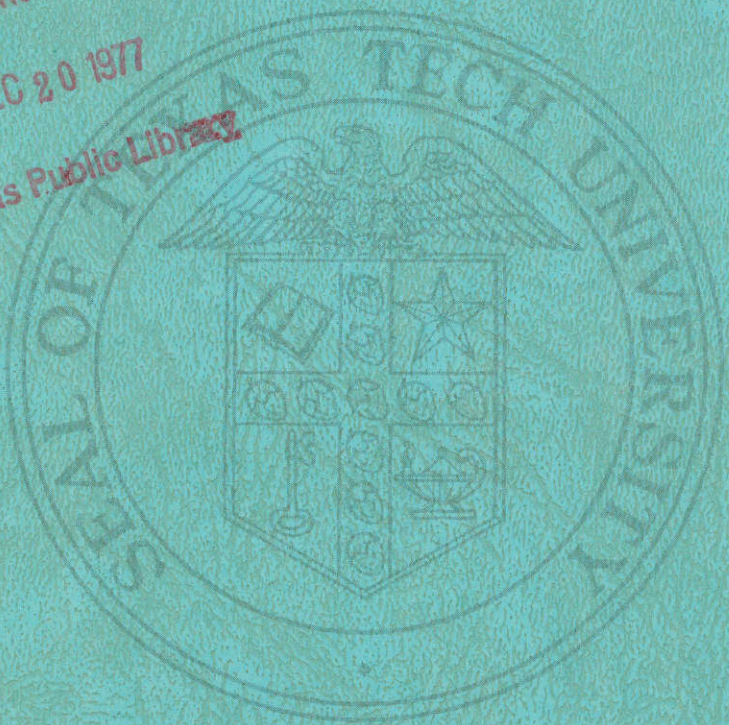
Demand for Pork: A Long-Run Analysis



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ABSTRACT

A possible major constraint to the longer run growth potential of the U.S. swine industry is the future trend in the demand for pork. The basic objective of the present study was to examine the possible changes in the long-run demand for pork and, more specifically, the changes in the demand elasticities for pork.

Ordinary least squares equations were developed with per capita consumption of pork as a function of per capita disposable income and retail prices of pork and beef. An equation was estimated for each of 15 periods of fit, beginning with 1950-1959, 1951-1960, etc., through 1964-1973. Thus, the periods of fit were updated successively by deleting the earliest year of the preceding period of fit and by adding an additional year at the end. The purpose of this approach was to examine the process of change in the coefficients or elasticities on a continuous basis. One set of equations was estimated using data in actual terms. A second set was based on variables in logarithmic terms yielding direct estimates of demand elasticities. Furthermore, linear trend equations were developed for each series of three different demand elasticities to investigate the presence of any significant and systematic changes in elasticities over the periods of fit.

The estimates of direct price elasticity of demand for pork for the fifteen periods of fit were clustered around -.7. The cross price elasticity of demand for pork with respect to beef price however fluctuated widely and, for the last two periods of fit, became small and

statistically insignificant. The elasticity coefficients associated with income were negative for earlier periods of fit, then approached zero, and finally became statistically significant positive values. The elasticity estimates thus indicated a fairly stable response in per capita pork consumption to pork price, and a relatively low dependence of pork consumption on the price of or demand for beef. The rising trend in income elasticities, particularly the significant positive coefficients for the more recent periods of fit, appeared to reflect a strengthening process in the demand for pork. This significant process of change may be attributed to the improved quality of the product and changes in consumers' tastes and preferences in recent years.

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INTRODUCTION

The long-run growth potential of the U. S. swine industry is dependent on two major constraints. On the supply side, production potential is influenced by the availability of resources, specifically by adequate feed supplies at reasonable costs. On the other hand, future expansion of the hog-pork sector, as with any other industry, is constrained by the potential trend in the demand for the product. The basic puspose of the present study is to concentrate on the latter issue by analyzing the past longer run demand trend. Such an analysis provides not only an explanation of past events, but also some insight into the long-run demand outlook for the sector.

The per capita consumption of pork varied between 60 and 70 pounds for most years during the last two decades. While the consumption of beef and poultry on a per capita basis rose substantially between 1950 and 1973, the per capita consumption of pork did not show any appreciable increase. Pork consumption in the early fifties was higher than beef consumption. Since 1953, however, consumption of beef surpassed the consumption of pork, and by the early 1970's was approximately 65 percent higher than the per capita consumption of pork. Consumers' disposable

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income rose steadily during the same period, yet the proportion of this income spent on pork seemed to decline. The U. S. population growth, a major determinant of the long-run total consumption trend, has tended to slow down in recent years.

The absence of any appreciable rising trend in the per capita consumption of pork, particularly in contrast to steadily rising trends for beef and poultry consumption, necessitates a study of the factors affecting the long-run demand for pork. An investigation of possible changes in the demand structure would be beneficial in relation to implications for future demand potentials.

Objectives of the Study

The overall objective of this study was to analyze changes in the longer run demand for pork. The specific objectives were:

1. to examine the long-run trend in the demand for pork, and to identify the major factors affecting the long-run demand;
2. to estimate the consumption-price relations for pork using annual data for the period 1950 through 1973;
3. to develop measures of elasticities of demand for pork, and to study possible changes in the elasticity coefficients.

PRODUCTION AND DEMAND IN THE U.S. HOG-PORK SECTOR

In recent decades, the swine industry has contributed substantially to total U.S. farm income. The sale of hogs for the period 1970 to 1972, for instance, amounted to about $4.7 billion annually, and comprised 15 percent of the total gross receipts for the livestock sector and 8.5 percent of the total gross receipts from farming [10].

Production of Hogs

Production of hogs has been centered mainly in the Corn Belt region including Iowa, Illinois, Indiana, Ohio and parts of surrounding states. The availability of adequate supplies of feed grains has essentially determined the regional location of hog production, since feed constitutes the major portion of production cost for the hog enterprise. The West North Central region including Iowa, Missouri, Minnesota, and Nebraska produces nearly half of the total U. S. hog production. Iowa, the leading hog producing state, alone accounts for a quarter of the U. S. production. Illinois, Indiana and Ohio are the major producing states in the East North Central region which accounts for about 25 percent of the nation's total hog production. Among the remaining production regions, about one-tenth of the total U. S. production is in each of the South Atlantic and South Central regions [10].

Hog production has undergone substantial changes during the past decades in terms of both production practices and organization of production enterprise. The unit of production has increased in size along with

a decline in the number of hog farms. Improved swine production practices including the development of more productive swine may have contributed to the increase in average litter size. Furthermore, these developments have also reduced the feeding time for the swine to reach market weights.

The total U. S. hog marketings rose from 72.7 million head in 1950 to 82.3 million head in 1973. The total supply of pork increased from an annual average of 10,932 million pounds for the period 1950-1953 to an average of 13,644 million pounds for 1969-1972 [10]. Although shorter run fluctuations persist, the pork supply series clearly indicates a rising long-run trend through the years.

The long-run trend in hog production has been characterized by cyclical variations. The length of the hog cycles has averaged slightly above four years during the last three and a half decades. The lagged response of production to the return-cost situation, as represented by the hog-corn ratio, is the prime reason for this cyclical phenomenon in hog production.

Consumption and Prices of Pork

Pork is marketed in several different cuts and in both processed and fresh forms. The term pork, as used in this study, includes all pork products excluding lard. While the total U. S. consumption of pork increased substantially during the study period, 1950-1973, the per capita consumption of pork did not indicate an increasing trend. The average annual per capita consumption of pork in fact declined

slightly from 67.4 pounds in 1950-1954 to an average of 66.7 pounds in 1969-1973 (Table 1). The increase in total pork consumption therefore can be attributed to the increased population. Although a long-run trend is not readily discernible for per capita consumption, significant annual variations in the series are quite apparent. For instance, the per capita pork consumption was 58.1 pounds in 1966, and 73.0 pounds in 1971.

In contrast to pork consumption data, the per capita consumption series for beef and poultry present a very different trend. The annual average consumption of beef increased from 67.9 pounds per capita in 1950-1954 to an average of 112.6 pounds for 1969-1973. Pork consumption, which was higher than beef consumption in 1950-1952, was surpassed by the latter since 1953. The per capita consumption of poultry rose from an average of 26.9 pounds per year to 51.0 pounds during the same period (Table 1). Thus, while beef and poultry consumption per capita increased by 65.8 and 89.6 percent respectively, the per capita consumption of pork showed a decline of 1.1 percent for the period under study.

The average annual retail prices of pork varied substantially over the years. For example, pork prices at the retail level ranged from a low of 51.4 cents in 1956 to a high of $1.10 per pound in 1973 (Table 1). Retail prices of pork since 1965 remained substantially higher than those in preceding years. A similar situation may be observed also in the retail beef price series. On the other hand, the retail poultry price declined considerably from the early 1950's through the middle sixties, mainly as a result of steadily increasing market supply of poultry.

Table 1. Consumption and Prices of Pork and Other Meats, and Related Variables

Years	Consumption of pork, per capita, lbs.[1/]	Retail Price of pork, cents per pound [1/]	Consumption of beef, per capita, lbs.[1/]	Retail Price of beef, cents per pound [1/]	Consumption of poultry, per capita, lbs.[2/]	Retail Price of poultry, cents per pound [2/]
1950	69.2	53.8	63.4	74.6	24.7	59.5
1951	71.9	57.8	56.1	87.3	26.1	61.8
1952	72.4	56.2	62.2	85.7	26.8	60.7
1953	63.5	62.1	77.6	68.4	26.7	59.7
1954	60.0	63.4	80.1	67.8	28.1	53.8
1955	66.8	53.6	82.0	66.8	26.3	55.9
1956	67.3	51.4	85.4	65.4	29.6	48.2
1957	61.1	59.4	84.6	69.9	31.4	46.9
1958	60.2	63.8	80.5	80.2	34.0	46.5
1959	67.6	56.3	81.4	82.0	35.2	42.0
1960	64.9	55.9	85.1	80.2	34.0	42.7
1961	62.0	58.4	87.8	78.4	37.3	38.5
1962	63.5	58.8	88.9	81.7	36.0	40.7
1963	65.4	56.6	94.5	78.5	37.6	40.1
1964	65.4	55.9	99.9	76.5	38.6	37.8
1965	58.7	65.8	99.5	80.1	40.8	39.0
1966	58.1	74.0	104.2	82.4	43.4	41.3
1967	64.0	68.2	106.5	82.6	45.1	38.1
1968	66.2	67.4	109.7	86.6	44.6	39.8
1969	65.0	74.3	110.8	96.2	46.7	42.2
1970	66.4	78.0	113.7	98.6	48.5	40.8
1971	73.0	70.3	113.0	104.3	48.8	41.0
1972	67.4	83.2	116.1	113.8	51.0	41.4
1973	61.6	109.8	109.6	135.5	49.2	59.6

[1/] Source: Livestock and Meat Situation [9] and Livestock and Meat Statistics [10]

[2/] Source: Poultry and Egg Situation [11]

Table 1. Continued

Years	Disposable personal income, dollars[3/]	Expenditure on food, per capita dollars [4/]	Retail Value of pork, per capita, dollars	Retail Value of beef, per capita, dollars	Retail Value of poultry, per capita, dollars
1950	1,364	303	37.23	47.30	14.70
1951	1,469	338	41.56	48.98	16.13
1952	1,518	348	40.69	53.31	16.27
1953	1,583	347	39.43	53.08	15.94
1954	1,585	348	38.04	54.31	15.12
1955	1,666	351	35.80	54.78	14.70
1956	1,743	359	34.59	55.85	14.27
1957	1,801	373	36.29	59.14	14.73
1958	1,831	383	38.41	64.56	15.81
1959	1,905	386	38.06	66.75	14.78
1960	1,937	388	36.28	68.25	14.52
1961	1,983	392	36.21	68.84	14.36
1962	2,064	398	37.34	72.63	14.65
1963	2,136	404	37.02	74.18	15.08
1964	2,272	419	36.56	76.42	14.59
1965	2,411	442	38.62	79.20	15.91
1966	2,599	472	42.99	85.86	17.92
1967	2,745	473	43.65	87.97	17.18
1968	2,946	497	44.62	95.00	17.75
1969	3,130	514	48.30	106.59	19.71
1970	3,358	558	51.79	112.11	19.79
1971	3,604	567	51.32	117.86	20.00
1972	3,817	596	56.08	132.01	21.11
1973	4,194	620	67.64	148.51	29.32

[3/] Source: Agricultural Statistics [7]

[4/] Source: Food Consumption, Prices, and Expenditures [8].

Pork price during the study period remained 6 to 34 percent below the beef price. The retail price of poultry, which was about 7 to 10 percent higher than the pork price in 1950-1952, was 41 to 50 percent below the retail pork price during 1965-1973 (Table 1).

The per capita disposable personal income, often a major factor affecting demand, has risen steadily in the U. S. from $1,364 in 1950 to $4,194 in 1973 (Table 1). Yet, a declining portion of the increased income was spent on food. The per capita food expenditure constituted 22-23 percent of the per capita disposable income in the early 1950's and dropped to an average of about 16 percent in the early seventies. However, the amount spent on food, measured in current dollars, increased from $303 to $620 per capita during the same period (Table 1).

While the per capita retail value of beef increased substantially through the years, the retail value of pork and poultry consumed per person did not show any appreciable trend between 1950 and 1964. Since 1965, the per capita retail value of both pork and poultry rose steadily through the early seventies. It is also apparent from Table 1 that pork's share of the consumer's disposable income has generally declined, and the proportion of per capita income spent on beef has remained fairly stable during the period of study. The retail value of beef consumed per person varied within a relatively narrow range of 3.2 to 3.5 percent of per capita disposable income without showing any significant trend. On the other hand, the portion of per capita income spent on pork by the consumer declined fairly steadily from about 2.7 percent in the early fifties to 1.5 percent approximately in the early 1970's (Table 1).

The effect of rising income on the per capita consumption of pork does not appear to be easily discernible from the preceding data and observations. It has been sometimes presumed that as income rose, the increased demand for meat was directed more toward beef with little effect on pork consumption.

This aspect of the income effect will be analyzed in detail in later sections of this report. The long-run demand for a food product, especially in the presence of substitute items, may also be affected by changes in tastes and preferences. As indicated earlier, the long-run rising trend in income may affect consumers' preferences for pork. Furthermore, the consumer's increased awareness of high cholesterol foods, including pork, may also contribute to possible changes in preferences.

Although the per capita consumption of pork did not show any appreciable increase, the total consumption generally increased over the years along with the growth in the U.S. population. For instance, the total population in the U.S. (48 states) increased by 34.3 percent between 1950 and 1970, indicating an average annual growth rate of 1.7 percent. However, the annual growth rate appears to have decreased to less than one percent between 1970 and 1975 [12]. It is therefore reasonable to assume that a substantial growth in the total pork supply may not be matched by a total demand dependent primarily on the growth in population, unless the per capita demand for pork rises in the future.

Elasticities of Demand for Pork

The nature of demand for pork has been characterized by a relatively

low direct or own price elasticity. Brandow [1, p. 17] and Hassler [4, p. 14] estimated the elasticity at the retail level between -.7 and -.8. In a study based on quarterly data, Tomek [6, p. 801] reported elasticity coefficients of -.83 and -.90 for the periods 1949-1956 and 1956-1964, respectively. Dean and Heady developed estimates of farm level price elasticities for two six-month marketing periods -- August 1 - February 1, and February 1 - August 1. The elasticity coefficients, based on data for 1938-1956, were reported to be -.65 and -.62 which indicated a marked decrease relative to elasticities (-1.59 and -2.75 respectively) for the earlier period, 1924-1937 [3].

The elasticity of demand for pork with respect to retail beef price was estimated by Brandow [1, p. 17] to be .13. However, the demand elasticity coefficient with respect to prices of chicken was negligible (.066). Thus, the substitution between pork and other major meat products appeared to be relatively small.

The income elasticity coefficients for the first six-month marketing period (August 1 - February 1) were reported by Dean and Heady [3, p. 858] as 1.56 for 1924-1937, and 1.04 for 1939-1956. Corresponding estimates for the second six-month period (February 1 - August 1) were 2.29 and .90 respectively. The decreases in income elasticities were attributed to "the proposition that pork has become more of a staple food in the diets of American families" [3, p. 859]. In contrast to these relatively high income elasticities, Brandow reported an income elasticity of .32 [1, p. 17]. Some researchers, such as Shepherd and Thompson-Barahona [5, pp. 4-5], on the other hand, found little effect and even a slightly

negative effect of income on pork consumption. The absence of a significant positive income effect would indicate serious implications in terms of longer run growth potentials of the demand for pork.

STATISTICAL ANALYSIS AND RESULTS

Method of Analysis

A series of equations were developed to analyze the effects of major causal factors on the consumption of pork at the retail level. These equations, estimated for different periods of fit, represented the annual per capita consumption of pork as a function of retail prices of pork, beef and poultry, and per capita disposable income:

$$C_t = f\ (RP_t,\ BP_t,\ PP_t,\ I_t)$$

where,

C_t = per capita consumption of pork, excluding lard, carcass weight, pounds;

RP_t = annual average retail price of pork, cents per pound, (estimated weighted average price of retail cuts);

BP_t = annual average retail price of choice grade beef, cents per pound, (estimated weighted average price of retail cuts);

PP_t = annual average broiler price, cents per pound;

I_t = per capita disposable income, current dollars [1/]

Under alternative specifications, poultry price (PP_t) was excluded from the equations because of the statistical insignificance of the related coefficient.

The first set of equations was estimated on the basis of variables in actual terms as defined. A second set of equations was developed using variables in logarithmic terms to obtain demand elasticity estimates directly from the equations.

[1/] Sources of data are presented in the footnotes of Table 1, pp. 6-7.

The equations in the two sets were based on data for the period 1950-1973. Altogether fifteen equations were estimated in each set by successively updating the period of fit by one year. The first period of fit was 1950 through 1959; the second period consisted of ten years, 1951 through 1960, etc.; and the final period of fit comprised data for 1964 through 1973. Thus, the period of fit was updated by excluding the earliest year of the preceding period of fit, and by adding an additional year at the end. The objectives of this procedure were to examine the "stability" of the coefficients (or elasticities) and to investigate possible changes in the coefficients continuously over the periods of study.

An alternative approach would have involved a comparison of coefficients of two equations each representing a completely separated period of fit. For instance, an equation estimated on the basis of data for 1950-1961 could be compared with another equation based on 1962-1973. Subsequently, statistical tests such as the Chow test [2], could be applied to examine possible differences between the two equations. The approach is, however, based on an arbitrary separation of two sub-periods. Furthermore, the process of change in the coefficient(s) is not clearly observed, since only two values of the coefficient under consideration are obtained and compared. The proposed method in the present study on the other hand would enable one to see the process of change in the coefficient on a more continuous basis. This approach may provide some additional insight and credence as to the "stability" or changes in the coefficient, since the process of change is observed through a series of values of the coefficient over successive periods of fit.

Having estimated the coefficients, ordinary least squares equations were developed in the second phase to examine the changes in these coefficients through time. Thus, a set of 15 estimates of a coefficient (e.g., coefficient relating pork consumption with pork price or with income, etc.) was regressed on coded values for periods of fit. These equations may be presented as follows:

$$b_{it} = f(T)$$

where, b_{it} is the coefficient of the i-th variable (pork price, beef price, income) for the t-th period of fit, and T is the coded value of the period of fit with T=1 for 1950-1959, T=2 for 1951-1960, etc., through T=15 for 1964-1973. This procedure was applied to coefficients of equations based on actual values, as well as logarithmic values of variables. However, results of only the latter analysis are presented in this report.

Results of Regression Analysis

Ordinary least squares estimates were obtained for the consumption-price equation which was expressed in linear arithmetic terms. Results of the equation for different periods of fit are presented in Table 2. As indicated earlier, the price of poultry (PP_t) was excluded from the equation in the final estimates. Estimated equations in Table 2 indicate satisfactory fits with reasonably low standard errors of estimate and R^2-values ranging between .85 and .96.

Estimated coefficients for retail pork price were highly significant for all periods of fit. The values of the coefficient, ranging between -.53 and -.87, appeared to be clustered around an average of -.72. However, the coefficient seemed to have trended downward for the last

Table 2. Least Squares Estimates of Equation (1) in Linear Arithmetic Terms; (Dependent Variable: Pork Consumption, C_t)

Period	Pork Price (RP_t)		Beef Price (BP_t)		Income (I_t)		Constant	R^2	SEE[a/]
	b	t-value	b	t-value	b	t-value			
1950-59	-.7332	-6.2756	.3054	5.0445	-.0084	-2.8793	99.4098	.9302	1.4907
1951-60	-.7887	-9.3742	.2878	7.0497	-.0131	-6.1623	111.9837	.9641	1.0383
1952-61	-.7970	-9.6264	.3006	6.2511	-.0142	-6.3554	113.3702	.9565	1.0177
1953-62	-.8254	-6.9483	.3693	2.8751	-.0154	-2.8675	112.3692	.8957	1.1418
1954-63	-.8022	-6.7701	.2231	2.0091	-.0056	-1.3534	103.9786	.8949	1.1651
1955-64	-.8701	-6.0636	.1987	2.0676	-.0020	- .7521	102.8300	.8719	1.1488
1956-65	-.7778	-7.2410	.1759	2.0907	.0001	.0605	95.0591	.9056	1.1378
1957-66	-.5685	-5.0202	.2515	1.6963	.0018	.6893	73.4929	.8480	1.5148
1958-67	-.7290	-5.3907	.7631	2.4691	.0057	2.4310	33.9315	.8496	1.4930
1959-68	-.7433	-5.4528	.6395	2.8321	.0061	2.4565	43.6556	.8523	1.4716
1960-69	-.7122	-6.4251	.2849	2.3081	.0082	3.6933	65.1916	.8795	1.2117
1961-70	-.7076	-6.4699	.2797	2.3313	.0089	3.7747	63.6882	.8934	1.1917
1962-71	-.6395	-6.9428	.2335	1.8423	.0082	3.0731	64.8793	.9368	1.2839
1963-72	-.6613	-7.1065	.0945	.6413	.0109	3.1491	70.7835	.9338	1.3359
1964-73	-.5293	-6.0455	.0884	.6059	.0104	3.3699	63.2689	.9390	1.3203

[a/] Standard error of estimate

six periods of fit. The coefficient relating retail beef price to per capita pork consumption, on the other hand, fluctuated over a relatively wide range of .09 to .76. The values of the coefficient were most frequently around .2 and .3. A sharp decline in the magnitude of the coefficient was apparent for the period 1958-1967 and subsequent period of fits. Furthermore, for most periods through 1962-1971, the coefficient was significantly different from zero at relatively low probability levels. In contrast, the coefficient value declined sharply for the last two periods of fit, and was found to be statistically insignificant. These findings appear to indicate reduced effects of variations in beef price on pork consumption for the most recent periods. For the earlier periods of fit, however, the per capita consumption of pork increased (or decreased) by one-fifth to seven-tenth of a pound with a one cent rise (or decline) in beef price.

Estimated values of the coefficient for per capita disposable income reveal some noteworthy features. The coefficient assumed both negative and positive values, ranging between -.0154 and +.0109. Statistically significant and negative values of the income coefficient were observed for the four earliest periods of fit. The negative coefficient tended to approach zero for the following two periods, 1954-1963 and 1955-1964, and was not significantly different from zero. Estimates of the coefficient for the next two periods of fit became positive, but were statistically insignificant. Beginning with 1958-1967, the positive income coefficients became significant values, trending upward from +.0057 to .0109 and .0104 for the last two periods of fit. Thus, the effect of income on pork con-

sumption appeared to have gone through a significant process of change during the period of study. The income coefficient, which was initially a negative significant value, approached zero, and gradually rose to significant positive values.

Statistical results of the consumption-price equation based on logarithmic values of the four variables, as presented in Table 3, are quite similar to those discussed in the preceding paragraphs. However, the estimated coefficients (b-values) are now interpreted as demand elasticities. The R^2-values, ranging between .96 to .85, and relatively small standard errors of estimate indicated reasonable fits for the equations.

Estimates of direct price elasticity of demand for pork varied within a relatively short range of -.57 to -.81, with an average of -.72. These values seem to be in line with elasticity estimates between -.7 and -.8 reported in earlier studies [1;4]. As indicated by the related t-statistic, the elasticity coefficient was highly significant for each of the fifteen equations. Furthermore, these elasticity values seemed to have gradually declined in absolute terms over the last six periods of fit. Despite this apparent decline, the price elasticity estimates appeared to indicate a fairly stable responsiveness of per capita consumption of pork to percent changes in retail pork price.

The elasticity of demand for pork with respect to beef price varied substantially within the range of 1.027 for 1958-1967 and .088 for 1964-1973. The estimates for the periods of fit prior to 1958-1967 ranged between .446 and .228, and implied a relatively low substitution between pork and beef during these periods.

Table 3. Least Squares Estimates of Equation (1) in Linear Logarithmic Terms; (Dependent Variable: Log C_t)

Period	log RP_t		log BP_t		Log I_t		Constant	R^2	SEE[a/]
	b	t-value	b	t-value	b	t-value			
1950-59	-.6583	-5.5085	.3479	4.2865	-.1968	-2.3443	2.9592	.9068	.0114
1951-60	-.7153	-9.7030	.3245	6.9444	-.3375	-6.1927	3.5579	.9643	.0068
1952-61	-.7179	-8.1675	.3381	5.1396	-.3641	-5.1359	3.6232	.9378	.0081
1953-62	-.7646	-6.6098	.4460	2.8192	-.4351	-2.7280	3.7366	.8883	.0081
1954-63	-.7353	-6.8324	.2619	1.9951	-.1471	-1.2092	3.0896	.9004	.0077
1955-64	-.7933	-5.5460	.2430	1.9191	-.0485	- .5281	2.9040	.8518	.0085
1956-65	-.7399	-8.1992	.2284	2.5140	.0022	.0366	2.6700	.9237	.0070
1957-66	-.5713	-5.5376	.2814	1.6503	.0509	.6347	2.1109	.8654	.0099
1958-67	-.7355	-5.3719	1.0271	2.4977	.1959	2.3598	.5028	.8476	.0105
1959-68	-.8081	-6.0901	.9057	3.4363	.2536	2.9465	.6688	.8784	.0093
1960-69	-.7657	-6.6864	.4729	3.0029	.3167	3.8422	1.2042	.8882	.0082
1961-70	-.7581	-6.3125	.4742	2.9559	.3363	3.6030	1.1215	.8874	.0086
1962-71	-.7121	-6.8797	.3960	2.4933	.3360	3.1681	1.1889	.9318	.0090
1963-72	-.7329	-7.5586	.2514	1.4125	.4278	3.1566	1.1907	.9395	.0086
1964-73	-.6402	-8.8563	.0876	.5832	.5386	5.0864	.9549	.9630	.0069

[a/] Standard error of estimate

A drastic rise in elasticity estimates occurred for the two successive equations based on data for 1958-1967 and 1959-1968. Subsequently, the elasticity declined steadily for successive periods of fit, finally assuming the smallest magnitude of .0876 for 1964-1973. For the last two periods of fit, the cross price elasticity coefficient became statistically insignificant.

As observed in the estimates of income coefficients in Table 2, results of the logarithmic equations in Table 3 also reveal some changes in the coefficient representing the income elasticity of demand for pork. The negative values of income elasticity for the first six periods of fit ranged from -.44 to -.049. While the negative estimates for the first four periods were significantly different from zero, the succeeding two estimates approached zero and were, in fact, statistically insignificant. For the subsequent periods of fit, beginning with 1956-1965, the elasticity values rose steadily from +.0022 to +.54 in 1964-1973. The positive elasticity coefficients for the latter seven periods were all statistically significant. The elasticity values for the most recent periods of fit indicated a one-third to one-half of one percent increase in the per capita consumption of pork in response to a one percent rise in per capita disposable income. Furthermore, elasticity estimates tended to rise gradually during these periods.

The three different series of elasticities were further analyzed by developing time trend equations for each series of elasticity values. Results of these linear trend equations relating the estimated elasticity coefficients to coded values of time are presented in Table 4. It may be recalled that time (T) is the coded value where T=1 for 1950-1959, T=2 for 1951-1960 etc. The elasticities, denoted by E_1, E_2, and E_3 in Table

Table 4. Least Squares Estimates of Linear Equations Relating Elasticities with Time

Dependent Variable[a/]	Constant Term	Coefficient of T[b/]	t-value	r^2	SEE[c/]
--------Periods of fit: 1-15, 1950-59 through 1964-73--------					
E_1	-.7221	-.00014	-.03872	.0001	.0632
E_2	.3801	.0032	.2067	.0033	.2598
E_3	-.4671	.06612	11.4516	.9098	.0966
---------Periods of fit: 1-7, 1950-59 through 1956-65--------					
E_1	-.6723	-.01494	-2.61722	.5781	.0302
E_2	.3982	-.02135	-1.7193	.3715	.0657
E_3	-.4170	.04971	1.8960	.4183	.1388
---------Periods of fit: 8-15, 1957-66 through 1964-73-------					
E_1	-.6917	-.00207	-.16435	.0045	.0816
E_2	1.4129	-.08051	-1.8829	.3714	.27710
E_3	-.3557	.05762	8.5831	.9247	.04351

[a/] The dependent variables are as follows: E_1 is the elasticity of demand for pork with respect to pork price; E_2 represents the elasticity of demand for pork with respect to beef price; E_3 is the income elasticity of demand for pork.

[b/] The variable T is defined as follows: T=1 for 1950-59, T=2 for 1951-60, etc., and T=15 for 1964-73.

[c/] Standard error of estimate.

4, are defined as the direct price elasticity of demand for pork, the elasticity of demand for pork with respect to retail beef price, and the income elasticity of demand for pork, respectively.

The equation for E_1 values for all 15 periods did not indicate any significant trend, since the coefficient of T was not statistically significant. The constant term (-.7221) indicates the average magnitude of the direct price elasticity of the periods under study. Neither was there a trend evident for E_2 values when all 15 periods were considered together. The r^2-values for these two equations for E_1 and E_2 were also extremely low. With regard to E_3 (income elasticity of demand), the linear time trend appeared to be highly significant, as indicated by the associated t-statistic of the coefficient. The positive coefficient, indicating a rising trend in the elasticity values, represented an average rate of increase of .066 for the 15 periods of fit. Furthermore, the r^2 value for the equation also appeared to be high.

Results of the trend equations for all 15 periods thus corroborate the earlier findings (based on Table 3) that the income elasticity estimates changed substantially and more or less systematically, beginnning with negative values, then approaching zero, and finally assuming significant positive values. In addition, the trend equations for E_1 and E_2 in Table 4 also confirm earlier observations regarding the absence of a pronounced systematic change in the direct and cross price elasticities of demand for pork.

Additional trend equations were also developed by using elasticity estimates in two separate sub-sets. The first sub-set contained the elas-

ticity estimates for the first seven periods of fit, and the second sub-set comprised estimates for the remaining eight periods of fit. Results of trend equations for the two sub-sets are included in the lower part of Table 4.

A slight but statistically significant negative trend, with a trend coefficient of -.01494, was observed for direct price elasticities (E_1) for the first seven periods of fit. Thus, the absolute magnitude of the elasticity tended to increase during these earlier periods. On the other hand, the trends in cross price elasticities (E_2) and income elasticities (E_3) appeared to be statistically insignificant or, at best, marginally significant. The equation for E_2 indicated a declining trend, while the equation for E_3 reflected a rising trend in the elasticity values. The equation for E_1 for the latter eight periods of fit (1957-1966 through 1964-1973) showed no significant trend in the direct price elasticity. The cross price elasticity (E_2) appeared to have a decreasing trend, although the trend coefficient was only marginally significant. The increasing trend for the income elasticity (E_3), as represented by the coefficient .05762, was however highly significant for the latter sub-set.

Results of equations in Table 4 thus point out a significant rising trend in the income elasticity values. The direct price elasticity estimates, with a declining trend in earlier periods, did not show a clear trend either for the latter eight periods or for all fifteen periods of fit. The trend in the positive cross price elasticity estimates, insignificant for all fifteen periods of fit, appeared to be only marginally significant for the two sub-sets. In both cases, the cross price elasticity tended to decline, as reflected in the negative coefficients of time.

CHANGES IN THE DEMAND FOR PORK AND IMPLICATIONS

Changes in the demand structure or the structure of any economic system as such imply changes in the coefficients or parameters that relate various relevant variables within the system. Analyses of supply, demand and price, based on time series data, are often faced with probable changes in structure. Consequently, such changes must be considered by economic analysts and the industry both in terms of policy analysis and long-run outlook for the sector.

In the light of foregoing statistical analyses and results, some questions regarding probable changes in the demand structure for pork merit further examination. First, what are the specific changes that seem to have occurred in the long-run demand structure? Second, what are the probable reasons for such changes? Finally, what are the implications of these apparent changes with regard to long-run demand potentials for pork?

The direct price elasticity of demand for pork seemed to have remained fairly stable particularly for the more recent periods of fit, although for earlier periods there was a slight trend in the coefficient. The elasticity value was estimated to be around -.7 for most periods of fit. The apparent stability of the direct price elasticity coefficient is particularly note worthy, since pork price during the period of study varied over a wide range. Furthermore, among the three elasticity coefficients, the direct price elasticity appeared to be the most stable coefficient. Studies based on data for periods prior to the 1960's indicated a decline in the magnitude of the price elasticity of demand

for pork [3]. It is often presumed that, with increased income, consumers generally respond less to varying price levels. Thus, the demand for pork would be expected to be more inelastic (or less elastic) with rising income. However, in a study comparing two periods, 1949-1956 and 1956-1964, Tomek found little change in the price elasticity and observed, " . . . if change is taking place, it seems to be in the direction of less inelastic demand" [6, p. 802]. Results of the present study also indicate the absence of a significant trend in price elasticities for more recent periods.

The demand elasticity of pork with respect to retail beef price appeared to fluctuate considerably from period to period and, for the most recent periods of fit, declined from a high of 1.03 to a low of .09. The substantial rise in cross price elasticities during 1958-67 and 1959-68 seems to be rather inexplicable in economic terms. However, with the exception of these two estimates, elasticity values for all other periods of fit remained relatively low -- .47 or less. It may be suggested that consumers' tastes and preferences for meat products may have changed in a manner that has made pork somewhat less dependent on the demand for or price of beef. Consequently, the substitution between beef and pork has become relatively low. If prices of pork and beef move drastically out of line relative to each other, the cross price elasticity may however tend to become high. As indicated earlier, the cross price elasticity of demand for pork with respect to poultry price was found to be consistently insignificant for all periods of fit.

The most conspicuous change seems to have occurred in the elasticity

coefficient associated with income. The elasticity value was negative in the earlier periods of fit, then approached zero, and finally became positive and statistically significant around .4 and .5 for the most recent periods of fit. The negative elasticity coefficient would most likely imply that with rising income pork consumption to some extent was substituted by beef. The change in the elasticity values may have been the result of changes in consumers' tastes and preferences and in the quality of the product. The image of pork as a meat primarily for the low-income population may have changed through the years.

It is generally believed that as income rises, the increase in food consumption becomes smaller; that is, the income elasticity declines. Although this is a valid generalization for most food products, the demand for pork appears to have changed differently. For the initial periods of fit, pork may have gone through a phase of being an "inferior" meat relative to beef. But, with standardization and improvements in quality through improved production and processing practices, pork seems to have been more widely accepted as a "normal" good.

A substantial increase in the total consumption of pork cannot be sustained through the growth in population alone, as the U.S. population growth seems to have slowed down in recent years. Given the observed stable inelastic demand for pork, and a relatively low substitution between beef and pork, the potential growth of the total demand for pork depends to a large extent on the changes in pork consumption associated with income. The negative elasticity coefficient associated with income for earlier periods did indicate an alarming trend in terms of growth

potentials. However, in view of observed changes in the elasticity coefficient in more recent periods, the demand for pork seems to have been strengthened. The continuation of this phase is of course dependent on a reasonable level of pork price and a relatively low substitution between beef and pork. In the event the relative prices or pork, beef and poultry tend to change substantially from the traditional levels, consumers may turn more toward beef and/or poultry.

The pork industry thus appears to be in a situation where consumer demand for pork seems to be stronger and less closely dependent on the demand for or price of beef than it was in earlier periods. Changes in tastes and preferences and improved quality of the product through the positive effect of income seem to have contributed to this strengthening process.

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