THE IMPACT OF HEALTH INFORMATION AND DEMOGRAPHIC CHANGES ON AGGREGATE MEAT DEMAND

Christiane Schroeter and Ken Foster*

Selected Paper Presented at the AAEA Annual Meeting

2004 Denver, Colorado, August 1-4

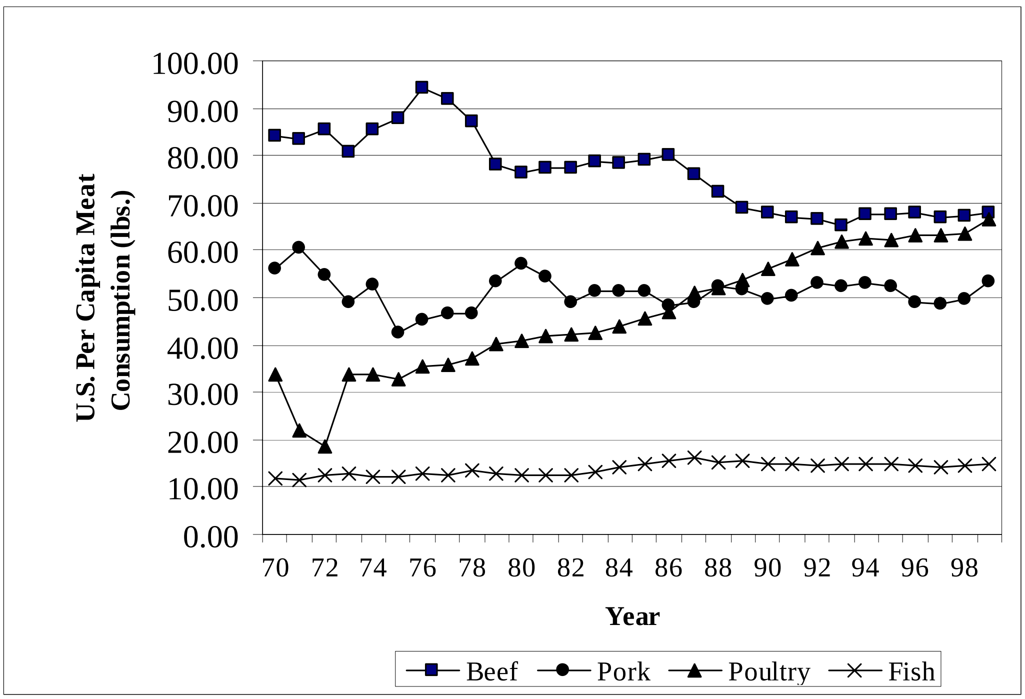
 This research was partially supported by the USDA CSREES National Research Initiative Project entitled Estimating Changing Market Conduct in the U.S. Pork Slaughter Industry.

* Authors are Ph.D. Student and Professor in the Department of Agricultural Economics, Purdue University. Contact: Christiane Schroeter, Department of Agricultural Economics, Purdue University, 403 W. State Street, West Lafayette, IN 47907-2056, PH: 765-494-9673, FAX: 765-494-9176, E-mail: cschroe@purdue.edu

INTRODUCTION AND OBJECTIVE

Over the past few decades, U.S. meat consumption patterns have changed. Figure 1 shows the U.S. per-capita meat consumption from 1970-1999. Consumers have increased their total meat consumption by 9.3% from 1970 to 1999, however, the composition of the meat consumption changed as well. While beef consumption has consistently decreased since 1985 - that of poultry and fish have increased. Per capita pork consumption has not changed on average from the 1970's to the 1990's.

FIGURE 1: U.S. PER-CAPITA MEAT CONSUMPTION FROM 1970-1999 (IN LBS.)



SOURCE: Figure based on data obtained from USDA/ERS

Shifts in shares of the meat complex usually depend on the relative prices of meat products and consumer preferences. Previously, income and relative price changes have been used to explain these shifts in shares of meat consumption (Chalfant and Alston;

Chavas, and others). With increasing levels of income, components of the meat consumption may change, while there is only a small change in total meat consumption.

Food choices reflect the complex way in which individuals select, consume, and utilize the available food supply based on factors such as cultural background, social and economic status, as well as the individual's health knowledge (Cosper and Wakefield). However, food choices are also influenced by changing demographic characteristics, changing lifestyles, increasing health and nutrition concerns. Prior research suggests that these factors have significant influence on the demand for meat (Capps and Schmitz; Kinnucan, Hsia, and Jackson). Evaluating the effects of changes on meat demand delivers information on the potential existence of structural change in the underlying utility function. However, it has not yet been determined how structural change depends on the endogeneity of prices and quantities.

The objective of this research is to statistically estimate the impact of health information and demographic information on the aggregate demand for beef, pork, poultry and fish by using an Almost Ideal Demand System (AIDS) as well as an Inverse Almost Ideal Demand System (IAIDS). This study directly estimates the effects of health information and women's participation in the labor force on aggregate meat demand from 1970 to 1999. By incorporating a demographic and a health information variable in the meat demand system, this study aims to quantify and interpret important non-price determinants of meat demand. The availability of this information will help producers develop products which better address changes in consumer tastes, preferences and demographics. Retailers will also benefit by developing more effective marketing strategies and an opportunity to expand market share. As a result, consumers could benefit from improved availability of products and information that meet their needs and circumstances.

MODEL, DATA AND PROCEDURES

THEORY OF THE ALMOST IDEAL DEMAND SYSTEM (AIDS)

This study uses the Almost Ideal Demand System (AIDS) by Deaton and Muellbauer, as well as the Inverse Almost Ideal Demand System (IAIDS) (Moschini and Vissa; Eales and Unnevehr). The AIDS has become especially popular when modeling the demand for meat (Chalfant; Moschini and Meilke; Wahl and Hayes; Poray, Foster and Dorfman), due to its well-defined preference structure, with consistent aggregation from the micro to the market level, and is tested for the cost minimizing consumer (Eales and Unnevehr).

For the past few years, inverse demand systems have been receiving increasing attention. In inverse demand functions, prices are functions of quantities. Several studies determined that the demands for food and agricultural products are well approximated by inverse demand systems (Barten and Bettendorf; Eales and Unnevehr).

The IAIDS is used in this study, because of the focus on perishable agricultural products; thus, it might seem appropriate to have quantities as exogenous permitting prices to adjust in order to allow short-run market clearance. Meats are subject to biological lags and supply can be treated as somewhat fixed in the short run (Moro and Schokai). However, this study employs a long run perspective by using annual data and supply might not be fixed for all meat commodities such as poultry and fish over an annual time span. Hence, it could also be argued that it might be appropriate to use the AIDS.

Both the IAIDS and the AIDS represent theoretically consistent, flexible consumer preferences, due to the existence of the budget share semi-log functional form. Inverse demand functions provide an alternative and fully dual approach to the standard analysis of consumer demand (Eales and Unnevehr).

DERIVING THE MODEL SPECIFICATIONS

The detailed derivations of the AIDS and IAIDS models are available elsewhere (Deaton and Muellbauer; Moschini and Vissa; Eales and Unnevehr). The general form of the derived share equations in the AIDS is

$$(1) \quad w_i = \alpha_i + \sum_j \gamma_{ij} \ln p_j + \beta_i \ln(x / P^*)$$

and in the IAIDS

$$(2) \quad w_i = \alpha_i + \sum_j \gamma_{ij} \ln q_j + \beta_i \ln Q^*$$

Where in the AIDS (IAIDS):

w_i is the expenditure share of the i^{th} commodities

α_i is the intercept

γ_{ij} is the coefficient of quantity (price) effect

p_j (q_j) is the price (quantity) of good j

β_i is the coefficient of the expenditure (scale) effect

x is the total per-capita expenditure

P^* (Q^*) is Stone's price (Stone's quantity) Index.

In both systems adding up, homogeneity, and symmetry restrictions involve the fixed and unknown coefficients. Hence, it can be easily imposed.

The restrictions are $\sum_i \alpha_i = 1, \sum_i \gamma_{ij} = 0, \sum_i \beta_i = 0$ (Adding up)

$\sum_j \gamma_{ij} = 0$ (Homogeneity)

$\gamma_{ij} = \gamma_{ji}$ with i≠j (Symmetry) (Eales and Unnevehr).

This study treats demographic and health information measures as concomitant variables in the AIDS and IAIDS share equations. The AIDS and IAIDS were first estimated in levels and corrected for autocorrelation. Upon correction for autocorrelation, the autoregressive coefficients were equal to or very close to one. Thus, the non-stationary component in budget shares was removed by using the following first-differenced linear approximation AIDS model:

(3) $\Delta w_i = \sum_j \gamma_{ij} \Delta \ln p_j + \gamma_i \Delta HEALTH + \gamma_i \Delta \ln WOMEN + \beta_i \ln(x / P^*)$

with Stone's price index $P^* = \Delta(\sum_j w_j \ln(p_j))$.

And the IAIDS model:

(4) $\Delta w_i = \sum_j \gamma_{ij} \Delta \ln q_j + \gamma_i \Delta HEALTH + \gamma_i \Delta \ln WOMEN + \beta_i \ln(Q^*)$

with Stone's quantity index $Q^* = \Delta(\sum_j w_j \ln(q_j))$.

Where in the AIDS (IAIDS):

p_j *(*q_j*)* is the price (quantity) of good j = Beef, Pork, Poultry, Fish

Health is a health information index

Women is the percentage of women in the work force.

The AIDS measures elasticities, while the IAIDS measures the sensitivities by flexibilities. Green and Alston determined the appropriate AIDS price elasticity formula when using linear approximation (Green and Alston). This paper employs the price elasticity formula by Chalfant, as well as an inverse form of it.

The own and cross-price elasticities are given by

$$(5)\quad e_{ij} = \frac{-\delta_{ij} + \left(\gamma_{ij} - \beta_i w_i\right)}{w_i}$$

and the own and cross-price flexibilities are

$$(6)\quad f_{ij} = \frac{-\delta_{ij} + \left(\gamma_{ij} + \beta_i w_i\right)}{w_i}$$

where δ_{ij} is the Kronecker delta (Eales and Unnevehr).

Own price flexibilities describe the percentage change in the price of a good, where the demand for that good increases by exactly one percent. There is no common terminology or interpretation of flexibilities. In this study the following convention will be used: the demand for a commodity is inflexible (flexible) if a one percent increase in consumption of that commodity leads to a greater (less) than 1% decrease in the marginal consumption value of that commodity. The cross-price flexibility is defined as the percentage change in price of a good, where the demand for another good increases by one percent. Goods are quantity-substitutes if their cross-price flexibility is negative, quantity-complements if their cross-price flexibility is positive. The smaller the cross-price flexibility, the more the goods are perfect substitutes. The larger the cross-price flexibility the more the goods are perfect complements (Roth *et al*.).

The equivalent to the expenditure elasticity in the AIDS,

(7) $$e_i = \frac{\beta_i}{w_i} + 1$$

is the scale flexibility in the IAIDS model

(8) $$f_i = \frac{\beta_i}{w_i} - 1.$$

The scale flexibility measures the percentage change in the normalized price of a good brought about by a proportional change in the aggregate quantity, hence a change in the scale of consumption. Scale flexibilities that are greater than -1 are scale flexible, which means they are luxuries. Scale flexibilities less than -1 are scale inflexible, and they are necessities (Roth *et al*.).

DATA

The annual data for the project consists of per capita consumption and the consumer price indices (CPI) of retail meat, which is beef, pork, poultry and fish from 1970-1999. The CPI's (1982-84=100) and the consumption data for the four meat groups were obtained from the U.S. Department of Agriculture, Economic Research Service (USDA/ERS). The quantities were divided by their sample mean before the logarithmic transformation.

The health information and demographic variables act as demand shifters in the model. Beside the two demand shifters used in this paper, different other demographic variables such as ethnic proportions were first entered into the two demand systems, but then dropped again, because they turned out to be not significant.

The female labor force as a percentage of the female population determined the proportion of women working. This data was obtained from the United States Census Bureau.

The cumulative sum of net numbers of medical journal articles published supporting the linkage between cholesterol and heart disease, thus, representing negative cholesterol information, formed the health index in the meat demand model. Cholesterol can be found in both muscle and fat of animal and seafood products. For the purpose of this study, Dr. Kinnucan at Auburn University provided the original weighted Brown and Schrader health information index. Using the original index as base data, Dr. Kinnucan and his coauthors weighted it by a factor representing the relative proportion of all medical journal articles providing negative cholesterol information. This weighted health index comprised quarterly observations from 1960.1 to 1993.4. However, because this study uses annual data, the quarterly health index observations were summed. Dr. Wilson, Purdue University, used an updated health index series through 1999 for a study and provided the updated data for the purpose of this study. Hence, this study uses the weighted health information index from 1970-1999. The descriptive statistics of the variables used in this study is shown in Table 1.

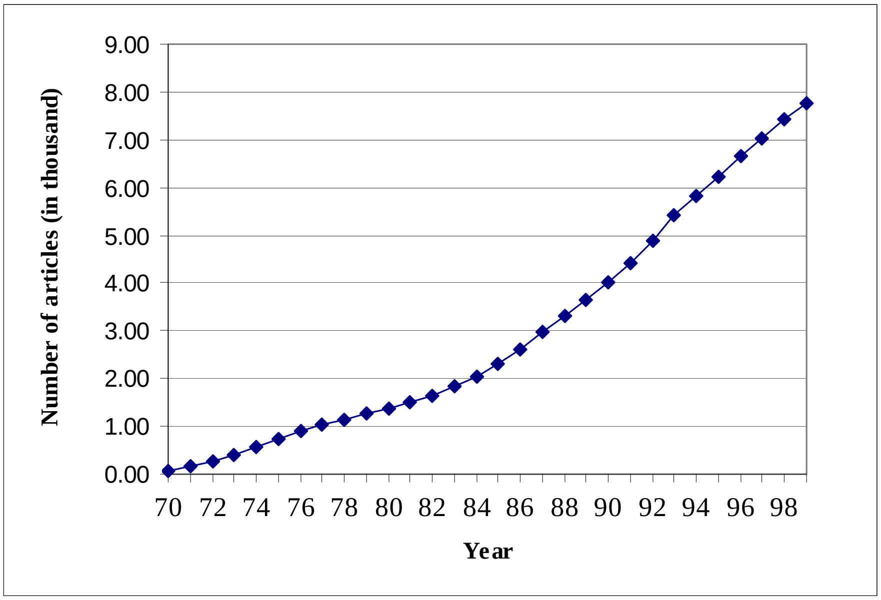
TABLE 1: DESCRIPTIVE STATISTICS OF VARIABLES USED IN DEMAND SYSTEMS

N=30	**Variable**	**Mean**	**Standard Deviation**
Quantities	**Beef**	76.464	8.456
(lbs/per capita))	**Pork**	51.162	3.608
	Poultry	46.764	13.147
	Fish	13.781	1.307
Prices	**Beef**	99.597	32.208
($/CWT)	**Pork**	102.250	32.764
(1982-84=100)	**Poultry**	107.830	32.382
	Fish	110.130	49.513
Health information (# of articles in thousand)	**Health**	2.982	2.419
Demographics (%)	**Women**	49.578	5.555

Table 1 shows that while beef has the highest mean per-capita consumption, it also has the lowest mean price, the opposite holds true for fish. The mean price of poultry is nearly as high as for fish, while the consumption of poultry is more than three times that of fish.

Furthermore, Table 1 shows the mean values for the health index and the percentage of women working in the labor force. The health index has been increasing exponentially over time, as can be seen in Figure 2. This exponential increase explains the large standard deviation in the health index.

FIGURE 2: CUMULATIVE NUMBER OF JOURNAL ARTICLES CONTAINING NEGATIVE CHOLESTEROL INFORMATION (IN THOUSAND), 1970-1999



SOURCE: Figure based on data obtained from Kinnucan and Wilson

It is assumed that rising media attention on cholesterol and the linkage to heart disease leads to increased public awareness. While cholesterol from meat consumption is less the issue (as opposed to fat), it is assumed that increased awareness about the health effects of cholesterol has an impact on consumer attitudes regarding the health benefits of meat consumption. Health-conscious consumers will take the negative health effects of cholesterol into account and decrease their consumption of cholesterol-rich foods while increasing the demand for healthier alternatives. It is also possible that the index of knowledge about the health affects of fat consumption closely parallels the index for cholesterol.

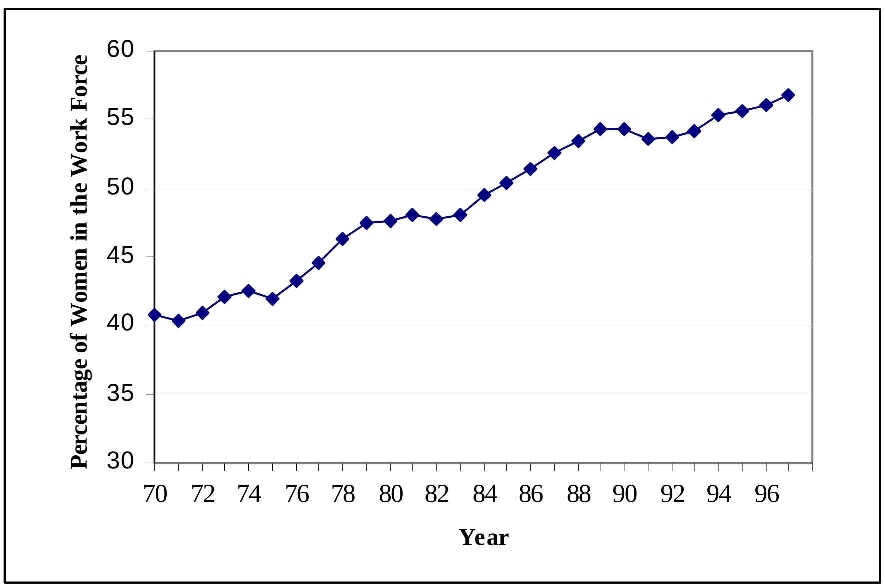
There are opposing views on how the health index influences the demand for different meat types. Previous studies using the health index suggest that poultry consumption increased at the expense of beef consumption (Kinnucan, Hsia, and Jackson, Capps and Schmitz). However, previous studies have not yet reached a clear conclusion how negative cholesterol information influences the demand for pork and fish. While Capps and Schmitz found that health information influences pork demand negatively, but increased the demand for fish, Kinnucan, Hsia, and Jackson determined no effect on the demand for pork and fish. McGuirk *et al.* suggested a positive relationship between the health index and pork demand by using a modified health information index. The different conclusions of previous studies could have been reached due to the use of different time periods, and the use of different models. McGuirk *et al*. and Capps and Schmitz used data from 1966-1988, while Kinnucan, Hsia, and Jackson used data from 1976-1993. Health information is updated constantly by additional research, which means that consumer attitudes constantly evolve and modify demand behavior accordingly. Thus, the health index could be related positively, negatively or show no correlation to the demand for different meat types, which will be discussed in the following.

This study uses four meat types, beef, pork, poultry and fish. The coefficient of the health effect is assumed to be positive for beef, which contains more cholesterol due to its higher fat content. Furthermore, negative signs are expected for poultry and fish demands, because these leaner meat types are lower in cholesterol. It is more difficult to determine what sign the health index could have on pork demand. Clearly, generic pork advertising aimed at spreading a healthier image of pork, implying that pork offers lean cuts of meat that are low in fat and cholesterol. However, even though there are leaner cuts of pork, much of this is accomplished by dividing the carcass resulting in some lean products (e.g. loins) and some fatter ones (e.g. bacon). Thus, the effect of health information on pork demand could be positive, negative or indifferent.

The index of the percentage of women in the work force represents several demographic changes that have occurred over the past two decades. More women, particularly mothers, work, which leads to an increase in households with both parents in the work force.

The trend of female labor force participation over time is presented in Figure 3.

FIGURE 3: PERCENTAGE OF WOMEN IN THE LABOR FORCE, 1970-1999



SOURCE: Figure based on data obtained from U.S. Census Bureau

With more time spent outside the household, less time can be devoted to preparing meals for the family. The demand for easy-to-prepare meal solutions rises, and leads to a modification in consumption behavior. Families with working parents might go out more often for meals, buy take-out, or use ready-to-prepare entrees. Two-income families tend to have a higher household income and can afford the typically more expensive convenience food products (Capps, Tedford, and Havlicek). The rise in the percentage of women in the work force influences the demand for meat insofar that if a meat type is represented in a wide arrangement of high-demand convenient dinner solutions, the effect of the women in the labor force variable on this meat type would be positive, hence increasing. McGuirk *et al.* found a negative effect of the women in the labor force variable on beef demand and a positive effect on pork and chicken demand. However, McGuirk *et al.* did not include fish in their study. Fish products offer many different convenient options in frozen or packaged easy-to-prepare form. Hence, it is assumed that an increasing share of women in the labor force decreases the demand for beef, but increases the demand for pork, poultry and fish.

EMPIRICAL RESULTS

The model was estimated using Seemingly Unrelated Regression (SUR). Although the coefficients were recovered from the regression in each system, using n-1 equations, this study used two regressions to develop coefficients for each good. The general model of each demand system has four equations and was first estimated omitting fish and then again estimated omitting poultry, due to singularity of the cross-equation covariance matrix. The model was estimated without a constant term due to the first differenced form of the share equations in the demand model.[†] Both the AIDS and the IAIDS were estimated first with the four meat types, then with the health index and

[†] The implied intercept of the re-integrated share equations would thus be the sample means of the shares.

finally, the percentage of women in the labor force was added. This final model consisted of 7 variables.

The results of the AIDS and IAIDS can be found in Tables 2 and 3.

TABLE 2: AIDS MODEL[1]

Equation	Price Effect				Expend.	Health	Women	R^2
	Beef	Pork	Poultry	Fish	Effect			
Beef	1.4824* (0.3505)	0.6703* (0.1422)	-1.8664* (0.3921)	-0.2862* (0.0809)	-0.5269* (0.1429)	-0.0482 (0.0984)	-1.9068 (1.7023)	0.9733
Pork	0.6703* (0.1422)	0.0335 (0.1578)	-0.8397* (0.1806)	0.1358* (0.0669)	-0.0446 (0.0609)	0.0327 (0.0406)	-2.1562* (0.7303)	0.9247
Poultry	-1.8664* (0.3921)	-0.8397* (0.1806)	2.9245* (0.4903)	-0.2186* (0.0826)	0.6604* (0.1700)	0.0329 (0.1158)	2.9019 (2.0205)	0.9505
Fish	-0.2862* (0.0898)	0.1358* (0.0669)	-0.2186* (0.0826)	0.3690* (0.0756)	-0.0889* (0.0282)	-0.0173 (0.0191)	1.1611* (0.3383)	0.9728

[1]ALL COEFFICIENTS AND ERRORS ARE MULTIPLIED WITH 100 FOR EASE OF PRESENTATION
*RATIO OF COEFFICIENT TO ITS STANDARD ERROR IS GREATER THAN TWO IN THE ABSOLUTE VALUE

TABLE 3: IAIDS MODEL[1]

Equation	Quantity Effect				Scale	Health	Women	R^2
	Beef	Pork	Poultry	Fish	Effect			
Beef	0.4392 (0.2388)	0.2552* (0.1074)	-0.7684* (0.0778)	0.0740* (0.2430)	-0.4863 (0.5734)	-0.0370 (0.0457)	-0.5764* (0.1009)	0.9902
Pork	0.2552* (0.1074)	0.3983* (0.1038)	-0.3228* (0.0758)	-0.3307* (0.1446)	0.7005 (0.5780)	0.0188 (0.0460)	-2.2129* (0.9439)	0.9653
Poultry	-0.7684* (0.0778)	-0.3228* (0.0758)	1.7591* (0.1172)	-0.6678* (0.0964)	-1.4507* (0.8290)	-0.0017 (0.0685)	0.4063 (1.3675)	0.9613
Fish	0.0740* (0.2430)	-0.3307* (0.1446)	-0.6678* (0.0964)	0.9246* (0.3254)	1.2365* (0.7065)	0.0199 (0.0550)	2.3831* (1.1930)	0.9776

[1]ALL COEFFICIENTS AND ERRORS ARE MULTIPLIED WITH 100 FOR EASE OF PRESENTATION
*RATIO OF COEFFICIENT TO ITS STANDARD ERROR IS GREATER THAN TWO IN THE ABSOLUTE VALUE

For all four meats, the health variable is not significant in any model, and the health effect has an unexpected negative (albeit statistically insignificant) effect on fish demand in the AIDS as well as on poultry demand in the IAIDS. This outcome is surprising, given that fish and poultry are generally perceived to be rather healthy goods.

While it is insignificant, the sign on the health index in beef demand is negative like that found by previous research (Kinnucan, Hsia, and Jackson; Capps and Schmitz. Both demand systems show the same sign of the health index in the case of the beef and pork equations. In general, when estimating the demand for a meat type which consists of high and low fat cuts, it could be of advantage to use a demand model with greater disaggregation into cuts by fat content. These results suggest that, in aggregate, the concerns about cholesterol consumption have had little, if any, effect on meat demand.

The index of the percentage of women in the labor force was designed to capture consumers' preferences for convenience in some sense as families devote less time to at-home food preparation. While the health variable was not significant, the index of the percentage of women in the work force is significant for most meat types in both models. In both models, this variable is negative for beef and pork, but positive for poultry and fish. The positive coefficients underline the fact that the poultry and fish industry have been meeting consumers demand for convenience, such as offering a variety of easy-to-prepare frozen dinners, while the beef and pork industries have not responded accordingly. Furthermore, families with no stay-at-home parent probably eat away from home more often or purchase take-out dinners more frequently than those with an adult working in the home. Hence, the index of the percentage of women in the labor force also signifies the meat demand change of the whole family with working parents. Prior research supports these findings. McGuirk *et al.* showed that with a higher percentage of women in the labor force, poultry consumption increased, while beef consumption decreased. However, in contrast to McGuirk *et al.*, we also found a negative and significant effect of the women in the labor force variable on pork demand in both the AIDS and IAIDS framework.

Tables 4 and 5 show the elasticities and flexibilities of the two demand systems.

TABLE 4: AIDS PRICE AND EXPENDITURE ELASTICITIES

	Expenditure Elasticities	**Price Elasticities Beef**	**Pork**	**Poultry**	**Fish**
Beef	1.3092	-0.4586	0.3454	0.2377	-0.1246
Pork	1.0392	0.4738	-0.7231	0.2639	-0.0146
Poultry	0.8545	0.2294	0.1862	-0.7824	0.3668
Fish	-0.9484	0.4784	0.2511	0.1694	-0.8990

All own price elasticities are negative and inelastic as expected. Given a 1% price increase for beef, pork, poultry, and fish, the demand for these four meat types will fall by 0.46%, 0.72%, 0.78%, and 0.90%, respectively. All but two of the cross-price elasticities are positive, indicating that all goods behave as substitutes to another good, given a price change in the second good. For example, given an increase in the pork price, a 0.34% increase in beef demand arises. Fish in the beef demand equation has a negative cross-price elasticity, which means that fish behaves as a complement to beef; however, their cross-price elasticities are very small, which indicates that they are only weak complements. The cross-price elasticities of fish and pork are negative and very small, which means that they are weak complements as well.

TABLE 5: IAIDS SCALE AND QUANTITY FLEXIBILITIES

	Scale Flexibilities	Quantity Flexibilities Beef	Pork	Poultry	Fish
Beef	-1.2023	-1.1974	-0.2217	-0.2467	-0.3341
Pork	-0.7140	-0.2215	-1.2100	-0.2921	-0.2764
Poultry	-0.8984	-0.3217	-0.2811	-1.3240	-0.0731
Fish	-1.0863	-0.2353	-0.2809	-0.1628	-1.3209

Table 5 shows that the own flexibilities (quantity flexibilities) for all meat types are inflexible, which means that the price of a meat type is reduced when the supplied quantity of that type is increased. All cross-price flexibilities are negative; hence all goods are quantity- substitutes. This means that when the price of a meat type is reduced, the supplied quantity of another meat type is increased.

CONCLUSIONS

A variety of factors influence changes in meat demand. The factors are economic elements, such as prices and income, demographic characteristics, lifestyle factors and dietary preferences. Explaining these effects of health information and changing demographics have been the special interest of this study. Results indicate that convenience in meal preparation plays an important role in modifying the aggregate demand for meat as measured by women in the work force. A greater percentage of women in the labor force has increased the demand for lean and convenient products such as poultry and fish. The poultry and fish industries appear to have capitalized on the transition of women in the work force by being responsive regarding the convenience aspects of meat.

In contrast to previous research (Kinnucan, Hsia, and Jackson; Capps and Schmitz), this study shows that the health information index does not have a significant effect on aggregate meat demand. These results suggest that in aggregate, the concerns about cholesterol consumption have had little, if any, effect on meat demand.

The findings of this study suggest that the effects of health information and demographic changes on meat demand merit further investigation most notably with panel data.

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