# FOOD DEMAND ANALYSIS

## Implications for Future Consumption

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# Population Scale, Composition, and Income Effects on Per Capita and Aggregate Beef Consumption: A Temporal and Spatial Assessment

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Perhaps now, more than at any other period, substantial changes can be observed in Americans' food consumption patterns. The increased availability of some foods, a rise in the proportion of meals eaten away from home, and the use of convenience and processed foods have altered intake levels for many commodities (Guenther and Chandler, 1980; Havlicek et al., 1982). Despite years of stability in the demand for beef, with utilization increasing at about the same rate as personal income and population, per capita and aggregate consumption for the past eight years have been changing. A variety of factors aid in explaining the fluctuations observed in beef consumption, including demographic and income effects, supply and price influences, governmental policy, and attitudes toward beef relative to possible substitutes.

This study was designed to assess the implications of demographic and income change on beef consumption over the next five to fifteen years, i.e. to 1990 and 2000. Beef represents an excellent commodity to analyze as a function of population parameters because of a sensitivity to income, age, and other individual characteristics (Sapp, 1984; Haidacher et al., 1982). Second, due to the small net exportation, U.S. beef is consumed in a relatively closed system where domestic population trends have a dominant influence. Third, fed-beef production and processing, as well as meat wholesaling, are becoming more geographically concentrated (USDA, 1974, 1984; Clary, 1984; Duewer, 1984), and distribution to major markets must be considered. For this reason, the locational configuration of the population is of interest in optimizing the economic environment for beef-related industries.

## National Beef Consumption Trends

Per capita consumption of beef has risen consistently since the earliest empirical estimates, with a 72 percent

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increase from 1910 to 1976 (Brewster and Jacobson, 1978). In the 12-year period between the 1965-66 Nationwide Food Consumption Survey (NFCS) and its counterpart in 1977-78, per capita beef intake rose 25 percent. From 1977 to 1984, however, per capita consumption declined in five of the eight years (USDA, 1985), so that now there is no clear trend-line from which to extrapolate future consumption patterns.

Between the last two NFCS periods, i.e. 1965 to 1977, aggregate beef utilization increased by 39 percent, due to population growth and to an increase in per capita intake. As with personal consumption, aggregate utilization began to show some fluctuation beginning in 1977, due to a reduction in population growth and variations in annual slaughter rates and prices, as well as to changing consumer preferences and purchasing patterns.

The next section summarizes procedures for projecting per capita and aggregate beef intake to 1990 and 2000. Following this methodological explanation are two sections which review results, one for projected U.S. consumption and the second representing projections for large geographic market areas. A final section summarizes the consequences of changing demographic and economic characteristics for beef utilization.

## Procedures

Estimates of future commodity utilization depend on the accurate assessment of consumption functions and on the reliable projection of major population changes affecting utilization. Procedures for projecting beef intakes, summarized as follows:

(1) selection of data sources for deriving estimation equations, in this case, 1977-78 NFCS data;
(2) determination of the independent variables for use in estimation equations;
(3) projections of each independent variable to the years of interest, i.e., 1990 and 2000, under varying assumptions;
(4) development of estimates for beef intake from the cross-sectional 1977-78 NFCS data for the nation and major geographic market areas;
(5) evaluation of goodness of fit for all areal estimates;
(6) insertion of projected demographic and economic characteristics into estimation models to obtain future per capita intakes;
(7) application of population scale parameters for all areal units to obtain aggregate consumption for

the years of interest, i.e., 1990 and 2000;
(8) decomposition of effects of independent variables; and
(9) derivation of expected changes in the distribution of aggregate consumption among geographic market areas.

Each step is described below.

## Selection of Data Set

The most comprehensive survey of food intake and food expenditures to date is the USDA Nationwide Food Consumption Survey (NFCS), last undertaken in 1977-78. In this survey, a 24-hour recall and a two-day food diary provided the basis for average daily consumption of food items. The survey also contains extensive information on the background characteristics of respondents and their households. The survey includes data for the 48 contiguous states and the District of Columbia. The smallest areal units for which survey data could be analyzed are the nine divisions of the nation designated by the U.S. Bureau of the Census (1984) as socioeconomically distinct areas.

## Variable Selection

Consumption, rather than expenditures, provides a useful focus for projection purposes, because of the direct link to future requirements for beef production. With expenditures, a shift toward more packaged and prepared foods would indicate an increase in expenditures even though physical quantities consumed do not increase. Individual consumption thus was utilized to more accurately portray to current and future production requirements. The NFCS data revealed that 65 percent of the sample population consume beef over any three-day period. The remainder of the sample (those not consuming beef) was assigned meaningful zeros for three-day average intakes in this study.

A number of beef estimation models were prepared to narrow the possible input variables. A constraint on variable selection was the availability of reliable projections for each independent variable included in the estimation model. Several input variables which improved the estimation model were difficult to adequately project for future years, including educational level, labor force participation rates (hours employed per week), occupational characteristics, and levels of urbanization. These parameters are thereby excluded from the final modeling effort.

**Estimation Model**

The final model includes the following elements:

$$C = \beta_{0r} + \beta_{1r}(Y) + \beta_{2r}(\log Y)^{-1} + \beta_{3r}(A) + \beta_{4r}(H) + \beta_{5r}(S) + \beta_{6r}(R) + U_r$$

The subscript "r" refers to the geographic area and the variables are:

C = average daily intake (in grams)
Y = annualized per capita personal income
A = age of individual (0-100)
H = household size
S = sex of individual
R = race (black and nonblack) of individual
U = stochastic residual

Consumption is treated as a function of age, sex, race, household size, income, and the inverse of income logged. Age and sex are included in the estimation model because of the physiological, as well as food preference, differences in age/sex groups. Household size furnishes a basis for differential utilization of foods, even after controlling for income and age of household head (Salathe and Buse, 1979). Several previous studies have placed age, sex, and household size in adult equivalency scales (Buse and Salathe, 1978). However, this research is concerned with the explanatory power of individual level, rather than household level, variables. Additionally, projections for intra-household characteristics are not available, thereby limiting the usefulness of households as units of analysis. Blacks and nonblacks are included to estimate the cultural or preference differences by race (Gibson, 1971). The consumption equation also incorporates both per capita personal disposable income as well as an inverse of income logged. If powers of income were included (see Haidacher et al., 1982), projected beef consumption would be unreasonably high. The log inverse of income introduces a curvilinearity which handles saturation effects associated with using powers of income (Musgrove, 1982).

Characteristics of the NFCS sample are presented in Table 1 for the United States, and major geographical areas. Comparison of these survey characteristics with estimates of population characteristics prepared by the U.S. Bureau of the Census and other sources provides an indication of the representatives of the sample. The male population is under-represented by approximately four percent, in the survey sample, consistent with many other household surveys. Mean age is one percent lower than estimated for 1977, and the black population is over-represented by approximately two

**Table 1. Descriptive Population Characteristics from NFCS Data, 1977-78, for the Nation and for Nine Divisions**

| | Sample Size | Mean Age | Mean Household Size | Per Capita Real Personal Income | Percent Black Population | Percent Male Population |
|---|---|---|---|---|---|---|
| United States | (30,737) | 29.3 | 2.96 | $4,565 | 13.4 | 45.0 |
| Northeast | | | | | | |
| New England | (1,745) | 31.3 | 2.90 | 4,728 | 1.1 | 45.6 |
| Middle Atlantic | (5,459) | 28.8 | 3.01 | 4,982 | 11.0 | 43.9 |
| North Central | | | | | | |
| East North Central | (5,205) | 28.3 | 3.13 | 4,653 | 9.4 | 46.4 |
| West North Central | (2,646) | 29.0 | 3.04 | 4,795 | 5.6 | 46.4 |
| South | | | | | | |
| South Atlantic | (4,623) | 29.0 | 3.02 | 3,968 | 25.5 | 45.2 |
| East South Central | (2,543) | 31.1 | 2.86 | 4,131 | 17.9 | 45.4 |
| West South Central | (3,572) | 30.8 | 2.79 | 3,668 | 26.9 | 42.7 |
| West | | | | | | |
| Mountain | (1,419) | 26.9 | 3.13 | 4,516 | 5.6 | 45.0 |
| Pacific | (3,525) | 29.4 | 2.74 | 5,496 | 5.5 | 44.8 |

percent. Personal income is almost one-third less in the NFCS than in Bureau of Economic Analysis (Friedenburg et al., 1980) estimates, indicating a substantially greater proportion of low income respondents in the survey than in the population generally.

The NFCS data contain no attitudinal or preference information or data on prices of beef products. While preferences, prices, governmental policy, and technological improvements are critical parameters affecting beef consumption, these factors are assumed fixed under all scenarios. Such dimensions, then, make no contribution to the differenes that exist between projections or between regions of the country in this particular study.

## Goodness of Fit

The NFCS data were originally used to fit consumption functions for nine major food commodities. The final variable set explaines the largest portion of variation for the commodities, as well as fits the criteria of having projections available--or that could be developed with reasonable accuracy--for the areal units of interest.

Coefficients of determination were highest for dairy products (0.22) and lowest for cereal/bakery items and poultry (0.01), partly because of the sensitivity of dairy products to age effects and the fact that grain and poultry consumption is conditioned by a number of factors not measured in this analysis. Coefficients of determination for beef intake ranged from 0.03 for the New England and Middle Atlantic states to 0.09 for Mountain states. Although all variables used to estimate beef consumption are statistically significant and have major impacts on projections of consumption for the years of interest, the low R2s suggest that projections based on these estimation models should be used with care. However, the projections provide insight into the role of population variables on commodity utilization and show the market impacts of changes in a limited number of variables. They cannot be considered forecasts, but rather as possible scenarios under varying income and demographic conditions.

## Demographic and Economic Projections

Projections of age and sex cohorts as well as total population were obtained from Bureau of the Census sources and income projections from the Bureau of Economic Analysis. Future racial composition and household size were independently derived, as timely projections were not available on a subnational basis for these two variables.

In each case, the projections are not forecasts but represent results of continuing patterns from some previous time period. These patterns represent assumptions for the future regarding rates of income change, birth rates, life expectancies, and migration rates, the latter being of special significance in spatial analyses.

Total Population. Projections of total population for the nation reflect three types--a low, middle and high series. The low series (Series 19, U.S. Bureau of the Census, 1984) is based on: (1) relatively high mortality, with life expectancies at 74.7 years to 2000; (2) low net immigration (around 250,000 annually); and (3) low ultimate fertility at 1.6 births per woman. The high growth series (Series 9) reflected: (1) greater increases in life expectancy (78.7 years for 2000); (2) high net immigraton at 750,000 persons per year; and (3) an ultimate fertility level of 2.3 births per woman.

The middle series (Series 14) projections are emphasized here, and represent the only projection series used for subnational purposes (refer to Table 2). Here, projected state populations are aggregated to comprose nine major geographic ares. Assumptions underlying the middle series projections include: (1) life expectancies at 76.7 for the year 2000; (2) immigration of 450,000 annually; and (3) ultimate fertility of 1.9.

For subnational projections, where state level data are utilized, the net migration among states has the greatest effect on population change, relative to fertility and mortality trends. For the provisional state projections (U.S. Bureau of the Census, 1983), future migration is based on past (1970-80) trends and is treated as a residual estimate; migration is not measured using actual place-to-place or gross migration data. Thus, net migration represents a rate calculated after state populations for 1970 and 1980 were tallied (adjusting for 1970 undercounts and controlling for births and deaths).

Overall, the U.S. mid-range projections indicate a 0.97 per annum population growth between 1980 and 1990, followed by 0.7 annual increases to 2000. Most of the rapidly growing states lie west of the Mississippi River. Nevada is projected to be the most rapidly growing state, with a population that will more than double by 2000. Other high growth states include Wyoming, Arizona and Utah--all located in the Mountain area of the nation (one of the nine areas designated as socioeconomically distinct by the Bureau). Between 1980 and 1990, Massachusetts, New York, Pennsylvania, Ohio, and the District of Columbia are anticipated to lose population. In the 1990-2000 decade, other states will join this list, including Rhode Island,

Connecticut, New Jersey, Illinois, Michigan, Iowa, and South Dakota.

Age of Individuals. The mean age of the population was derived from the three projection series described above. As expected, the mean age of the population continues to increase under all three population series through the year 2000 (Table 2 shows mid-series mean age for areal units of interest). The Northeastern states exhibit the oldest age distribution, with the West mirroring the youngest population. Overall, the number of dependent persons (those under 16 and over 64) should decrease over the next 15 years.

Sex of Individuals. Mid-series projections assume that life expectancy for males will increase to 73.3 and for females to 81.3 (in 2005). Mountain and Middle Atlantic states show the smallest proportion of males for both 1990 and 2000, partly due to continued geographic relocation.

Race of Individuals. The projections for racial composition are derived as an extrapolation of state-level trends in black and nonblack populations, 1970-80. Table 2 depicts large subnational differences in projections of the black population, with East South Central states--followed by Middle Atlantic, West South Central, and East North Central states--showing the largest shares of blacks in 1990 and 2000. However, the heavy concentration of blacks in a small number of geographic locations continues to lessen. Overall, the proportion of blacks continues to increase slowly, showing younger mean ages than their white counterparts.

Household Size. Mean household size is calculated on a subnational basis by extrapolating from 1970-80 state level trends and adjusting to projected household size for the nation (U.S. Bureau of the Census, 1979, Household Size Series A, Population Series I). The latter adjustment is used to prevent unreasonably low household size scenarios, and that particular series most closely approximates the actual 1980 household size parameter for the nation.

The South has generally evidenced higher numbers of persons per household, and projections of future household size suggest this differential will remain, especially for the East South Central states. Smallest households for 1990 and 2000 lie in West North Central and Pacific states, where mean ages are young relative to most other states.

Personal Income. Projections of per capita personal income for states and the nation are based on Bureau of Economic Analysis (BEA) forecasts of average annual income growth. The projections were made in two steps--first for

*Table 2. Projections of Demographic and Economic Characteristics for Major Geographic Market Areas*

| | Mean Age | | Mean Household Size | | Per Capita Real Personal Income | | Percent Black Population | | Percent Male Population | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1990 | 2000 | 1990 | 2000 | 1990 | 2000 | 1990 | 2000 | 1990 | 2000 |
| United States | 34.90 | 36.59 | 2.60 | 2.43 | $10,173 | $12,539 | .12 | .13 | .48 | .48 |
| New England | 36.44 | 38.38 | 2.59 | 2.42 | 10,101 | 12,268 | .04 | .05 | .48 | .47 |
| Middle Atlantic | 36.65 | 38.36 | 2.59 | 2.43 | 10,554 | 12,910 | .13 | .15 | .47 | .47 |
| East North Central | 34.66 | 36.30 | 2.63 | 2.46 | 10,742 | 13,112 | .12 | .14 | .48 | .48 |
| West North Central | 34.51 | 36.20 | 2.54 | 2.37 | 9,949 | 12,304 | .05 | .05 | .49 | .49 |
| South Atlantic | 36.37 | 38.59 | 2.58 | 2.41 | 9,648 | 12,105 | .20 | .20 | .48 | .48 |
| East South Central | 34.49 | 36.13 | 2.68 | 2.51 | 8,846 | 11,292 | .19 | .18 | .48 | .48 |
| West South Central | 32.29 | 34.72 | 2.65 | 2.48 | 9,743 | 12,200 | .14 | .13 | .49 | .49 |
| Mountain | 33.76 | 34.20 | 2.65 | 2.48 | 9,798 | 12,241 | .03 | .03 | .46 | .46 |
| Pacific | 34.07 | 35.47 | 2.52 | 2.35 | 10,985 | 13,311 | .07 | .08 | .50 | .45 |

the nation and then for states. At the national level, future Gross National Product (GNP) was estimated, based on mid-series projections of population, labor force participation rates, employment levels, and hours paid per employee per year. Total earnings and personal income were then projected, based on GNP.

At the state level, future earnings by industry were estimated and adjusted to national totals. Industries at the state level were grouped into basic and service sectors. A state's relative growth in income was assumed to depend on the stimulus provided by its basic industries, i.e., those that derived earnings mainly from exports to other states. The service industries were assumed to derive earnings mainly from within the state, and thereby had little influence on a state's relative advantage, in terms of potential for income growth.

In each state, trends in earnings were extrapolated to future periods, but in all cases, the projected change was assumed to decelerate, so that no state would be projected to have an unreasonably large or small share of national earnings. Personal income for states was aggregated to represent nine geographic divisions of the country. Income was presented in 1977 dollars for the projection periods.

The United States is expected to show an average annual income growth of 2.5 percent between 1978 and 2000. Mountain states which, along with West South Central states, showed the highest growth in personal income during the 1970s, were projected to have annual rates of growth under three percent. On the other hand, the East South Central and South Atlantic states were projected as having the greatest average income growth in the 1980s and 1990s. That income and population projections do not show a consistent relationship is evident in the states forecast by BEA to have the slowest per capita personal income growth--Nevada (the state with the largest projected population increase), followed by Connecticut, California, Wyoming, and Washington.

**Decomposition of Effects**

The general question of how population growth and the distribution of population affects food requirements has been considered in a number of earlier studies (Raunikar et al., 1969; Serow, 1972). Similarly, changes in disposable income and labor force productivity have been evaluated in consumption forecasts, with the distributional aspects of purchasing power of particular interest. Food consumption also has been shown to be sensitive to compositional changes

in the population, especially the consuming population and their locational configuration (Salathe, 1979).

The relative significance of all three dimensions--income, composition, and scale--is of interest in this analysis. Income elasticities appear to be declining for foods generally (Musgrove, 1982) and personal income is becoming more similar across regions (Friedenburg, et al. 1980). The comparative effect of these trends on beef consumption through the year 2000 is thus of considerable importance.

The composition effect includes variables viewed, to some extent, as interdependent. Mean age, household size, sex, and racial identity are not partitioned in the decomposition analysis due to the underlying phenomena they often represent, namely, differences in birth rates for specific cohorts over time. Demographically-related shifts in consumption become particularly pronounced when the population grows rapidly (Guseman and Sapp, 1984). Further vast changes in food requirements emerge in various parts of the country as people relocate. These population scale effects begin to dominate when personal income grows slowly.

At a micro or individual level, the changes in composition and personal income delineate the total structural effect on beef composition, both aggregate and per capita utilization. Likewise, changes in the total population and in population composition provide the total demographic effect on aggregate beef consumption.

The relative effects of the three dimensions can be isolated following an approach taken by Musgrove (1982: 18-29) in examining expenditure growth for sectors of the economy. The equations for decomposition are as follows:[2]

I. Scale Effects (SE): $$\frac{C_0 [(P_1/P_0) - 1]}{C_{1Y} - C_0}$$

II. Composition Effects (CE): $$\frac{C_1 - [C_0 (P_1/P_0)]}{C_{1Y} - C_0}$$

[2]Scale effects are positive when $P_1 > P_0$, and/or $C_{1Y} > C_0$. Income effects are positive when the commodity is normal. Composition effects are positive when $P_1 > P_0$ and/or when the commodity is normal. Negative effects occur under converse conditions.

III. Income Effects (IE): $\frac{C_{1Y} - C_1}{C_{1Y} - C_0}$

where:

$P_0$ = population at base period

$P_1$ = population at estimate period

$C_0$ = consumption at base period

$C_1$ = consumption at estimate period with no income growth

$C_{1Y}$ = consumption at estimate period with income growth

Then, SE + CE + IE = 1.0 and; SE + CE = share of total change in consumption, $(C_1 - C_0)$, attributable to demographic factors; and CE + IE = share of change in consumption, $(C_{1Y} - [C_0 (P_1/P_0)])$, attributable to structural factors.

**Measuring Changes in Distribution of Aggregate Beef Consumption**

A final step in the analysis entails allocating projected changes in aggregate consumption to geographic areas. Spatial variation in future aggregate consumption was based on comparing 1977 intakes with alternative scenarios for the years of interest, i.e. 1990 and 2000. An earlier study (Raunikar et al., 1969) showed projected changes in aggregate beef demand, over a 15 year period, to range from 104 percent to 7 percent, based on the specific geographic location. Justification for measurements of change in geographic shares of the beef market lies in the need to continually evaluate efficiencies in the beef industry through a spatial and temporal context.

**Projections of U.S. Beef Consumption**

Personal per capita income, compositional characteristics of the population, and population scale effects on beef consumption demonstrate the importance of considering the population influences on food demand. Table 3 compares Texas A&M University (TAMU) illustrative projections of beef consumption under varying conditions, as well as projections prepared by the Joint Council on Food and Agricultural Sciences (JCFAS, 1984) and the Food and

*Table 3: Comparative Projections of U.S. Beef and Meat Consumption, 1990 and 2000*

| | Texas A&M University Middle Population Series: No Income Growth | Texas A&M University Low Demographic Series: With Income Growth | Texas A&M University Middle Demograhic Series: With Income Growth | Texas A&M University High Demographic Series: With Income Growth | Joint Council on Food and Agricultural Sciences | Food and Agriculture Organization |
|---|---|---|---|---|---|---|
| | | | [Beef Only] | | [Beef, Veal, Pork & Poultry] | [Beef & Veal] |
| Per Capita Consumption (in grams per average day) | | | | | | |
| 1990 | 141 | 161 | 167 | 167 | --- | --- |
| 2000 | 142 | 179 | 178 (308)[a] | 178 | 303 | --- |
| Aggregate Consumption (in million metric tons annually) | | | | | | |
| 1990 | 12.9 | 15.0 | 15.3 | 15.6 | ___ | ___ |
| 2000 | 13.9 | 16.8 | 17.5 (30.1)[b] | 18.5 | 29.2 | 17.7 |

[a] 308 grams per average day for beef, veal, pork, and poultry

[b] 30.1 million metric tons for beef, veal, pork, and poultry

Agricultural Organization (FAO, 1981). Three of the four TAMU population series are based on the low, middle, and high population growth series described earlier and differ primarily in regard to projected mean age and total population, but are comparable in assuming income growth. A fourth TAMU scenario uses the mid-range population projections and assumes that no income growth will occur.

At an individual level, based on TAMU projections, income growth conditions play the largest role in future beef utilization. At a societal level, population size also shows a strong influence over aggregate utilization. Under the middle demographic series, with income growth assumed, income effects explain 55 percent of the expected aggregate consumption increases for both 1990 and 2000, while population scale effects expalin 39 and 40 percent for the two decennial periods (refer to earlier explanations regarding decomposition of effects). Of the three major dimensions under consideration, population composition accounts for the smallest portion of the expected growth in beef consumption, six percent for 1990 and five percent for the year 2000. Unlike dairy products, fruits, and vegetables, beef continuess to represent a commodity which is sensitive to personal income, rather than age, race, or other structural characteristics of the population.

Table 3 also presents projections prepared under different sets of underlying conditions. The TAMU projections depend on 1977-78 NFCS data and demographic projection series for the 48 contiguous states, while JCFAS and FAO projections encompass Alaska and Hawaii. These states, however, contain less than one prcent of the total projected U.S. population for the periods of interest. More important are the units of observation involved in the projections, with JCFAS using "all meat" and FAO focusing on "beef and veal." As veal constitutes approximately two percent of combined beef and veal intake, the exclusion of veal in the TAMU projections should be noted.

Underlying conditions for the JCFAS projections included: (1) low income elasticities; (2) a 2.7 percent annual average growth in real GNP; (3) a 0.7 percent annual increase in population to 1990, followed by a 0.5 percent annual increase until 2000; and (4) a continuation of current agricultural policy. Specific assumptions underlying FAO projections were not available, but were loosely based on some measure of population growth, a slight growth in caloric intake and a favorable economic and political enviornment for domestic agriculture (FAO, 1981).

The JCFAS projections of per capita nad aggregate meat consumption for the year 2000 are comparable to TAMU middle series projections, varying less than three percent in both

cases. Likewise, the FAO scenario and the TAMU middle series projection under conditions of income growth show highly similar patterns of future aggregate consumption. Projections prepared under varying assumptions rarely yield similar results; the consistency of these illustrative scenarios lends greater credence to all projection series. Nevertheless, a comprehensive analysis of long-term consumption patterns cannot easily depict the consequences of future supply and prices, of the quality of resources and technology, or of the effects of governmental policy and consumer attitudes.

## Projections of Beef Consumption by Geographic Market Area

No recent subnational projections of beef consumption are available for comparison with the TAMU geographically-based projections described in this section. Additionally, it has been difficult to obtain estimates on aggregate or per capita consumption of commodities, such as beef, specified by geographic area. NFCS consumption data can be analyzed according to the nine divisions estabished by the U.S. Bureau of the Census (1984). With these intake data and with demographic and economic projections available for these areas, the market potential for beef can be assessed in a spatial context.

The divisions are treated as market areas in a geographic sense and as a way of segmenting populations according to subnational socioeconomic differences. Variations within the four major regions of the Northeast, North Central, South, and West can be obfuscated in analyses dependent on these regional comparisons alone. For example, the West South Central states--Texas, Oklahoma, Arkansas, and Louisiana--show substantially higher real average incomes, a lower black population, and a younger mean age than do other portions of the Southern region.

In addition, the West South Central states have unique consumption patterns relative to Southern counterparts in the East South Central and South Atlantic states. In 1977-78, consumers in the West South Central states had higher per capita intakes of cereal/bakery items and poultry than any of the remaining eight subregions of the country (Table 8). These states also showed smaller intakes of fats and oils than other areas, and lower consumption of dairy products, fresh fruits, and fresh vegetables than other Southern states. Finally, examination of regional data alone show Southerners as the lowest per capita users of beef, concealing the market potential for beef in the West South Central states, where intakes were higher than in other Southern locations. Information on intake levels by subregions thus provides the basis for evaluating the

relative position of these geographic markets and suggests potential locations for beef-related industries.

Because of temporal variation in the rate of population growth by subregion and pronounced changes in population composition by market area over time, estimates of future per capita and aggregate beef consumption need to take into account these changes. Also, the economic characteristics of subregional populations have a stronger effect on beef consumption than on any other major agricultural commodity (Purcell and Raunikar, 1967; Capps, 1981). Thus, estimates of future income by geographic market area should be incorporated into projected market requirements for beef.

This portion of the analysis concentrates on projections of beef utilization for subregional markets based on state-level economic and population projection series. Projections of locations incurring the largest and smallest increases in per capita and aggregate beef intakes are described under two scenarios--income growth and income stagnation conditions.[3]

Table 4 presents beef utilization for 1990 and 2000 where no real income growth has occurred. Per capita increases are shown for all geographic locations except the East South Central and West North Central states, because the average age of a heretofore young population is increasing. Largest per capita increases in beef consumption (with no change in real income) occur for the West South Central states, followed by the eight Mountain states and New England. A common characteristic of these areas is sharp projected declines in household size, as well as a young mean age, the latter particularly characteristic of West South Central and Mountain states.

Projections of aggregate consumption include the population scale parameter. The rates of increase in aggregate beef utilization (under conditions of income stationarity) for the nine geographic areas closely follow projections of population growth, with areas of the Southern and Western regions showing the greatest increases. Likewise, Northeastern and North Central geographic markets

[3]The subnational projections of future beef consumption are based on the two income scenarios (rather than a series of population size and composition scenarios) for two reasons: (1) income was shown as the prominent factor in comparable analyses at the national level; and (2) recent U.S. Bureau of the Census population projections for subnational areas were prepared only for the mid-series projections, so that other population scenarios were not readily available. Thus, the projections of future beef consumption in Tables 4 and 5 differ only with regard to income growth.

**Table 4. Illustrative Projections of Beef Consumption, Assuming No Income Growth, 1977 to 2000, by U.S. Divisions**

| Divisions | Per Capita Consumption (grams per average day) | | | Aggregate Consumption (thousand metric tons) | | | Percent Change in Aggregate Consumption | |
|---|---|---|---|---|---|---|---|---|
| | 1977 | 1990 | 2000 | 1977 | 1990 | 2000 | 1977-1990 | 1977-2000 |
| New England | 147 | 152 | 153 | 679.7 | 716.3 | 724.5 | 5.4 | 6.6 |
| Middle Atlantic | 134 | 137 | 138 | 1,831.3 | 1,811.9 | 1,720.2 | -1.1 | -6.1 |
| East North Central | 137 | 137 | 137 | 2,081.1 | 2,140.1 | 2,109.1 | 2.8 | 1.3 |
| West North Central | 159 | 151 | 152 | 946.2 | 999.3 | 1,012.3 | 5.6 | 7.0 |
| South Atlantic | 131 | 133 | 134 | 1,611.6 | 2,117.0 | 2,420.9 | 31.4 | 50.2 |
| East South Central | 123 | 120 | 120 | 650.1 | 714.8 | 760.8 | 9.9 | 17.0 |
| West South Central | 136 | 143 | 144 | 1,101.4 | 1,496.8 | 1,738.4 | 35.9 | 57.8 |
| Mountain | 132 | 138 | 139 | 473.3 | 785.7 | 1,033.2 | 66.0 | 118.3 |
| Pacific | 162 | 167 | 165 | 1,661.6 | 2,211.7 | 2,471.5 | 33.1 | 48.1 |

show negligible increases, with the Middle Atlantic states indicating a decline in aggregate consumption.

A second portion in the analysis of future beef requirements incorporates projections comparable to those in Table 4, but with Bureau of Economic Analysis (Friedenburg, 1980) projections of income growth included (Table 5). Per capita intake diverges from Table 4 in this second income growth scenario. Mountain and West South Central states still show large increases in per capita intakes. However, East South Central states, for which a slight decline in individual utilization has been projected, now reflect a sizeable increase.

With both anticipated income and population growth incorporated into one set of projections, sharp increases in aggregate consumption are observed. Mountain states show a 126 percent increase by 2000. West South Central states also show large increases, with a 74 percent increase over a five year period (to 1990) and a 119 percent increase for the 15 year period to 2000. Middle Atlantic states exhibit the smallest increase, primarily because of the slow expected population growth in this area of the country.

Overall, isolation of causative factors explaining the change in beef utilization shows income to be the key factor (Table 6). Income growth, in a strict sense, represents increases in labor force productivity through the projection periods (Musgrove, 1982). Thus, large productivity increases are expected for Middle Atlantic, East North Central, and East South Central states, as well as other Northeastern and North Central areas. Pacific and South Atlantic states reflect the importance of population growth relative to structural change. Composition effects were not viewed as critical predictors for most of these subregions.

The total difference in consumption from 1977 to 1990 and to 2000 is measured through a total demographic effect, i.e., scale and compositional change, or a total structural effect, i.e., per capita changes in composition and income (Table 6). The structural effect reigns as most important for all but two subregions, pointing to the importance of increased, as opposed to constant, labor force productivity.

Geographically-derived shares of the beef market are arrayed in Figures 1, 2, and 3, according to the proportions of beef consumed in 1977 and projected aggregate utilization under income growth conditions in 1990 and 2000. The greatest increase in the proporation of beef required lies within the Mountain and West South Central states. Thus, beef produced in the High Plains and Nebraska should optimally serve these two geographic markets. Producers of Iowa and Nebraska beef, who now primarily serve markets in

**Table 5. Illustrative Projections of Beef Consumption, Assuming Income Growth, 1977 to 2000, by U.S. Divisions**

| Divisions | Per Capita Consumption (grams per average day) | | | Aggregate Consumption (thousand metric tons) | | | Percent Change in Aggregate Consumption | |
|---|---|---|---|---|---|---|---|---|
| | 1977 | 1990 | 2000 | 1977 | 1990 | 2000 | 1977-1990 | 1977-2000 |
| New England | 147 | 158 | 163 | 679.7 | 747.5 | 768.6 | 9.9 | 13.1 |
| Middle Atlantic | 134 | 153 | 160 | 1,831.3 | 2,016.2 | 1,987.4 | 10.1 | 8.5 |
| East North Central | 137 | 164 | 175 | 2,081.1 | 2,572.3 | 2,688.1 | 23.6 | 29.2 |
| West North Central | 159 | 175 | 187 | 946.2 | 1,160.3 | 1,249.9 | 22.6 | 32.1 |
| South Atlantic | 131 | 158 | 170 | 1,611.6 | 2,522.2 | 3,074.9 | 56.5 | 90.8 |
| East South Central | 123 | 169 | 195 | 650.1 | 1,006.9 | 1,237.8 | 54.9 | 90.4 |
| West South Central | 136 | 183 | 200 | 1,101.4 | 1,915.8 | 2,344.1 | 73.9 | 119.0 |
| Mountain | 132 | 187 | 210 | 473.3 | 1,064.1 | 1,566.0 | 125.8 | 230.9 |
| Pacific | 162 | 183 | 190 | 1,661.6 | 2,430.8 | 2,840.1 | 46.3 | 70.9 |

**Table 6. Isolation of Population Scale, Composition, and Income effects for Consumption Growth of Beef Products**

| Subregions | Decompostion of Change in Beef Consumption | | | | |
|---|---|---|---|---|---|
| | Scale Effects | Composition Effects | Income Effects | Total Demographic Effect (SE + CE) | Total Structural Effect (CE + IE) |
| New England | | | | | |
| 1990 | 0.41 | 0.13 | 0.45 | 0.54 | 0.59 |
| 2000 | 0.33 | 0.17 | 0.50 | 0.50 | 0.66 |
| Middle Atlantic | | | | | |
| 1990 | -0.37 | 0.26 | 1.10 | -0.10 | 1.37 |
| 2000 | -1.09 | 0.38 | 1.71 | -0.71 | 2.09 |
| East North Central | | | | | |
| 1990 | 0.13 | -0.01 | 0.88 | 0.12 | 0.86 |
| 2000 | 0.05 | 0.00 | 0.95 | 0.05 | 0.95 |
| West North Central | | | | | |
| 1990 | 0.26 | -0.01 | 0.75 | 0.25 | 0.74 |
| 2000 | 0.21 | 0.00 | 0.78 | 0.21 | 0.78 |
| South Atlantic | | | | | |
| 1990 | 0.46 | 0.10 | 0.44 | 0.55 | 0.54 |
| 2000 | 0.47 | 0.08 | 0.45 | 0.55 | 0.53 |
| East South Central | | | | | |
| 1990 | 0.30 | -0.12 | 0.82 | 0.18 | 0.70 |
| 2000 | 0.27 | -0.08 | 0.81 | 0.19 | 0.73 |
| West South Central | | | | | |
| 1990 | 0.41 | 0.07 | 0.51 | 0.48 | 0.59 |
| 2000 | 0.42 | 0.06 | 0.52 | 0.48 | 0.58 |
| Mountain | | | | | |
| 1990 | 0.42 | 0.10 | 0.47 | 0.53 | 0.57 |
| 2000 | 0.43 | 0.08 | 0.49 | 0.51 | 0.56 |
| Pacific | | | | | |
| 1900 | 0.61 | 0.10 | 0.28 | 0.71 | 0.39 |
| 2000 | 0.63 | 0.06 | 0.31 | 0.69 | 0.37 |

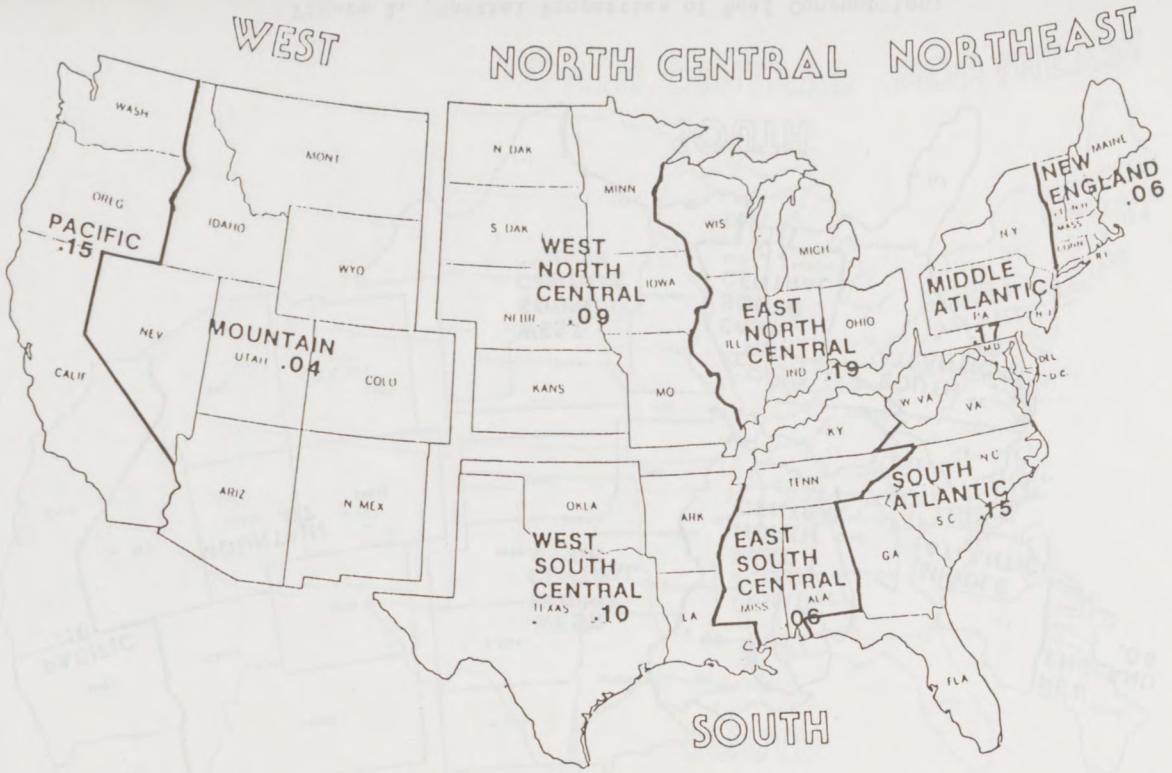


Figure 1. Spatial Properties of Beef Consumption:
Shares for Major Geographic Market Areas, 1977

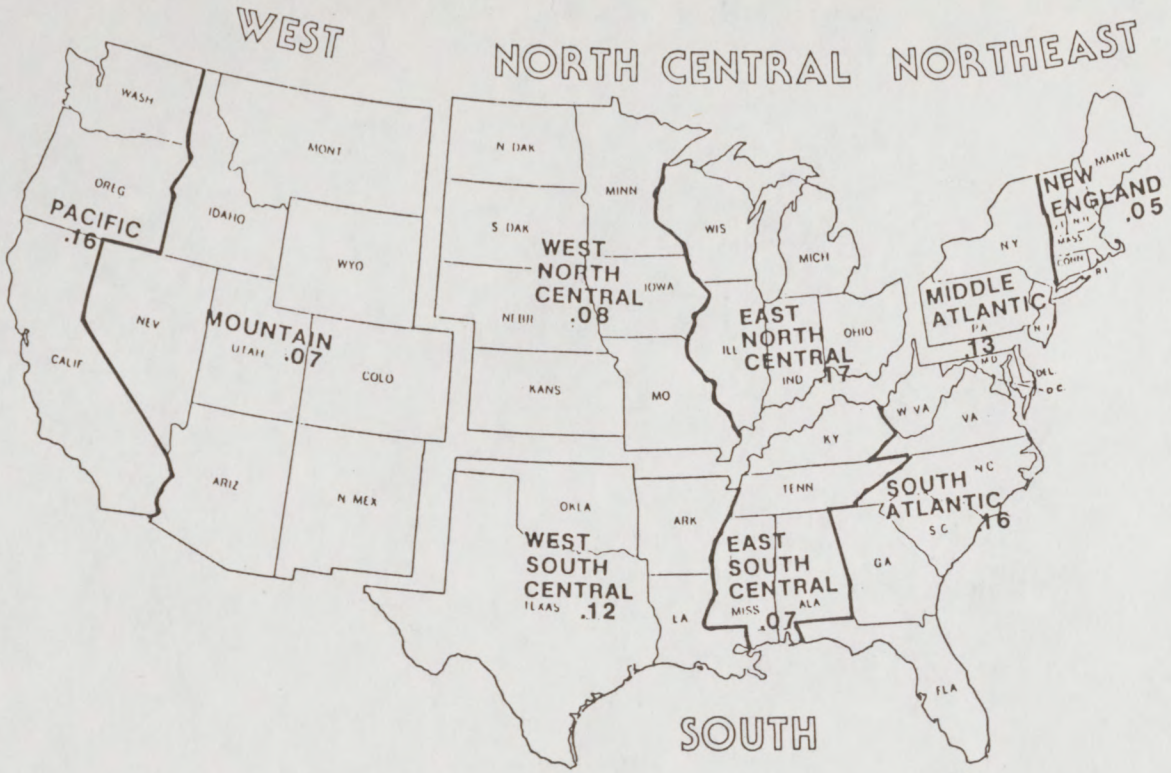


Figure 2. Spatial Properties of Beef Consumption:
Projected Shares for Major Geographic Market Areas, 1990

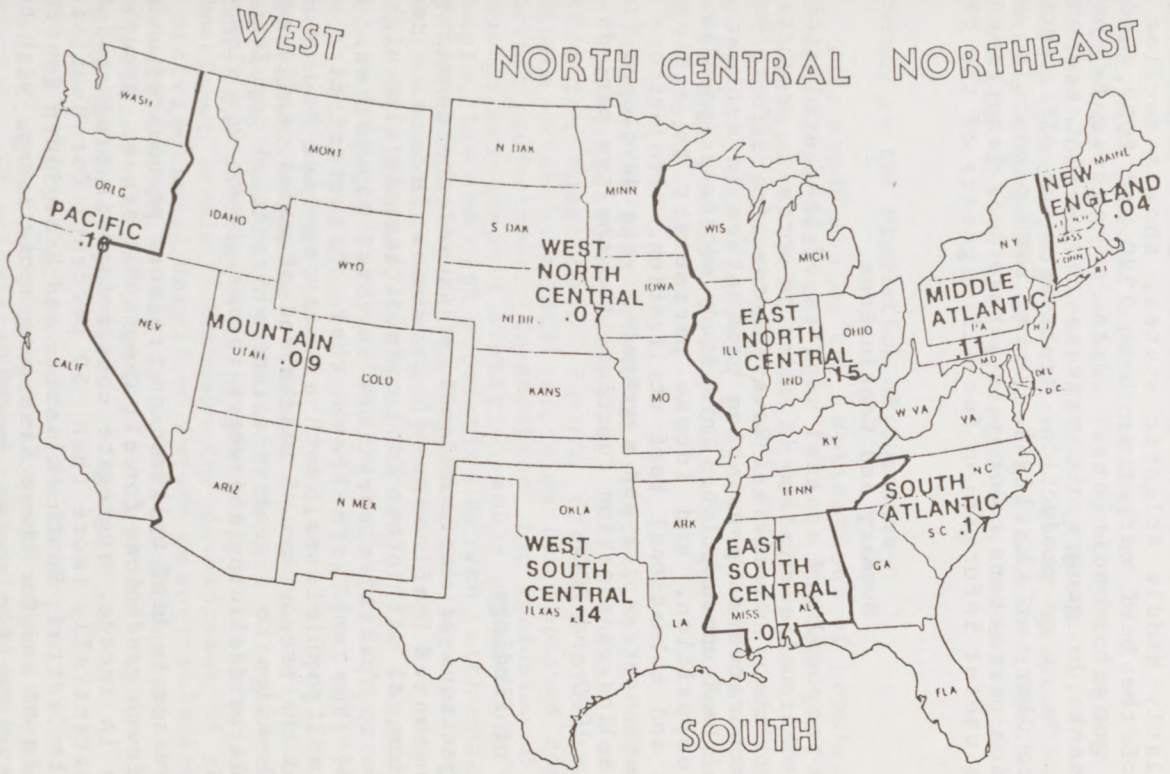


Figure 3. Spatial Properties of Beef Consumption:
Projected Shares for Major Geographic Market Areas, 2000

the Northeast, should consider market potential in Southwestern locations, particularly given increased transportation and slaughter costs.

East and West North Central states, New England, and particularly Middle Atlantic states, show a decline in shares of the beef market in both 1990 and 2000, under income growth conditions. Data on aggregate beef requirements by geographic markets complement economic scenarios based on production/ transportation efficiencies (refer to Clary et al., 1984). Using both production and population parameters to project future beef requirements provides useful information for all segments of the beef industry.

## Summary and Conclusions

The temporal and spatial aspects of beef utilization require continual evaluation in order to optimize production and distribution capacities. However, research efforts have not concentrated on population parameters in estimation models of beef consumption. This study addresses population size, composition, and income parameters to estimate national and subnational beef utilization. Projections of beef intake, per capita and aggregate, were developed from these baseline consumption functions for the two periods of interest, 1990 and 2000.

### Overview of Findings

Projections of beef utilization showed the consistent and pronounced influence of personal income. Beef consumption, as with other food commodities, is also highly sensitive to spatial alterations in total population. As expected, the analysis shows that characteristics of subregional populations, such as mean age and household size, and the proportion of blacks and of males, influenced beef utilization to a greater extent where total population was stable or declining and where income growth was slow or unchanged.

Increases in beef utilization are more pronounced under income growth conditions for all geographic areas. Assuming increases in income, aggregate consumption is projected to rise substantially (more than 50 percent) for Mountain, West South Central, South Atlantic, and East South Central states in 1990 and for these same geographic areas, with the inclusion of Pacific states, in 2000.

Even without income growth, population redistribution and growth processes furnish the basis for expecting

proportionate increases in aggregate consumption of beef in West South Central, South Atlantic, Mountain, and Pacific states. Other geographic markets are expected to show a decline in the proportion of beef consumed, especially Middle Atlantic and East North Central locations.

As with income stationarity, conditions of income growth reveal that the same four geographic market areas--West South Central, South Atlantic, Mountain, and Pacific states--gained in proportion to other geographic areas. With the assumption of income growth, East South Central states also show slight proportionate increases in 1990 and 2000.

**Accuracy in the Prediction of Outcomes**

This study assess the implications of population and income change over the next five to fifteen years on the consumption of beef. An important criterion in the selection of independent variables was the availability of demographic and economic projections which were fairly stable and perhaps less volatile than other potential indicators.

Because of this selection criteria, the goodness-of-fit for independent variables was fairly weak across all estimation equations. Future research efforts should evaluate other potential variables for improved commodity-specific projections. In addition, the inclusion of a broad range of demographic scenarios would prove fruitful. For example, low and high population growth (with concomitant population characteristics for these two secarios) should be added to the mid-series projections used for subnational purposes. However, the U.S. Bureau of the Census has not prepared these series (based current indicators) for divisions of the country. Similarly, the availability of demographic projections for the distributional aspects of independent variables, such as income distributed across age, sex, household size, and racial categories, would enhance the usefulness of projections of beef consumation of subnational levels. Although the development of this sort of distributional detail on future demographic and income characteristics is costly and time-consuming, commodity projections should ideally contain as high a level of disaggregation as possible.

The TAMU projections are conditioned on the maintenance of existing patterns, primarily with regard to migration, fertility, and mortality. Other projections, prepared by FAO and ICFAS under variant assumptions regarding demographic, political, and economic "futures," yielded similar future beef utilization patterns. Although these were national-

level projections and did not account for the spatial context of consumption, the consistency among scenarios lends credence to the projecton series and to the plausibility of undertaking further projections of agricultural commodity requirements.

In the next five to fifteen years, major changes in beef consumption patterns can be expected. The interest in processed and prepared meats is likely to incrase as well as the proportion of beef eaten away from home (Farris, 1984; Havlicek et al., 1982; Guenther and Chandler, 1980). Increased attention by consumer and medically-oriented groups on the healthful aspects of foods also should have a strong influence on per capita consumption (Joint Council on Food and Agricutlural Sciences, 1984). The outcome of these influences on attitudes regarding beef is difficult to measure.[4] Governmental policies also have a direct bearing on annual consumption, as well as price and income patterns, and technological improvements. To "bracket" in some future consumption pattern, an array of factors must be considered. It is possible that each predictive dimension, considered separately, may provide an outcome which conflicts with outcomes based on other explanatory factors.

## Summary

This research provides a set of procedures for incorporating population and income parameters to develop a series of projections of beef consumption. The projections show strong increases in aggregate utilization at national and subnational levels based primarily on population scale and income growth effects on changing consumption behavior and aggregate utilization. The locational configuration of projected increases in aggregate consumption indicates that Texas and other West South Central and Mountain states represent more advantageous areas for beef production and associated processing and distribution facilities in the next five to fifteen years than exists under current conditions.

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[4]One time-series assessment (Sapp and Guseman, 1984) showed a direct negative relation between utilization of beef and the number of beef/health-related articles in the printed media, controlling for price and personal income.

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