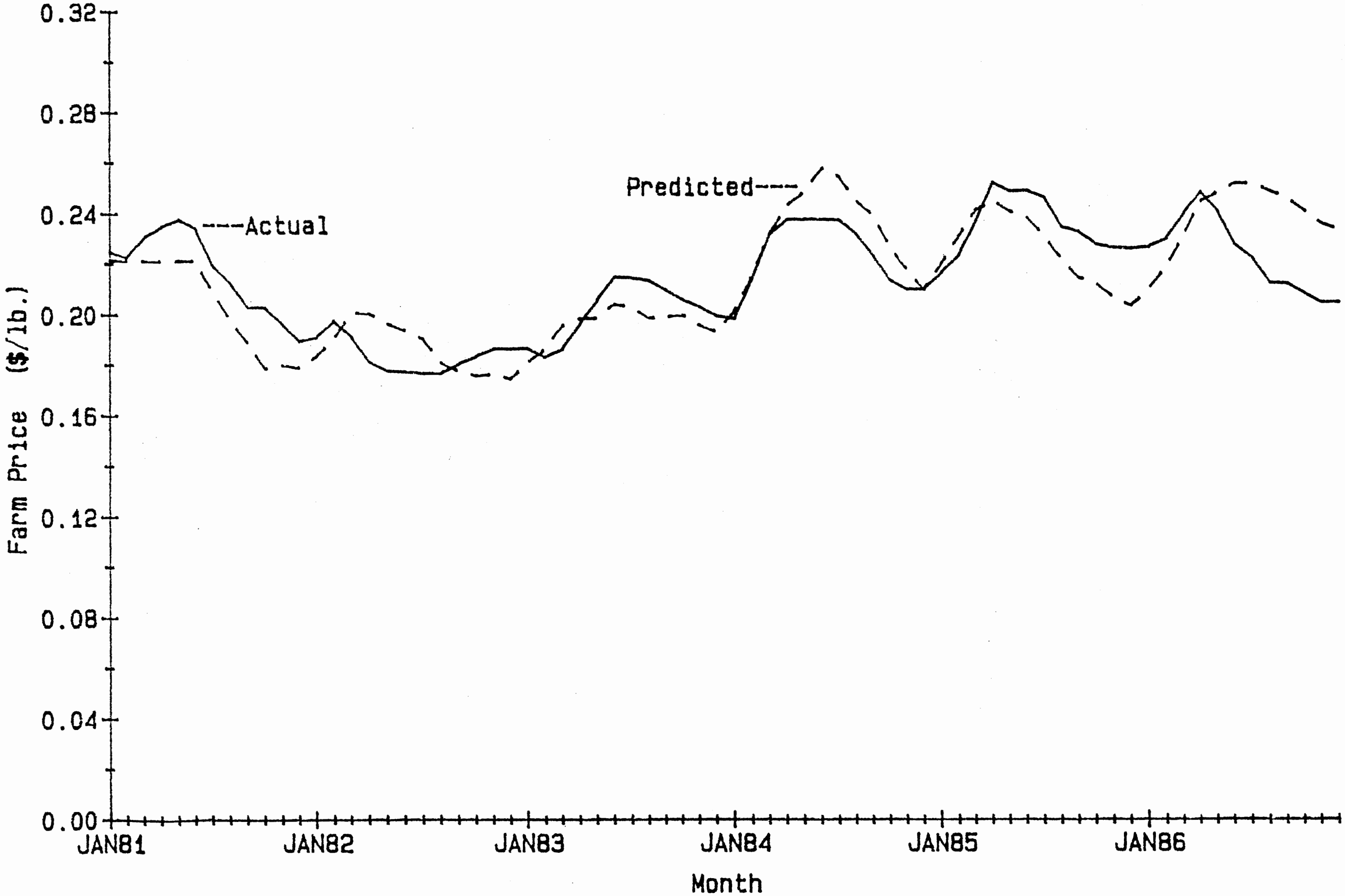

Figure 13. Farm Price Of Catfish: Actual and Predicted.

CHAPTER IV

IMPLICATIONS

In this chapter, findings related to each of the five objectives of this study are presented. The objectives are to:

a) determine the nature of the demand for catfish from processors;

b) determined the relationship between prices received by processors and the prices paid to farmers;

c) examine the extent to which catfish production responds to changes in prices and feeding costs;

d) evaluate the nature of the demand for catfish imports from Brazil; and

e) discover the price determination process and the effects of price change on the processors.

Demand From Processors

The demand for catfish from the processors is responsive to changes in consumer income. Based on the reduced form coefficient, every one percent increase in consumer income leads to 1.98 percent increase in the consumption of catfish. When consumer income increases, a higher quantity of catfish is demanded.

The own price elasticity of demand for catfish was estimated to be -1.43. Every one percent increase (decrease) in the wholesale price will be expected to decrease (increase) wholesale demand for catfish by 1.43 percent.

The price of chicken does not affect wholesale demand for catfish. Therefore, chicken is not a close substitute for catfish in the meat market.

The long run demand for catfish appeared to be expanding over time. This growing demand may be derived from the changes in consumer choice towards leaner cuts of meat and the increasing number of families accepting catfish in their seafood diet.

Wholesale Price and Farm Price

The price receive by processors (wholesale price) and the price paid to farmers (farm price) are positively related. As was shown when comparing Figure 2 with Figure 3 in chapter I, the farm price of catfish is closely correlated to the wholesale price.

In Table 7 of chapter III, the estimated results for the farm price equation were presented. Farm price was said to be a function of wholesale price, since almost all of the farm production of catfish were sold to the processors. The farmers received the price the processors are willing to pay and the processors' decision depends on the wholesale price they get. The wholesale price coefficient was found to be 0.5340, indicating that farm prices are at about fifty-three percent of wholesale prices.

Farm Production

The farm production of catfish was specified to be a function of farm price for catfish and cost of feed. Farmers are assumed to base their production on the price receive for catfish and the cost of production. It is a logical expectation that the farmers will increase (decrease) production when farm price for catfish increases (decreases) and decrease (increase) production when feed cost increases (decreases).

The responsiveness of farm production to farm price changes is 0.90. That is, farm production increases (decreases) by 0.90 percent for every one percent increase (decrease) in farm price.

The farm supply quantity is also responsive to feed price changes. Every one percent increase (decrease) in feed price will result in 1.33 percent decrease (increase) in the quantity of catfish supplied.

Import Demand

The demand for imported catfish is responsive to domestic catfish price. The cross price elasticity of the U.S. wholesale price on the Brazilian imports was found to be 1.56, indicated that increasing (decreasing) domestic price by one percent would increase (decrease) quantity of catfish imported by 1.56 percent.

The response of imported quantity to import price changes is inelastic. The import price elasticity of catfish imported from Brazil was estimated to be at -0.41. For every one percent increase (decrease) in the import price of catfish, import quantity demanded will only decrease (increase) by 0.41 percent. Therefore, if the Brazilian exporter were to increase the price of catfish by one percent, the quantity of imports demanded from the U.S. will only decrease by 0.41 percent.

Producers and processors in the U.S. catfish market are not expected to be affected to any great extent by Brazilian imports because of the relatively small quantity of catfish imported when compared to the domestic production.

Wholesale Price

The wholesale price is evidently a very important variable in the catfish market system. Three equations in the system are directly affected by any wholesale price changes and two equations are affected indirectly.

The processor's monthly inventory level and the previous month's price are important factors to be considered by the processors in making pricing decision. When the current month's inventory is larger relative to the previous month's inventory, processors will decrease the price.

An advantage to the processor in lowering the wholesale price is in foreign import competition of catfish from

Brazil. As the cross price elasticity of imports is price responsive, a one percent reduction in domestic catfish price will lead to more than one percent decrease in quantity imported. Lowering wholesale price will weaken the potential competition from Brazilian imports.

CHAPTER V

SUMMARY AND CONCLUSIONS

Summary

Since the 1960's, the production and processing of catfish has became an important industry in the southern region of the United States. Many farmers in the South have adopted catfish as an additional farm enterprise. The overall objective of this study is to provide information to the industry's decision makers as the market for catfish continues to grow. Seven simultaneous, linear equations are used in a model to depict the demand and supply dynamics of the U.S. catfish marketing system. The relationships among sales price, demand, supply, prices farmers receive, quantity of imports and inventory of catfish are explored.

Three-stage least squares regression method is used to provide a consistent estimates of the simultaneous equation parameters. Structural and reduced form coefficients are estimated. Elasticities are calculated at the mean of prices and quantities.

Conclusions

The general conclusion is that the model appears to accurately represent the relationships among variables in the U.S. catfish marketing system. All except one of the parameters are plausible, and the predictive capabilities of the equations are satisfactory except for imports. The model is dynamically stable.

The demand for catfish was found to be income elastic. As consumer income increases, consumption of catfish is expected to increase by 1.9 percent based on the reduced form coefficients.

The demand response of catfish sales to price changes was estimated to be elastic. For every one percent increase (decrease) in wholesale price, quantity of catfish demanded was expected to decrease (increase) by 1.43 percent.

The long-run market demand for catfish appears to be expanding over time. This growing trend in demand for catfish was probably a result of changes in consumer preferences and greater distribution of catfish products.

The supply of farm raised catfish was estimated to be responsive to price and feed cost changes. A one percent increase (decrease) in farm price of catfish will lead to 0.90 percent increase (decrease) in quantity supplied. A one percent increase (decrease) in feed price will lead to 1.33 percent decrease (increase) in quantity of catfish supplied.

The quantity of catfish supplied by processors is a function of quantity of catfish sold to processing plants by the farmers.

Farm price or price received by farmers for catfish depends on the wholesale price the processors receive. Farm prices increase (decrease) as wholesale prices increase (decrease).

Imports of catfish from Brazil were found to be responsive to domestic wholesale price changes. Every one percent increase (decrease) in the U.S. wholesale price of catfish is expected to induced 1.56 percent increase (decrease) in the quantity of catfish imported.

Suggestions for Future Research

Because of the rapid growth of the catfish industry, many changes will be taking place. Continuing analysis using updated data is encouraged.

Further research employing additional explanatory variables should improve the predicting performance of the catfish import equation. More information about Brazilian catfish production practices, pricing mechanisms and trade relationships with the U.S. should be obtained.

In this study, the role of retailer in the catfish market was not examined due to lack of dependable data to the researcher. Activities such as retailer's wholesale demand for catfish from the processor, supply to consumers, price determining process and retail inventory management could be investigated to provide additional marketing information.

A SELECTED BIBLIOGRAPHY

(1) Boleware, Valerie and James G. Dillard. "Consumer Awareness and Acceptance of Farm-Raised Catfish." Information Bulletin 54, Mississippi Agricultural and Forestry Experiment Station, Mississippi State, Mississippi. June 1984.

(2) Dixon, D. Andrew Jr., J. Scott Miller, L. Richard Conner and John E. Waldrop. "Survey of Market Channels for Farm-Raised Catfish." Agr. Econ. Res. Rept No.132, Mississippi State University, March 1982.

(3) Johnston, J. "Econometric Methods." 3rd Edition. New York: McGraw-Hill Book Company, 1984.

(4) Kennedy, Peter. "A Guide to Econometrics." Cambridge, Massachusetts: The MIT Press, 1986.

(5) Kinnucan, Henry and Gregory Sullivan. "Monopsonistic Food Processing and Farm Prices: The Case of the West Alabama Catfish Industry." Southern Journal of Agricultural Economics 18, 2(1986): 15-23.

(6) Malick, William Michael. "A Simultaneous Equation Model of The Florida Orange Juice Marketing System." Master's Thesis. Gainsville, Florida: University of Florida. 1980.

(7) Miller, J. Scott, J. Richard Conner and John E. Waldrop. "Survey of Commercial Catfish Processors--Structural and Operational Characteristics and Procurement and Marketing Practices." Agr. Res. Rept. No.130, Mississippi State University, October 1981.

(8) Perry, Janet E. and Daniel S. Tilley. "Marketing Processed Farm-Raised Catfish Products." Department of Agricultural Economics, Oklahoma State University, Research Report No.P-890, March 1987.

(9) Phlips, Louis. "Applied Consumption Analysis." New York: American Elsevier Publishing Inc., 1974.

(10) Raulerson, Richard and Warren Trotter. "Demand for Farm Raised Catfish in Supermarket: Analysis of A Selected Market." USDA Economic Research Service, Marketing Research Report No.993, 1973.

(11) "SAS/ETS User's Guide: Econometrics and Time-Series Library, 1982 Edition." Cary, North Carolina: SAS Institute Inc. 1982.

(12) United States Department of Agriculture. "Agricultural Prices." National Agricultural Statistical Services, Agricultural Statistics Board. 1987.

(13) United States Department of Agriculture. "Agricultural Statistics." Statistical Reporting Service. 1987.

(14) United States Department of Agriculture. "Catfish." Crop Reporting Board, Economics and Statistical Services, Washington, D.C., 1981 through 1986.

(15) United States Department of Commerce. "Current Population Reports." Bureau of Census. 1986.

(16) United States Department of Commerce. "Survey of Current Business." Bureau of Economic Analysis. Various Issues.

(17) United States Department of Commerce. "U.S. General Import." Bureau of Census. Report FT135. Washington, D.C. 1981-1986.

(18) Williams, Ken., Donald P. Schwartz, Glen E. Gebhart and Eugene Maughan. "Small Scale Cage Fish Culture in Oklahoma Farm Ponds." Agricultural Research, Langston University. Langston, Oklahoma. 1985.

VITA 2

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