THE DEMAND FOR ALCOHOLIC BEVERAGES
An Experiment in Econometric Method

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PREFACE

The study reported in this paper is the empirical core of a dissertation prepared as partial fulfillment of the requirements for the degree of Doctor of Philosophy in Economics at the University of Chicago. The larger study includes two sections not reproduced here. One describes the structure of taxes and controls on the alcoholic beverage market, the major developments in this market during the post-Repeal period, and the important features of the longer historical experience. The other describes a large number of secondary experiments with the demand functions, using different variables and equation forms, and a set of preliminary experiments with the social cost function. The entire dissertation, including a tabular presentation of the study data, will be available from the University of Chicago.

This study was initiated in Chicago in 1957 at the suggestion and under the guidance of Professor Arnold Harberger. The study is also indebted to the counsel provided at various stages of the research by Professors Martin Bailey, Carl Christ, and Zvi Griliches. The initial work on this study was sponsored by the Ford Foundation.

The author was employed by The RAND Corporation in the fall of 1957, and did not resume work on this study until late 1961. A number of people contributed to the computational tasks at this stage, but a special debt is owed to Leola Cutler for writing the program for the generalized least squares estimates. Most of the work on this study was sponsored by RAND.

This study is witness to the generous cooperation of many people from the alcoholic beverage industry, trade associations, state liquor control boards, and various government agencies. Their contributions of data and clarification of various issues have been invaluable.
SUMMARY

Consumers of alcoholic beverages pay higher taxes and are confronted by more extensive public controls than apply to any other major product. A thorough evaluation of the structure of taxes and controls, however, has not been made, since the aggregate characteristics of this market have been poorly understood. This study is designed to provide the basic quantitative framework for an evaluation of these programs.

Chapter 1 presents an econometric model of the alcoholic beverage market. The model consists of seven structural equations which represent demand and supply functions, respectively, for legally produced spirits, beer, and wine, plus a supply function for illegally produced spirits. Estimates of the demand and supply functions in each market were made from a sample of 22 annual observations from the years 1934-1941 and 1947-1960.

Consumer behavior during the post-Repeal period has been characterized by the following relations:

(a) Consumption of each beverage is significantly related to its own price. The own price elasticity of spirits is around -2.0; beer, around -0.6; and wine, around -0.7.

(b) Consumption of each beverage is primarily determined by conditions within each separate market. Spirits and beer appear to be weak substitutes, but the relations between the spirits and wine markets and the beer and wine markets are highly variable.

(c) Consumption of illegal spirits has averaged around 10 to 15 per cent of the consumption of legal spirits.

(d) Consumption of each beverage is significantly related to the level
of personal disposable income. The income elasticity of spirits is around 0.4; beer, around -0.3; and wine, around 1.0.

(e) Consumption of spirits and beer is significantly related to the level of the money supply. The money elasticity of spirits is around 0.4; and of beer, around 0.3.

Supply behavior during this period has been characterized by the following relations:

(a) Production of spirits and beer appears to be subject to significant economies of scale. The elasticity of per capita supply to the price, excluding the tax, for spirits is around -2.4; and for beer, around -1.6. This result is consistent with the rapid increase in the average output per establishment throughout this period, and the large volume of advertising expenditures. Under conditions of such scale economies, the prices of these beverages have changed by more than the amount of the changes in the tax rates.

(b) For a given level of production, the spirits price has changed by around 80 per cent of the change in the tax rate. Beer and wine prices have changed by the approximate amount of the change in the tax rates, but these relations have been highly variable.

(c) The prices of spirits and wine are negatively related to the level of producers' stocks at the beginning of the year. A 10-per-cent increase in the stock of spirits has reduced the spirits price by around 1 per cent, and a corresponding increase in the stock of wine has reduced the wine price by around 5 per cent.

(d) The price of each beverage has been negatively related to a simple time trend, reflecting, in part, a greater increase in productivity in these industries than in the general economy.
(e) The supply of illegal spirits cannot be described by a simple relation, partly because the available data reflect the activity of both the illegal producers and the enforcing agents. Some evidence is presented which indicates that the volume of illegal spirits is positively related to the level of the spirits tax and negatively related to the time trend.

A three-stage procedure, recently developed by H. Theil and A. Zellner, is used to estimate the parameters of the basic model. This paper describes this technique and compares the resulting estimates with those obtained by direct least squares. Price and tax variables used in this study are indices compiled as part of this study; they have not been available heretofore.

Chapter 2 presents an analysis of the alcoholic beverage taxes. The actual tax rates during the post-Repeal period are compared to the rates which would have been most consistent with three public objectives: maximum public revenue, control of consumption, and the elimination of the illegal production of spirits. The actual and "objective" tax programs have been characterized by the following relations:

(a) The actual spirits tax has been highly correlated with the tax which would yield the maximum public revenue, but has averaged around $2.00 more per gallon (in 1947 dollars) than the maximum revenue rate. For ten years, from 1934 to 1943, the spirits tax would have had to average around $1.92 less than the actual tax and $0.68 less than the maximum revenue tax to eliminate the illegal production.

(b) The actual beer tax has been uncorrelated with the maximum revenue rates and has averaged around $0.06 less per gallon.

(c) The actual wine tax has been negatively related to the maximum revenue rates and has averaged around $1.20 less per gallon.
(d) Actual revenues during the post-Repeal period averaged around 10 per cent less than the estimated revenues from a maximum revenue policy.

A suggested tax program, based on the social cost argument, concludes this study. The suggested tax rates are based on an estimate of the relation of the average consumption of each beverage to the total social cost of intemperate consumption behavior.

This argument suggests the following tax policies for alcoholic beverages:

(a) Reduce the federal excise on spirits in one step to $6.00 per proof gallon. Depending on subsequent experience, a second reduction to $1.50 per proof gallon is indicated.

(b) Do not change the federal excise on beer.

(c) Increase the federal excise on table wine to $0.65 per gallon and on dessert wine to $1.00 per gallon.

(d) Change the tax rates only when the unit costs of the items in the social cost estimate change, or when a new relation between the social costs and consumption is established.

(3) Revenues from the federal and state alcoholic beverage taxes should be used only for public programs to alleviate the social consequences of alcoholism. Since the state governments are primarily responsible for these programs, most of the federal revenues should be returned to the states in proportion to the consumption in each state.

This study, by identifying and quantifying those characteristics of consistent behavior in the market for alcoholic beverages, should provide some order to what Ben Jonson termed "the wild anarchy of drink."
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THE DEMAND FOR ALCOHOLIC BEVERAGES
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Introduction

A SUMMARY OF THE CHARACTERISTICS OF THE CURRENT MARKET

American consumers spent $11.5 billion for alcoholic beverages in 1960 -- around $220 per household, amounting to 3.3 per cent of personal disposable income.** Consumption of legal spirits was around 2.2 gallons per adult; of illegal spirits, probably around 0.2 gallons; of beer, 25.1 gallons; and of wine, 1.5 gallons. Average expenditures and consumption per adult are somewhat below the peak post-Repeal level, and current consumption of spirits and beer is considerably below the pre-Prohibition levels. Consumption varies substantially, however, within the adult population. Around 62 per cent of adults drink some alcoholic beverage, but the consumption of spirits and wine is concentrated in a rather smaller group.

Public revenues from alcoholic beverages in 1960 totaled $4.4 billion. The combined federal and state excise taxes constitute just over 50 per cent of the average retail price of spirits, around 20 per cent of the price of beer, and around 25 per cent of the price of wine. Public control of the alcoholic beverage market is exercised through four major instruments other than the excise taxes: restrictions on the number and location of retail

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**Sources of the data presented in this section are referenced in Chapter 1.
outlets, state monopoly of the distribution of spirits and wine, resale price maintenance, and local prohibition. In addition, the market is subject to an incredible maze of restrictions on retailing practices and advertising content that is too complex to summarize.
Chapter 1

A MODEL OF THE ALCOHOLIC BEVERAGE MARKET

THE MODEL

Structural Equations

A model, consisting of seven linear equations, is formulated to describe the behavior of the various groups purchasing or supplying the three alcoholic beverages. These equations include two types of variables: "endogenous" variables, determined within the market during the current year, and "exogenous" variables, which may influence the market but are determined outside it. Apparent consumption and price within each component market, for example, are endogenous variables, and personal incomes and tax rates are exogenous variables. The model as a whole determines the level of the endogenous variables in terms of the relationships among one or more of the endogenous variables and some of the exogenous variables. A general matrix representation of the structural equation system is given by

\[ (1.0) \quad B Y_t^i + \Gamma Z_t^i = U_t^i \]

where \( B \) is a matrix of coefficients of the endogenous variables \( X_t^i \), \( \Gamma \) is a matrix of coefficients of the exogenous variables \( Z_t^i \), and \( U_t^i \) is a vector of disturbances. Each of the seven structural equations is expressed in explicit form below, followed by a brief description of the variables:
(1.1) \[ Q_s^D = f_1 \left[ P_s, (P_b), (P_w), S, Y, M \right] + u_1 \]

(1.2) \[ Q_b^D = f_2 \left[ (P_s), P_b, (P_w), Y, M \right] + u_2 \]

(1.3) \[ Q_w^D = f_3 \left[ (P_s), (P_b), P_w, Y, M \right] + u_3 \]

(1.4) \[ Q_s^S = f_4 \left[ P_s, X_s, I_s, T \right] + u_4 \]

(1.5) \[ Q_b^S = f_5 \left[ P_b, X_b, T \right] + u_5 \]

(1.6) \[ Q_w^S = f_6 \left[ P_w, X_w, I_w, T \right] + u_6 \]

(1.7) \[ S^S = f_7 \left[ P_s, T \right] + u_7 \]

**Endogenous Variables**

- \( Q_s \) = apparent consumption of legal spirits per adult (gallons per year)
- \( Q_b \) = apparent consumption of beer per adult (gallons per year)
- \( Q_w \) = apparent consumption of wine per adult (gallons per year)
- \( P_s \) = producers' price of legal spirits (1947 dollars per gallon)
- \( P_b \) = retail price of beer (1947 dollars per gallon)
- \( P_w \) = producers' price of wine (1947 dollars per gallon)
- \( S \) = capacity of stills seized per adult (gallons per year)

**Exogenous Variables**

- \( Y \) = disposable personal income per capita (1947 dollars per year)
- \( M \) = demand deposits and currency per capita (1947 dollars)
- \( X_s \) = combined federal and state excise on spirits (1947 dollars per gallon)
- \( X_b \) = combined federal and state excise on beer (1947 dollars per gallon)
- \( X_w \) = combined federal and state excise on wine (1947 dollars per gallon)
- \( I_s \) = producers' inventories of spirits at beginning of year (millions of gallons)
- \( I_w \) = producers' inventories of wine at beginning of year (millions of gallons)
- \( T \) = time trend (last two digits of observation year)
Each of these equations is linear in the original variables. A more detailed description of the variables is given later in this chapter.

Equations (1.1)-(1.3) represent demand functions for legal spirits, beer, and wine, respectively. Each demand function includes the price of all three beverages plus personal income and the stock of money. The demand function for legal spirits includes, in addition, a proxy variable for the quantity of illegal spirits supplied; this function can be transformed into a demand function for all spirits (considering the legal and illegal products to be homogeneous) by subtracting the product of $S$ and its coefficient from both sides of the equation.

Equations (1.4)-(1.7) represent supply functions for legal spirits, beer, wine, and illegal spirits, respectively. The supply function of each of the legal beverages describes the relation of consumption per adult, price, the tax rate, and a time trend.* The time trend is both a scale variable (to correct for the deflation of consumption) and a proxy for the relative productivity of the industry. The spirits and wine functions also include the producers' inventories of the respective products at the beginning of the observation year; these stock variables limit the supply relations to relatively short-run adjustments. The illegal spirits function includes only the price of legal spirits and a time trend; this simple function may be inadequate, since the available data reflect the activity

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*A total consumption variable would be more appropriate in these supply functions. Population (used as a deflator of total consumption) has no particular relevance in the supply functions except as a measure of the available labor force. The same quantity variable, however, must be used in both demand and supply functions; one possible formulation would be to use a total consumption variable in both functions and include an independent population variable in the demand function. A formulation using per capita variables in both functions divides the effects of scale in the supply function between the consumption variable and the time trend.
of both the illegal producers and the enforcing agents. The supply of illegal spirits should be invariant to the spirits tax, given the price of legal spirits, unless the factor costs in the legal and illegal industry are highly correlated.

Equations (1.1)-(1.7) describe an integrated market which jointly determines the consumption and price of each beverage. If there are no significant relationships among the demands for the three beverages, the above equation system can be divided into three systems describing the three component markets.* In this case, Eqs. (1.1), (1.4), and (1.7) describe the spirits market, Eqs. (1.2) and (1.5) describe the beer market, and Eqs. (1.3) and (1.6) describe the wine market. Estimates of the coefficients of the seven equations are presented later in this chapter for both of these cases.

Reduced Form Equations

Each of the structural equations describes the behavior of one group of consumers or suppliers in the alcoholic beverage market but does not, by itself, determine the level of any one of the included endogenous variables. A second group of equations, called "reduced form" equations, describes the joint behavior of consumers and suppliers in determining the level of each of the endogenous variables. Each reduced form equation determines one endogenous variable in terms of all of the exogenous variables in the system. A general matrix representation of the reduced form equation system is given

*The supply functions include no variables jointly determined among the producers. Some common cereal grains are used for the production of grain spirits and beer, but both consume a very small proportion of the grain harvest. Production of brandy and wine, similarly, use a common raw material, but only a small proportion of the grape harvest is used for brandy.
by

\[ Y_t' = -B^{-1} \Gamma Z_t' + B^{-1} U_t' \]

(2.0) or

\[ Y_t' = \Pi Z_t' + V_t' \]

where \( \Pi \) equals \(-B^{-1} \Gamma\) and \( V_t' \) equals \( B^{-1} U_t'\). The reduced form equation for \( Q_s \), for example, considering the three beverages as part of one market, is given by

\[ Q_s = g_1(Y, A, X_s, X_B, X_w, I_s, I_w, T) + v_1. \]

The corresponding equation for \( Q_s \), where the spirits market is considered separately, is given by

\[ Q_s = g_1(Y, A, X_s, I_s, T) + v_1. \]

The reduced form coefficients are of less direct interest than the structural coefficients, but they serve a number of important purposes. Estimation of the endogenous variables from the reduced form equations is an integral part of the procedure used to obtain the estimates of the structural coefficients. The reduced form estimates are also used as the basis for the analysis of the alcoholic beverage taxes in Chapter 2.

**THE VARIABLES**

**Sample Period**

Estimates of the structural and reduced form coefficients have been obtained from a sample of 22 annual observations from the periods 1934-1941.
and 1947-1960. Observations from the years prior to national Prohibition are not included in the sample, since comparable price data for these years are not available. The years 1942-1946 are not included because of the many controls on consumption, prices, and production during this period. A considerable -- but unsuccessful -- effort was made to identify, and, where possible, quantify the effects of these controls.

Consumption

Apparent consumption per adult of legal spirits, beer, and wine (variables $Q_s$, $Q_b$, and $Q_w$) are derived by dividing total apparent consumption of each beverage during each calendar year by the estimated total resident population 21 years of age and older on July 1 of that year.* The cubic capacity of illegal stills seized per adult (variable $S$) is derived by dividing the total capacity of stills seized during the fiscal year ending

*Consumption data for the period 1934-1960 are drawn from the following sources, including earlier volumes of these annual publications: Distilled Spirits Institute, Annual Statistical Review of the Distilled Spirits Industry 1960, Washington, 1961, p. 40. United States Brewers Association, Inc., The Brewing Industry in the United States: The Brewers Almanac 1961, New York, 1961, p. 52. Wine Advisory Board, Wine Industry Bulletin: Twentififth Annual Wine Industry Statistical Summary, Part II, San Francisco, 1961, p. 5. The apparent consumption data, in general, represent the volume of shipments to wholesalers; actual retail sales are reported only for the spirits and wine sold by the state monopoly distributors. Retail purchases will differ from the apparent consumption totals by the net change in distributor inventories; accurate data on the level or change in these inventories are not available. Actual consumption, in turn, will differ from retail purchases by the net change in household inventories. A substantial part of the year-to-year changes in the apparent consumption of spirits and wine may be due to changes in the distributor and household inventories.

on June 30 by the adult population at that time; $S$ is thus a proxy for the illegal spirits produced during the year beginning six months before the calendar year.* Figure 1 illustrates the level of these four variables from 1934 through 1960. $S$ is multiplied by 10 for presentation in Fig. 1; the coefficient on $S$ in Eq. (1.1) turns out to be around 10, however, so that the graphed value of $S$ represents the approximate magnitude of the illegal spirits consumed per adult.

Prices
Real prices of legal spirits, beer, and wine (variables $P_s$, $P_b$, and $P_w$) are derived by dividing indices of the current level of these prices by the implicit price deflator for personal consumption expenditures in the GNP accounts; these prices, and all other monetary variables in this model, are expressed in 1947 dollars.** Price indices for the three alcoholic beverages have been prepared as part of this study, since no relevant indices are available from government or industry sources.***

Basic data for the spirits and wine indices are the liquor purchase records of the Washington State Liquor Control Board.**** The recorded

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*A historical record of stills seized by federal agents is reported in Alcohol and Tobacco Tax Division, U.S. Internal Revenue Service, Treasury Department, Comparative Report of Seizures and Arrests by the Alcohol and Tobacco Tax Division, By Regions, Fiscal Years 1935 Through 1956, IRS-24038, Government Printing Office, Washington, D.C., 1956. Data for the years 1957-1960 were obtained directly from the Alcohol and Tobacco Tax Division.


***Wholesale price indices for spirits, beer, and wine are prepared by the Bureau of Labor Statistics. These indices represent changes in the cost of domestic production; they do not include the cost of imported beverages or the federal and state tax rates, and they are not available before 1947.

Fig. 1 — Consumption of Alcoholic Beverages per Adult
prices include the federal taxes and duties and are quoted f.o.b. the
distillery, winery, or port of entry. Spirits price data were collected
for three to six brands of six types of spirits. Wine price data were
collected for three to six brands of five types of wine. Brands were
chosen on the basis of their rank in current national sales, the proportion
of national sales by price group, and the brand continuity. When more than
one price quotation is recorded, the last quotation of the fiscal year (end-
ing on September 30) is used, except where this quotation represents a
special sale or a seasonal product such as holiday decanters. Prices were
chosen for the predominant bottle size for each product and year; before
World War II most prices were quoted for cases of 12 quarts and, since 1942,
for cases of 12 fifths. Prices, by brand, within each type were averaged
to obtain a single price for each type. The weighted average excise tax in
the license states was then added to the average price of each type.

Basic data for the beer index are the estimates prepared by the Office
of Business Economics of the total expenditures for beer.* Average prices
for draught and package beer are obtained by an indirect procedure based on
a constant relation of these prices exclusive of the federal and state
excise taxes. First, the total expenditure for beer is expressed as the
sum of expenditures for the two types, as given by

\[ E = Q_d (P_d + X_d) + Q_p (P_p + X_p), \]

*Annual estimates of the total expenditure for alcoholic beverages are
prepared by the Office of Business Economics and are available directly from
this office. This total includes part of the expense of entertainment and
other service charges of eating and drinking establishments where a separate
charge is not made for such items. Annual estimates of the component
expenditures for spirits, beer, and wine are also prepared but have not been
available to the public since 1953.
where \( E \) is the estimate of total expenditures for beer, \( Q_d \) and \( Q_p \) are the total consumption of draught and package beer, \( P_d \) and \( P_p \) are the respective prices exclusive of the tax, and \( X_d \) and \( X_p \) are the respective tax rates.

Data from the Census of Manufactures in 1947, 1954, and 1958 suggest that the average wholesale value of packaged beer, exclusive of all excise taxes, was around 1.8 times the average value of draught beer in each year. *

Solving Eq. (3.1) with \( P_p \) equal to 1.8 \( P_d \) yields the two prices exclusive of the taxes, as given by

\[
(3.1) \quad P_d = \left( Q_d + 1.8Q_p \right)^{-1} \left( E - Q_d X_d - Q_p X_p \right); \text{ and}
\]

\[
(3.2) \quad P_p = 1.8 \left[ \left( Q_d + 1.8Q_p \right)^{-1} \left( E - Q_d X_d - Q_p X_p \right) \right].
\]

Average retail prices for both types are obtained by adding the respective federal and state taxes to the above prices. For the year 1960, for example, this procedure yields a retail price of $1.20 for a sixpack of 12-ounce cans and $0.76 for the same amount of draught beer.

Aggregate price indices for spirits, beer, and wine are derived by using a moving consumption base. The ratio of prices between any two adjacent years is given by

\[
(4.1) \quad R(P)_t = \frac{\sum_i P_{i,t} q_{i,t-1}}{\sum_i P_{i,t-1} q_{i,t-1}},
\]

where \( R(P)_t \) is the price ratio, \( P_{i,t} \) is the average price including tax of product type \( i \) in year \( t \), \( P_{i,t-1} \) is the price of type \( i \) in year \( t-1 \), and \( q_{i,t-1} \) is the apparent consumption of type \( i \) in year \( t-1 \).

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The value of the price index in any one year is given by

\[
P_t = P_{1934} \frac{1}{t=1934} R(p)_t
\]

where \(P_t\) is the current price in year \(t\), \(P_{1934}\) is the average price in 1934, and \(R(p)_t\) is the ratio of the prices in year \(t\) and in year \(t-1\). Price indices prepared in this way are significantly more accurate than the usual fixed base indices for a market in which there are large price differences by type and a continuously changing consumption mix.

Estimates of the consumption of spirits, by type, were prepared from data on bottled output and imports since 1939, and from tax-paid withdrawals and imports before that year. Estimates of the mix of beer and wine consumption were prepared from the record of tax-paid withdrawals and imports.

Spirits and wine indices used in this study, in summary, indicate the level of producers' prices including all excise taxes, and the beer index indicates the level of retail prices including all taxes. The values of these three indices in 1947 dollars are illustrated on Fig. 2 for the entire post-Repeal period.

Income and Money

Consumer purchasing power is represented by two variables in each demand function: average disposable personal income during the calendar year, and the stock of demand deposits and currency at the end of June.* Both variables

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Fig. 2 — Real Prices of Spirits, Wine, and Beer (1947 dollars)
are divided by the total resident population on July 1 and by the implicit price deflator (1947=100) for personal consumption expenditures. The combination of current income and money assets may represent a more effective budget constraint than use of either variable independently. The money variable may also be a proxy for aggregate personal wealth or expected income.* Use of the money variable is also suggested by the unusually high consumption of spirits and beer during the years 1942-1946 (not included in the sample). A variable representing personal money holdings only may be preferable to the variable used, but a consistent series of personal money assets is not available before 1939. The levels of per capita disposable personal income and money assets in 1947 dollars (variables Y and M) are illustrated in Fig. 3.

Excise Tax Rates

Indices of the combined federal and state excise tax rates on each of the three alcoholic beverages have been prepared as part of this study. The real tax rates on these beverages (variables $X_{sp}$, $X_{bp}$, and $X_w$) are derived by dividing the indices of the current tax rates by the implicit price deflator used above. A simple sum of the basic federal rates and the average state rates is not an accurate indication of the effective tax rates in any year, because of the different tax rates by type for each product and the different tax rates among the states. A shift of consumption from types of spirits taxed at a high rate to types taxed at a lower rate, or a shift from high-tax states to low-tax states, for example, will lower the

* A theory of consumer demand incorporating the role of money is developed in Gregory C. Chow, Demand for Automobiles in the United States, North Holland Publishing Co., Amsterdam, 1957, pp. 14-27. Chow suggests that most non-durable commodities are "asset-inferior," i.e., for a given income, an increase in money reduces the consumption of these goods.
effective spirits tax with no changes in the legal rates. For this reason, tax indices, similar to the price indices, have been prepared to correct for changes in the composition of consumption, by type and by state.

Basic data for the spirits tax index are the federal tax rates per wine gallon for five types and the tax rates on all spirits in the license states.

![Graph showing per capita income and money assets from 1947 to 1960.](image)

Fig. 3 -- Per Capita Income and Money Assets (1947 dollars)

The beer index was prepared from the federal tax rate on all beer and the tax rates on draught and package beer in all states. The wine index was prepared from the federal tax rates on four types and the tax rates on table and dessert wine in the license states.* Average tax rates by type

and by state during a year in which the rates are changed are derived by
weighting the rates by the proportion of the year the rates are effective.
State tax data for a given year exclude those states changing to "wet"
status during that year.

Tax indices for each beverage were prepared in the same manner as the
price indices, as described by Eqs. (4.1) and (4.2) above. Indices of the
state tax for each type were first prepared; the weighted average state
taxes for spirits and wine in the license states are used to represent the
effective tax rates in all states. The state tax indices were then added
to the federal rates by type and the aggregate tax indices were prepared.
The values of the three aggregate tax indices in 1947 dollars are illustrated
in Fig. 4.

Producers' Stocks and the Time Trend

The supply functions for spirits and wine include a variable representing
the inventory position of producers at the beginning of the year, and
each of the four supply functions includes a time trend.* The total stock
of distilled spirits in bonded storage (Variable $I_s$), is measured in original
entry tax gallons except for whiskey bottled in bond. This series has not
been corrected for the changes in the type or age composition of the stocks,
losses in storage due to evaporation and leaking (around 22 per cent in four
years), or for the difference between tax and wine gallons; this series
particularly overstates the growth of spirits stocks available for consump-
tion during the first years following Repeal and the first post-war years.

*The spirits stocks are reported in the Statistical Review of the
Distilled Spirits Industry 1950. The wine stocks are reported in the
Twenty-Fifth Annual Wine Industry Statistical Summary, Part II.
Fig. 4 — Combined Federal and State Tax on Alcoholic Beverages
(1947 dollars)
The stock of spirits at the beginning of calendar 1934 are estimated from production and withdrawal records during that year. The total wine inventory in bonded storage (variable \( I_w \)) is also uncorrected for changes in the type or age composition of the stocks. Wine inventories at the beginning of 1935 and 1936 represent the California inventories only; those at the beginning of 1934 are estimated from production and withdrawal records. The time trend (variable \( T \)), is represented by the last two digits of the observation year. These three "supply shifts" are illustrated in Fig. 5.

**COMPUTATION OF THE ESTIMATES**

Estimates of the structural coefficients of the primary model are computed by a three stage least squares procedure. This procedure, and the reasons for its use, are described below. Consider the equation given by

\[
y = \beta \beta + Z \chi + u,
\]

where

\[
y = \begin{bmatrix}
y(1) \\
\vdots \\
y(T)
\end{bmatrix} ; \quad \begin{bmatrix}
y(1) \\
\vdots \\
y(T)
\end{bmatrix} = \begin{bmatrix}
y_1(1) & \cdots & y_\mu(1)
y_1(T) & \cdots & y_\mu(T)
\end{bmatrix} ; \quad \beta = \begin{bmatrix}
\beta_1 \\
\vdots \\
\beta_\mu
\end{bmatrix};
\]

\[
Z = \begin{bmatrix}
Z_1(1) & \cdots & Z_\ell(1) \\
\vdots & \ddots & \vdots \\
Z_1(T) & \cdots & Z_\ell(T)
\end{bmatrix} ; \quad \chi = \begin{bmatrix}
\chi_1 \\
\vdots \\
\chi_\ell
\end{bmatrix} ; \quad u = \begin{bmatrix}
\epsilon(1) \\
\vdots \\
\epsilon(T)
\end{bmatrix}.
\]

This equation is part of a system of simultaneous linear equations, such as (1.0) above, in which there are \( M \geq \mu + 1 \) endogenous variables and \( \Lambda \geq \mu + \ell \).
exogenous variables. Direct least squares estimation of the coefficients $\beta_1 \ldots \beta_\mu$ and $Y_1 \ldots Y_\mu$ is appropriate under the following set of conditions:

Fig. 5 -- Producers' Stocks and the Time Trend

(a) The $\mu T$ values of $Y$ and the $\lambda T$ values of $Z$ are nonstochastic, i.e., uncorrelated with the disturbances;

(b) The disturbances $u(1) \ldots u(T)$ are uncorrelated with the disturbances in the same year in other equations; and
(c) The disturbances \( u(1) \ldots u(T) \) have zero mean value, constant variance, and are uncorrelated from year to year.

The traditional "simultaneous equations problem" arises when some of the values of \( Y \) are stochastic numbers, i.e., some of the elements of the \([Y Z]'\) matrix are non-zero. In this case the direct least squares estimates are biased for all sample sizes.* A number of procedures have been developed to estimate the coefficients of an equation in a system of equations. The various procedures yield slightly different estimates (except for equations where \( \Lambda = \mu + \lambda \)), but all the procedures yield asymptotically unbiased estimates with a larger variance than the direct least squares estimates. One procedure, however, a "two stage technique" developed by H. Theil, requires much less computation and, thus, allows more experimentation with the structure of the model.** Estimates from the Theil procedure are dependent on which of the endogenous variables in an equation is chosen as the dependent variable, but the difference among these estimates diminishes as the sample size increases. In most cases the variable which will yield the best estimates is obvious from the structure of the model.

Each structural equation, such as Eq. (5.0), is first solved for the \( \mu + 1 \) reduced form equations as given by

\[
[y \; Y]' = \Pi Z' + V',
\]

---


**For a thorough description of this procedure, see H. Theil, Economic Forecasts and Policy, North Holland Publishing Co., Amsterdam, 1958, pp. 223-229, 334-361.
where $Z'$ includes all the exogenous variables in the system. For the whole model, there are $M \geq \mu + 1$ reduced form equations. Estimates of the reduced form coefficients are obtained by direct least squares; the least squares estimator of $\Pi$, $P = [Z' Z]^{-1} [Z' (y Y)]$ is unbiased if condition a above is applicable. Substituting for $\Pi$ in (5.1) gives

$$(5.2) \quad [y Y]' = \left( [Z' Z]^{-1} [Z' (y Y)] \right) Z' + \hat{V}'. \quad$$

Subtracting the estimated reduced form disturbances $V$ from $Y$ and rewriting (5.0) gives

$$(5.3) \quad y = (Y - \hat{V}) \beta + Z \gamma + (u + \hat{V} \beta). \quad$$

The variables $(y - \hat{y})$ are the estimated values of the $y$ variables from the reduced form equations. Estimates of the coefficients $\beta_1 \ldots \beta_\mu$ and $\gamma, \ldots \gamma_\lambda$ are then obtained by least squares on Eq. (5.3), using the "reduced" variables instead of the original endogenous variables. Estimates from this second stage are still biased for small samples, as $V \neq \hat{V}$, but they are asymptotically unbiased if the reduced form estimates are consistent.

Another type of problem arises when the disturbances of one equation in a system are correlated with the disturbances of other equations and the independent variables are not common to all equations. In this case, the estimates obtained by least squares, applied one equation at a time, are less efficient than the estimates obtained by minimizing a transformation of the disturbances of the entire system. A procedure to obtain more efficient estimates for the coefficients of an equation system has recently been developed by A. Zellner.* Regression coefficients in all equations are simultaneously estimated by applying Aitken's "generalized least squares" to

---

*For a thorough description of this procedure see Arnold Zellner, "An Efficient Method of Estimating Seemingly Unrelated Regressions and Tests for
the whole system. For this study the Aitken estimators are constructed from the moment matrices and disturbances of the second stage regressions. Substituting \( X \) for \( \left[ (Y - \hat{\nu})Z \right] \) and \( w \) for \( (u + \hat{\nu} \beta) \) in Eq. (5.3) gives

\[
y = X \delta + w.
\]

Equation (5.4) is part of the system of second stage equations which may be written as

\[
\begin{bmatrix}
    y_1 \\
    y_2 \\
    \vdots \\
    y_M
\end{bmatrix}
= \begin{bmatrix}
    X_1 & 0 & \cdots & 0 \\
    0 & X_2 & \cdots & 0 \\
    \vdots & \vdots & \ddots & \vdots \\
    0 & 0 & \cdots & X_M
\end{bmatrix}
\begin{bmatrix}
    \delta_1 \\
    \delta_2 \\
    \vdots \\
    \delta_M
\end{bmatrix}
+ \begin{bmatrix}
    w_1 \\
    w_2 \\
    \vdots \\
    w_M
\end{bmatrix}.
\]

(5.5)

The disturbance vector of (5.5) is assumed to have the following variance-covariance matrix:

\[
\begin{bmatrix}
    w_1 \\
    w_2 \\
    \vdots \\
    w_M
\end{bmatrix}
= \begin{bmatrix}
    \sigma_{11} & \sigma_{12} & \cdots & \sigma_{1M} \\
    \sigma_{21} & \sigma_{22} & \cdots & \sigma_{2M} \\
    \vdots & \vdots & \ddots & \vdots \\
    \sigma_{M1} & \sigma_{M2} & \cdots & \sigma_{MM}
\end{bmatrix}
I,
\]

(5.6)

where $I$ is a $T \times T$ unit matrix and where $\sigma_{ij} = E(w_{it} w_{jt})$ for $t = 1 \ldots T$ and $i, j = 1 \ldots M$. The form of $\sum$ implies constant variances and covariances from year to year and the absence of any auto or serial correlation of the disturbance terms. The Aitken estimator for the equation system 5.5 is

\begin{equation}
\hat{d} = (X' \sum^{-1} x)^{-1} X' \sum^{-1} y
\end{equation}

and the variance-covariance matrix of the estimator $\hat{d}$ is

\begin{equation}
V(\hat{d}) = (X' \sum^{-1} x)^{-1}.
\end{equation}

The true $\sum$ matrix, of course, is not known, but estimates of the elements $\sigma_{ij}$ can be derived from the estimated disturbances of the second stage equations. For $\sigma_{ij}$ we use the unbiased estimator given by

\begin{equation}
s_{ij} = \hat{w}_i \hat{w}_j \left[ T - \lambda_i - \lambda_j + (\text{smaller of } \lambda_i, \lambda_j) \rho^2 \right]^{-1}
\end{equation}

where $\hat{w}_i$ and $\hat{w}_j$ are the moments of the estimated disturbances, $\lambda_i$ and $\lambda_j$ are the total number of variables in equations $i$ and $j$, and $\rho$ is Hooper's trace correlation coefficient. Zellner has shown that the $d$ estimates based on the estimated $\sum$ are asymptotically efficient under fairly general conditions and the greatest gain in efficiency is realized when the disturbances among equations are highly correlated and the independent variables among equations are not correlated.

A third estimation problem arises when the disturbances of an equation

---

are correlated from year to year. In this case the procedures used at the second and third stage of the analysis yield biased estimates. No a priori transformations have been applied to the equations of the basic model to correct for this condition, but the equations have been subject to a test for autocorrelation at the first two stages. A one-tailed runs-test has been used to test the existence of positive autocorrelation of the disturbances, i.e., fewer runs than would be expected in the absence of positive autocorrelation. The test statistic is

\[
K = \frac{3R - 2T + 2.5}{\sqrt{\frac{16T - 29}{10}}},
\]

where \( K \) is the standard normal variable, \( R \) is the number of runs, and \( T \) is the number of observations.* This runs-test, under some conditions, is a less powerful test for autocorrelation than the Durbin-Watson test based on the actual values of the disturbances, but the runs statistic is considerably easier to compute, is independent of the true distribution of the disturbances, and is not subject to the discontinuous distribution of the parametric statistic.

A review of the properties of the estimates from this three-stage procedure is appropriate at this point. Estimates of the reduced form coefficients are unbiased and efficient, irrespective of any correlation of the disturbances among equations; these first stage estimates are consistent if the disturbances have constant variance and are not autocorrelated, and they are maximum likelihood estimates if, in addition, the disturbances are normally distributed. Estimates of the structural coefficients of the second stage equations are asymptotically unbiased if the reduced form

estimates are consistent, but they are not efficient if there any correlations of the disturbances among equations; again, these estimates are consistent if the disturbances have constant variance and are not autocorrelated. The third stage estimates, in addition, are asymptotically efficient if the second stage estimates are consistent.

A complex estimation procedure, such as that described in this section, does not always yield better estimates from small samples than do single equation least squares. Small sample properties of the simultaneous equation estimates are not known, but the reduced asymptotic bias of these estimates is generally obtained at the cost of larger variances of the coefficient estimates. The value of an estimate is best represented by the expected value of the squared difference of the estimate and the population parameter; this value is equal to the variance of the estimate plus the square of the expected bias. This criterion is used in the next section to compare the estimates of the second and third stage structural equations with those obtained by single equation least squares.

THE ESTIMATES

Reduced Form Estimates from the Basic Model

Reduced form equations, in many cases, are more valuable for predictive and analytical purposes than the structural equations from which they are derived, since they conveniently summarize the effects of all the exogenous variables in the system on each of the endogenous variables, and the estimates of the coefficients of these equations have superior statistical properties. Our economic theory, however, is formulated in terms of the structural equations, and the theory tells us little about the expected sign or magni-

*This criterion was suggested to the author by Professor Carl Christ.
tuide of the reduced form coefficients. For this study the reduced form equations are used for two purposes: estimation of the endogenous variables during the sample years in order to obtain the second stage estimates, and prediction of the endogenous variables during selected non-sample years. In addition, the reduced form coefficients are used in the next chapter for the analysis of the alcoholic beverage taxes.

Table 1 presents the estimates of the reduced form coefficients of the basic model. Each estimate represents the partial effect of a one-unit change in an exogenous variable on the level of an endogenous variable; the standard deviation is given below each estimate in parentheses. The ratio of the estimate to its standard deviation, the t statistic, is used to test the significance of each estimate; each significant estimate is marked by an asterisk. The coefficient of determination, the $R^2$ statistic uncorrected for the degrees of freedom, indicates the ratio of the "explained" variance over the total variance of each equation. A one-tailed runs-test is used to test for positive autocorrelation of the disturbances; the K statistic is the standard normal variable. A 5-per-cent probability of a Type I error is used as the critical level for all tests of significance.

An inspection of the reduced form estimates suggests a number of features of this market, some of which are later reflected in the structural estimates:

(a) Values of Q and P for each component market appear to be primarily determined within that market; relations among the three markets, with one exception, appear to be highly variable. Notice, for example that the consumption of each product is not significantly related to the tax rates on the other products.
Table 1

ESTIMATES OF THE REDUCED FORM COEFFICIENTS

<table>
<thead>
<tr>
<th>Endogenous Variables</th>
<th>Y</th>
<th>M</th>
<th>X_s</th>
<th>X_b</th>
<th>X_w</th>
<th>I_s</th>
<th>I_w</th>
<th>T</th>
<th>R²</th>
<th>K</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q_s</td>
<td>.00074</td>
<td>(.00068)</td>
<td>.00441*</td>
<td>(.0127)</td>
<td>-.43417*</td>
<td>(.16359)</td>
<td>.65971</td>
<td>(1.02190)</td>
<td>.09930</td>
<td>(.00003)</td>
</tr>
<tr>
<td>Q_b</td>
<td>.00443</td>
<td>(.00496)</td>
<td>.01770</td>
<td>(.00925)</td>
<td>.08724</td>
<td>(1.19355)</td>
<td>-.5907155*</td>
<td>(7.45594)</td>
<td>-.5.57236</td>
<td>(.00195)</td>
</tr>
<tr>
<td>Q_w</td>
<td>.00130</td>
<td>(.00089)</td>
<td>-.00330</td>
<td>(.00167)</td>
<td>.04620</td>
<td>(1.21502)</td>
<td>1.13183</td>
<td>(1.34321)</td>
<td>-.58906</td>
<td>(.00011)</td>
</tr>
<tr>
<td>P_s</td>
<td>.00090</td>
<td>(.00272)</td>
<td>-.00948</td>
<td>(.00508)</td>
<td>1.79483*</td>
<td>(.65504)</td>
<td>-.2.43682</td>
<td>(4.09198)</td>
<td>-.2.26741</td>
<td>(.00283*)</td>
</tr>
<tr>
<td>P_b</td>
<td>.00035</td>
<td>(.00047)</td>
<td>-.00157</td>
<td>(.00087)</td>
<td>.06584</td>
<td>(.1.1249)</td>
<td>3.82734*</td>
<td>(.70269)</td>
<td>-.38000</td>
<td>(.00028)</td>
</tr>
<tr>
<td>P_w</td>
<td>-.00105</td>
<td>(.00104)</td>
<td>-.00257</td>
<td>(.00195)</td>
<td>.03845</td>
<td>(1.25095)</td>
<td>6.13517*</td>
<td>(1.56768)</td>
<td>2.14787</td>
<td>(.00040)</td>
</tr>
<tr>
<td>S</td>
<td>.00019*</td>
<td>(.00006)</td>
<td>-.0031*</td>
<td>(.00011)</td>
<td>.03295*</td>
<td>(.01420)</td>
<td>-.1.0972</td>
<td>(.08871)</td>
<td>-.1.3359</td>
<td>(.00001)</td>
</tr>
</tbody>
</table>

NOTE: Critical values at 5 per cent:

\[
t = 2.160 \text{ for } n = 13, \text{ for a two-tailed test.}
\]

\[
K = -1.645 \text{ for a one-tailed test.}
\]
(b) A puzzling and possibly inconsistent relation between the beer and wine markets is suggested. Notice the highly significant \( Q_b : I_w \) and \( P_w : X_b \) estimates.

(c) Changes in the alcoholic beverage taxes appear to be compounded as a result of a percentage markup practice or the effects of economies of scale. Notice that the estimates of \( P_s : X_s \), \( P_b : X_b \), and \( P_w : X_w \) are larger than unity.

(d) Spirits and wine prices are significantly reduced by increases in the level of producers' stocks.

(e) The illegal spirits variable is unexpectedly related to 5 of the exogenous variables -- positively related with income and the spirits tax and negatively related with the money stock, the wine stocks, and the time trend.

**Demand Elasticities from the Basic Model**

For presentation and analysis, the relations between consumption and the various independent variables are expressed in this section as elasticities, representing the ratio of the percentage change in consumption over a given percentage change in the independent variables. The coefficients of the basic model, however, express a relation between the absolute changes. The elasticities are derived from the estimates of the linear parameters by multiplying the estimates by the ratio of the sample mean of the independent variables over the sample mean of consumption. The own price elasticity for spirits, for example, is given by

\[
(7.0) \quad \varepsilon_{Q_s : P_s} = b_{Q_s : P_s} \frac{\bar{P}_s}{\bar{Q}_s},
\]
where $\epsilon_{Q_s:P_s}$ is the price elasticity, $b_{Q_s:P_s}$ is the estimate of the structural coefficient, $\bar{P}_s$ is the sample mean of the spirits prices, and $\bar{Q}_s$ is the sample mean of spirits consumption. The linear formulation of the basic model implies a certain satiation effect on the proportionate influence of the independent variables; the elasticity decreases as the level of consumption increases relative to the level of the independent variables. The standard deviation of the elasticities are derived in the same manner, and are relevant, of course, only at the sample mean.

A solution of the three stage estimation procedure outlined above yields estimates of the structural coefficients at the second and third stage. A comparison of the elasticities from this procedure with the elasticities obtained by direct least squares dramatically illustrates the advantages and disadvantages of these techniques.

Table 2 presents the direct least squares estimates of the demand elasticities. These estimates are biased for all sample sizes if the price variables are correlated with the disturbances. The absolute value of the own-price effects are underestimated, but the direction of the bias of the other estimates cannot be inferred.

These estimates suggest the following characteristics of consumer behavior:

(a) Consumption of spirits is substantially more sensitive to its own price than is the consumption of beer and wine.

(b) Spirits and beer appear to be substitutes, but spirits and wine may be complementary. The beer-wine relations are not consistent between equations.

(c) Consumption of illegal spirits may total 8 per cent or more of legal consumption.
(d) Consumption of each beverage is significantly related to income, but beer is apparently an inferior good. Money stocks do not appear to have a significant effect on consumption.

Table 2
DIRECT LEAST SQUARES ESTIMATES OF THE DEMAND ELASTICITIES

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Independent Variables</th>
<th>Statistics$^a$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$P_s$</td>
<td>$P_b$</td>
</tr>
<tr>
<td>$Q_s$</td>
<td>-.929* (.375)</td>
<td>.646* (.300)</td>
</tr>
<tr>
<td>$Q_b$</td>
<td>.416 (.222)</td>
<td>-.333* (.182)</td>
</tr>
<tr>
<td>$Q_w$</td>
<td>-.543 (.484)</td>
<td>.240 (.396)</td>
</tr>
</tbody>
</table>

NOTE: Critical values at 5 per cent:

\[ t = 2.131 \text{ for } n = 15, \ 2.120 \text{ for } n = 16, \text{ for a two-tailed test,} \]
\[ = 1.733 \text{ for } n = 15, \ 1.746 \text{ for } n = 16, \text{ for a one-tailed test.} \]

$^a$ A runs-test was not computed for these equations.

Table 3 presents the estimates of the demand elasticities from the two stage Theil procedure. These estimates differ widely from the single equation estimates but the variance of these estimates is also larger; the average absolute difference between the direct least squares estimates and the two stage estimates is equal to 68 per cent of the former, and the average variance is increased by 141 per cent!
One hesitates to infer any characteristics of consumer behavior from the two stage estimates because of the large divergence from the direct least squares estimates and their very high variance. These estimates differ from the direct least squares estimates in the following respects: the own price elasticities of spirits and beer are substantially lower, the

Table 3
ESTIMATES OF THE SECOND STAGE DEMAND ELASTICITIES

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Independent Variables</th>
<th>Statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$P_s$</td>
<td>$P_b$</td>
</tr>
<tr>
<td>$Q_s$</td>
<td>-.624* (.533)</td>
<td>.917* (.420)</td>
</tr>
<tr>
<td>$Q_b$</td>
<td>.763* (.326)</td>
<td>-.076 (.265)</td>
</tr>
<tr>
<td>$Q_w$</td>
<td>-.010* (.825)</td>
<td>.901 (.671)</td>
</tr>
</tbody>
</table>

NOTE: Critical values at 5 per cent:

$t = 2.131$ for $n = 15, 2.120$ for $n = 16$, for a two-tailed test,
$= 1.753$ for $n = 15, 1.746$ for $n = 16$, for a one-tailed test.

$K = -1.645$ for a one-tailed test.

cross-elasticities are generally higher, the estimate of illegal spirits consumption is higher, and the income elasticities are higher. Are the two stage estimates better, by a statistical criterion, than those obtained by direct least squares? The average squared bias of the direct least squares estimates, assuming that the expected bias of the two stage estimates is zero, is 0.108; adding the average variance of 0.077 to the squared bias yields a total squared error of 0.185. The average variance of the two
stage estimates is 0.186. For this sample size, the two stage procedure does not yield better estimates of the structural coefficients.

Table 4 presents the estimates of the demand elasticities from the three stage procedure, incorporating the Theil technique and the generalized least squares technique. Two groups of wine estimates are presented: the

Table 4

ESTIMATES OF THE THIRD STAGE DEMAND ELASTICITIES

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Independent Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$P_s$</td>
</tr>
<tr>
<td>$Q_s$</td>
<td>-1.329*</td>
</tr>
<tr>
<td></td>
<td>(.292)</td>
</tr>
<tr>
<td>$Q_b$</td>
<td>.362</td>
</tr>
<tr>
<td></td>
<td>(.229)</td>
</tr>
<tr>
<td>$Q_w$</td>
<td>1.361*</td>
</tr>
<tr>
<td></td>
<td>(.673)</td>
</tr>
</tbody>
</table>

Alternate Wine Estimates

| $Q_w$ | .624   | 1.258* | -1.101* | 1.451* | -.182  |
|       | (.695) | (.575)| (.546) | (.326) | (.380) |

NOTE: Critical values at 5 per cent:

t = 2.131 for n = 15, 2.120 for n = 16, for a two-tailed test;
= 1.753 for n = 15, 1.746 for n = 16, for a one-tailed test.

primary estimates are part of the solution of the full seven-equation model; the large values of these estimates suggest a very high correlation among the demand functions. The alternate estimates are part of the solution of a reduced system of five equations which excludes the other two demand functions. The three stage spirits and beer estimates are much more con-
sistent with the direct least squares estimates than with the two stage estimates. Considering the spirits and beer functions only, the average absolute difference between the direct least squares and the three stage estimates is 35 per cent of the former, but the average difference of the two stage and three stage estimates is 77 per cent of the former; the average variance of the three stage spirits and beer estimates is 74 per cent of the direct least squares estimates and only 38 per cent of the two stage estimates.

These estimates confirm the general characteristics of consumer behavior suggested by the direct least squares estimates. The own price elasticities and the illegal spirits estimate are somewhat higher, the cross-elasticities in the spirits and beer functions are lower, and the money stock now appears to have a significant effect on spirits consumption. Both the primary and alternate wine estimates of this basic model must be regarded as unsatisfactory.

Again, it is interesting to compare the average squared error of the direct least squares estimates with those obtained by a more complex procedure. Considering the spirits and beer functions only, the average squared bias of the direct least squares estimates is 0.042; adding the average variance of 0.051 to the squared bias yields a total squared error of 0.093. The average variance of the three stage spirits and beer estimates is 0.038, around 40 per cent of the total squared error of the direct least squares estimates. A reduction of this magnitude in the errors of estimation often justifies the increased computational cost.

Two transformations of the third stage estimates should be made to yield strictly comparable estimates among the three equations. The spirits
and wine prices used in the basic model are producers' prices including both federal and state taxes. The elasticities with respect to the retail price of spirits and wine will be the same as those shown in Table 4 only if the distributors' margin has been the same proportion of the producers' price throughout the sample period. During short periods alcoholic beverage distributors generally follow percentage markup practices; over a longer period, however, the percentage markup has decreased with major increases in the tax rates. Higher retail price elasticities are obtained if the distributors' margin has been more nearly constant in absolute real dollars. An estimate of these higher elasticities can be derived by multiplying the third stage estimates of the structural coefficients by the ratio of the mean implicit retail prices (from the Office of Business Economics estimates of expenditures by type) over the respective quantities. Since some proportion of the tax and producers' price changes are undoubtedly compounded in the distributors' margin, because of the higher cost of holding inventories, the actual retail price elasticities will be somewhat below these higher estimates. Second, the spirits elasticities represent the effect of various price and budget variables on the sale of legal spirits, but the beer and wine elasticities apply to the total sale of these products. The effects of the price and budget variables on the sale of total spirits can be derived by adding the mean estimated quantity of illegal spirits to the mean quantity of legal spirits and multiplying the estimates of the structural coefficients by the ratio of the mean value of the independent variables over the mean estimated total quantity. Since the denominator of this ratio is around 14 per cent higher, the elasticities of total spirits consumption on these variables is correspondingly lower.
Table 5 presents the revised demand elasticities based on the third stage structural coefficients, the estimated mean retail prices, and the estimated mean consumption of illegal spirits; the wine elasticities are based on the

Table 5

ESTIMATES OF THE THIRD STAGE DEMAND ELASTICITIES
ASSUMING A CONSTANT REAL DISTRIBUTORS' MARGIN

<table>
<thead>
<tr>
<th>Dependent Variables</th>
<th>Independent Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>P_s</td>
</tr>
<tr>
<td>Q_s (legal)</td>
<td>-2.027* (.445)</td>
</tr>
<tr>
<td>Q_s (total)</td>
<td>-1.773* (.389)</td>
</tr>
<tr>
<td>Q_w</td>
<td>.552 (.349)</td>
</tr>
<tr>
<td>Q_m</td>
<td>.952 (1.150)</td>
</tr>
</tbody>
</table>

NOTE: Critical values at 5 per cent:

\[ t = 2.131 \text{ for } n = 15, \ 2.120 \text{ for } n = 16, \text{ for a two-tailed test;} \]
\[ = 1.753 \text{ for } n = 15, \ 1.746 \text{ for } n = 16, \text{ for a one-tailed test.} \]

alternate estimates of the structural coefficients. Estimates of the standard deviations of these transformed elasticities are derived in the same manner.

The theory of consumer demand suggests that the elasticities within
and between demand functions should exhibit the following properties:*

(a) The own price elasticity for each product should be negative;

(b) For each product, the algebraic sum of the own price elasticities and the cross elasticities on all other goods should be zero; and

(c) For two products, the ratio of their cross-elasticities should be approximately equal to the inverse of the ratio of the expenditures on these products.

A comparison of the elasticities presented in Table 5 against these properties is interesting. Each of the own price elasticities is consistent with property a, and a one-tailed test of these estimates indicates that each one is highly significant. A direct check of these estimates against property b is not possible, since the demand functions include only the prices of closely related commodities. Under most conditions, however, a stronger property holds: The algebraic sum of the own price elasticity and the cross-elasticities on closely related products should be negative. The spirits and beer estimates are consistent with this stronger property but the wine estimates are not. The cross-elasticities, according to property c, should be equal to the following ratios: beer: spirits, around 1; wine: spirits, around 9; and wine: beer, also around 9. A test for the difference of the spirits and beer estimates, neglecting the covariance of the estimates, indicates that they are not significantly different. The wine

---

* A rigorous analysis of these properties was developed by E. Slutsky in "Sulla teoria del bilancio del consumatore," Giornale degli Economisti, Vol. 51, 1915, pp. 1-26. For a more modern treatment, see J. R. Hicks, Value and Capital, Oxford University Press, London, 1939, pp. 305-314, and Herman Wold, Demand Analysis, John Wiley and Sons, New York, 1953, pp. lll-126. The author is indebted to Professor Arnold Harberger for clarifying a misunderstanding concerning these properties.
and spirits cross elasticities are inconsistent in sign, but the estimate in the spirits function is not significantly different from the value of +0.1 that is consistent with the estimate in the wine function. The wine and beer cross-elasticities are also inconsistent in sign, and the estimate in the beer function is significantly different from the value of +0.14 that is consistent with the estimate in the wine function. Spirits and beer are apparently weak substitutes, although this relation is highly variable, and the other relations cannot be established.

**Demand Elasticities from the Alternate Model**

Estimates from the basic model suggest that the relations among the three markets are weak. Most of the cross-product estimates are independently insignificant, some are inconsistent, and some are highly unstable between the successive stages of the estimation procedure. A three stage procedure was also used to estimate the coefficients of the seven structural equations, omitting the prices of the other two beverages in the three demand functions; this reduces the basic model to three separate models independently describing the three markets. The reduced form equations of these three models also omit the tax rates and producers' stocks of the other products. Only the third stage estimates of the three demand functions are reported in this section; it is sufficient to note that these estimates were much more stable from stage to stage than were the estimates from the basic model. Table 6 presents the estimates of the third stage demand elasticities from this alternate approach. These estimates are transformed to yield the retail price elasticities and are, thus, comparable with those presented in the preceding table.
The spirits and beer estimates from the alternate model are not significantly different from the corresponding estimates of the basic model; the own price elasticity and the money elasticity are somewhat higher in

Table 6
ESTIMATES OF THE THIRD STAGE DEMAND ELASTICITIES FROM THE ALTERNATE MODEL ASSUMING A CONSTANT REAL DISTRIBUTORS' MARGIN

<table>
<thead>
<tr>
<th>Dependent Variables</th>
<th>( P_s )</th>
<th>( P_b )</th>
<th>( P_w )</th>
<th>( S )</th>
<th>( Y )</th>
<th>( M )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( Q_s ) (legal)</td>
<td>-2.343*</td>
<td>.604*</td>
<td>-.101*</td>
<td>.256</td>
<td>.545*</td>
<td>(.352) (.207) (.063) (.176) (.164)</td>
</tr>
<tr>
<td>( Q_s ) (total)</td>
<td>-2.129*</td>
<td></td>
<td></td>
<td>.232</td>
<td>.495*</td>
<td>(.319)       (.159) (.148)</td>
</tr>
<tr>
<td>( Q_b )</td>
<td></td>
<td>-.711*</td>
<td></td>
<td>-.266</td>
<td>.396*</td>
<td>(.302) (.158) (.083)</td>
</tr>
<tr>
<td>( Q_w )</td>
<td></td>
<td></td>
<td>-.711*</td>
<td>.679*</td>
<td>-.054</td>
<td>(.302) (.179) (.144)</td>
</tr>
</tbody>
</table>

NOTE: Critical values at 5 per cent:

\[ t = 2.110 \text{ for } n = 17, \ 2.101 \text{ for } n = 18, \text{ for a two-tailed test,} \]
\[ = 1.740 \text{ for } n = 17, \ 1.734 \text{ for } n = 18, \text{ for a one-tailed test.} \]

each function and the income elasticities are lower. The wine estimates from the alternate model are considerably lower but their variance is also proportionately lower.
Some Secondary Tests of the Demand Function

A large number of direct least squares tests of the demand function were made using different variables, combinations of variables, equation forms, and samples.\(^*\) The characteristic of primary interest is the significance of the regression equation, measured by either the corrected \(R^2\) or the variance ratio.

Use of the total adult population as a consumption deflator yielded better estimates than did the total population, the total wet state population, or the adult wet state population. The money stock is the best single shift variable for spirits and beer, and income for wine, when only the own price is included in the demand functions; the income variable alone is more powerful than money, consumption, and time or any combination of these variables when all of the prices are included. No combination of the three prices yields better estimates than do the own prices used independently, and the functions with two of the three prices usually yield inconsistent cross-elasticities between equations.

The price indices prepared for this study yield significantly better estimates than do the implicit prices of the total expenditures estimates prepared by the Office of Business Economics, used singly or in combination. Quantity indices, prepared in the same manner as the price indices, yield much more significant estimates than does the use of the physical quantity variable, and, interestingly, rather higher income elasticities. Demand functions using the basic sample yield much better estimates than does a sample including the war years, and no simple shift variable for these

\(^*\)With a few exceptions, all these tests were made after the variables and the form of the basic model were fixed.
years is adequate. Demand functions using the basic sample were, finally, tested using four alternative equation forms: linear, semi-logarithmic (with the quantity variable in the original form), logarithmic, and linear first differences. The linear form yields the best estimates of the beer function, and the semi-logarithmic form the best estimates of the spirits and wine functions. The first difference estimates are least powerful, as expected, but their values are remarkably close to the basic linear estimates.

A group of tests were also made using a budget-study sample and a cross-section sample. The budget-study tests show a strong income elasticity of expenditures for spirits and wine and no income effect on beer; for a given household income, an increase in household size reduces the expenditures for spirits and increases the expenditures for beer. The cross-section estimates yield price and income elasticities that are remarkably close to the time series estimates, but their variances are considerably larger. The consumption pattern among states manifests no identified relation to the differences in the demographic composition.

A Summary of the Characteristics of Consumer Behavior

A synthesis of the estimates from the basic model, the alternate model, and the various secondary tests suggests the following characteristics of the consumer demand for alcoholic beverages:

(a) Consumption of each beverage is significantly related to its own price. The own price elasticity of spirits is around -2.0; of beer, around -0.6; and of wine, around -0.7.

(b) Consumption of each beverage is primarily determined by conditions
within each separate market. Spirits and beer appear to be weak substitutes, but the relations between the spirits and wine markets and the beer and wine markets are highly unstable.

(c) Consumption illegal spirits has averaged around 10 to 15 per cent of the consumption of legal spirits. The total volume of illegal spirits is probably around 6 to 9 times the total cubic capacity of stills seized by federal agents each year.

(d) Consumption of each beverage is significantly related to the level of personal disposable income. The income elasticity of spirits is around 0.4; of beer, around -0.3; and of wine, around 1.0. The income elasticities of expenditures for these beverages are somewhat higher.

(e) Consumption of spirits and beer is significantly related to the level of the money supply. The money elasticity of spirits is around 0.4; and of beer, around 0.3.

Of the various characteristics summarized above, the wine estimates are the most subject to error.

Supply Coefficients from the Basic Model

Attention is focused in this study on the characteristics of the demand for alcoholic beverages, but in any such demand analysis, one usually learns a great deal about the supply of the product. Identification of the major influences on the supply of the product is necessary, in most cases, to obtain unbiased estimates of the demand relations. The supply relations, of course, are also interesting, and, for some public policies, an understanding of both sides of the market is mandatory. Only the third stage estimates of the four supply functions of the basic model are presented in this section; the supply estimates from the three stage procedure, as it
developed, are very close to the direct least squares estimates but their variances are somewhat lower. The three price variables were used as the dependent variable for the legal spirits, beer, and wine estimates because of the direct linear relation between the price and tax variables; the price variables also yielded more significant functional relations in the direct least squares tests than did the use of the quantity variables. Table 7

<table>
<thead>
<tr>
<th>Dependent Variables</th>
<th>Independent Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Quantity</td>
</tr>
<tr>
<td>P_s</td>
<td>-1.49847*</td>
</tr>
<tr>
<td></td>
<td>(.26545)</td>
</tr>
<tr>
<td>P_b</td>
<td>-.04244*</td>
</tr>
<tr>
<td></td>
<td>(.00405)</td>
</tr>
<tr>
<td>P_w</td>
<td>-.10009</td>
</tr>
<tr>
<td></td>
<td>(.59840)</td>
</tr>
<tr>
<td>S</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**NOTE:** Critical values at 5 per cent:  

\[ t = 2.110 \text{ for } n = 17, \ 2.101 \text{ for } n = 18, \text{ and } 2.093 \text{ for } n = 19, \text{ for a two-tailed test.} \]

Table 7 presents the third stage estimates of the supply coefficients. Each estimate represents the partial effect of a one unit change in one of the independent variables on the level of one of the dependent variables.

These characteristics suggest the following characteristics of the supply of alcoholic beverages:
(a) Production of spirits and beer appears to be subject to significant economies of scale. The elasticity of per capita supply to the price, excluding the tax, for spirits is around -2.4; and for beer, -1.6. This result is surprising, but the rapid increase in the average output per establishment during the post-Repeal period, and the large volume of advertising expenditures, are dramatic witness to these economies. Table 8 presents the relevant output data for the spirits and beer industries by five-year intervals since 1940. *

Under conditions of such scale economies, the prices of these beverages have changed by more than the amount of the changes in the tax rates.

(b) For a given level of production, the spirits price has changed by around 80 per cent of the change in the tax rate. The beer and wine

---

prices have changed by the approximate amount of the change in the tax rates, but these relations have been highly variable.

(c) The prices of spirits and wine are negatively related to the level of producers' stocks at the beginning of the year. A 10-per-cent increase in the stock of spirits has reduced the spirits price by around 1 per cent, and a corresponding increase in the stock of wine has reduced the wine price by around 5 per cent. The larger effect of the wine stocks is undoubtedly due to the shorter aging period.

(d) The price of each beverage has been negatively related to a simple time trend, reflecting, in part, a greater growth of productivity in these industries than in the general economy. The time trend, in combination with the per capita quantity variable, also indicates the effect of the level of total production, so the independent significance of these estimates is overstated.

(e) The supply of illegal spirits apparently cannot be described by a simple function, partly because the available data reflect the activity of both the illegal producers and the enforcing agents. The reduced form equation yields a more accurate estimate of the characteristics of the supply of illegal spirits -- showing a strong positive relation with the tax rate and a significant negative relation with the time trend.
Chapter 2

AN ANALYSIS OF THE ALCOHOLIC BEVERAGE TAXES

OBJECTIVES OF ALCOHOLIC BEVERAGE TAX POLICY

Official, explicit statements of the objectives of tax policy, unfortunately, are seldom written. Taxation of alcoholic beverages in the United States is as old as the Constitution and as ubiquitous as government, but the official objectives of the tax program have never been made quite clear. One cannot, therefore, directly test the effectiveness of the alcoholic beverage taxes toward achieving the objectives the legislators have in mind. An indirect approach, however, is feasible and answers most of the interesting questions: First, a number of tax objectives are explicitly formulated. Second, a set of tax rates are determined, using the statistical relations developed in Chapter 1 which are most consistent with each of the tax objectives. And last, the tax rates and revenues which are determined by this analysis are compared with actual tax rates and revenues. This approach identifies the objectives which the taxing authorities in fact have followed, and suggests the changes in the tax structure that would be consistent with the various objectives.

Public discussion of the alcoholic beverage tax policy suggests three general objectives: the provision of public revenue, the control of alcoholic beverage consumption, and the control of the illegal production and distribution of spirits. Various writers have urged that one or another objective be given the highest priority, but the objectives have not been made more explicit. These objectives may or may not be inconsistent.

*One of the most influential arguments for reform proposed that control of consumption be considered the primary objective of the alcoholic beverage taxes. See Raymond B. Fosdick and Albert L. Scott, Toward Liquor Control, Harper and Bros., New York, 1933. Fosdick and Scott greatly underestimated the effects of the taxes on consumption, however, and the rates they proposed were considerably higher than the actual rates in the first post-Repeal years.
depending on the degree a particular objective is emphasized and the conditions of consumer demand. A belief prevails, for example, that an increase in public revenues from alcoholic beverages will necessarily reduce consumption but will increase the volume of illegal spirits; under some conditions, as will be demonstrated, this belief is incorrect on both counts.* For this analysis, four tax policies will be distinguished:

(A) *The Actual Policy* — Objectives of the actual, or historical, policy are not known, but the resulting tax rates and revenues are historical data.

(B) *An Unconstrained Maximum Revenue Policy* — Tax rates are set independently to maximize the expected public revenues from each beverage, regardless of the consequences on consumption or the volume of illegal spirits.

(C) *A Maximum Revenue Policy with a Constraint on Consumption* — Tax rates are set jointly to maximize the expected total revenue, subject to a constraint that the expected equivalent volume of alcohol consumed be no higher than the actual volume in each year.

(D) *A Maximum Revenue Policy with Constraints on Consumption and Illegal Spirits* — Tax rates are set jointly to maximize the expected total revenue subject to the above constraint on consumption and a constraint that the expected volume of illegal spirits be no higher than zero.

Tax policies B, C, and D thus incorporate one or more of the general objectives of the alcoholic beverage taxes. For consistency, the tax rates

*A reduction of the spirits tax will increase revenue, increase the consumption of spirits, and reduce the volume of illegal spirits. See pp. 50, 56, 61.*
of each policy are set to maximize revenue, but the procedure used to determine the tax rates for policies C and D could also be used to minimize the expected value of one of the constraints subject to a given expected revenue.

TAX RATES AND REVENUES

An Unconstrained Maximum Revenue Policy

Tax rates which yield the maximum expected revenue in each period are derived by differentiating an expected revenue function with respect to the three rates. The expected revenue for year \( t \) is given by

\[
\hat{R}(t) = X_s(t)\hat{Q}_s(t) + X_b(t)\hat{Q}_b(t) + X_w(t)\hat{Q}_w(t),
\]

where \( \hat{R}(t) \) is the expected total revenue; \( X_s(t), X_b(t), \) and \( X_w(t) \) are the tax rates on each beverage; and \( \hat{Q}_s(t), \hat{Q}_b(t), \) and \( \hat{Q}_w(t) \) are the expected consumption of each beverage. Consumption of each beverage, of course, is a function of the tax rates and other variables, a function described by the reduced form equations of the basic and alternate models.

Our attention is first focused on a tax policy which sets the tax rates on the three beverages to maximize the expected revenue from each source. These rates are determined by replacing \( \hat{Q}_s(t), \hat{Q}_b(t), \) and \( \hat{Q}_w(t) \) in (8.0) by the reduced form equations of the alternate model, which gives

\[
\hat{R}(t) = X_s(t) \left[ (0.03212 + 0.00073 Y(t) + 0.00509 M(t) + 0.00015 I_s(t) + 0.02771 T(t) \right] - 0.4317 X_s(t) \\
+ X_b(t) \left[ (32.03822 + 0.00562 Y(t) + 0.02425 M(t) - 0.025987 T(t) \right] - 51.35371 X_b(t) \\
+ X_w(t) \left[ (0.12294 + 0.00141 Y(t) - 0.00014 M(t) + 0.00226 I_w(t) - 0.01435 T(t) \right] - 0.39291 X_w(t).
\]
Differentiating (9.1) with respect to $X_s(t)$, $X_b(t)$, and $X_w(t)$ and setting these derivatives equal to zero yields

\[
\begin{bmatrix}
\dot{X}_s(t) \\
\dot{X}_b(t) \\
\dot{X}_w(t)
\end{bmatrix} =
\begin{bmatrix}
.88634 \\
102.70742 \\
.78582
\end{bmatrix}
\begin{bmatrix}
X_s(t) \\
X_b(t) \\
X_w(t)
\end{bmatrix}
\]

where $\dot{X}_s(t)$, $\dot{X}_b(t)$, and $\dot{X}_w(t)$ are sums of the values within the parentheses and are equal to the estimated consumption of each beverage in the absence of a tax. Solving these equations for the tax rates yields the rates illustrated as line B in Figs. 6, 7, and 8 for each year from 1934 through 1960.

The average maximum revenue spirits tax is $2.05 less (in 1947 dollars) than the actual tax rates indicated by line A and is lower in every year of this period. The average maximum revenue beer tax is $0.064 higher than the actual tax, although it is slightly lower than the actual tax until 1941. The average maximum revenue wine tax is $1.21 higher than the actual tax and is higher in every year of the period.

Expected total revenue from the maximum revenue rates averages 10.1 per cent higher than the actual revenues; spirits revenue is 10.2 per cent higher, beer revenue 4.5 per cent higher, and wine revenue 77.1 per cent higher.

Expected total revenue during the sample years averages only 12.2 per cent higher than actual revenue. Over the entire period from 1934-1960 the maximum revenue policy would have returned $6.4 billion more (in 1947 dollars) than the actual policy; at a 3-per-cent interest rate, the difference in the present value of these revenues as of 1960 is $8.4 billion. The relation of the expected revenue from this policy and the actual revenue is illustrated
in the top section of Fig. 9. Actual revenues throughout the period have been remarkably close to the maximum expected revenues, differing at most by around 20 per cent. This is not sufficient proof, however, that the tax authorities have followed a maximum revenue policy, since a wide range of tax rates will yield revenues close to the maximum obtainable. An inspection of the relation between tax rates and revenue shows that this function is quite flat in the area of the maximum revenue tax. Fig. 10 illustrates the relations between the revenue per adult and the three tax rates for values of $A_s$, $A_b$, and $A_w$ at the sample mean. With this level of general demand,
the spirits tax can vary from $4.00 to $8.00 (in 1947 dollars) without more than a 10-per-cent loss in revenue, the beer tax from around $0.25 to $0.50, and the wine tax from $1.20 to $2.40. The tax authorities, it appears, can select from a wide range those tax rates which achieve other objectives without a significant loss of revenue.

Fig. 7 — Beer Tax Rates of the Alternative Policies (1947 dollars)

Some idea of the effect of general demand conditions on revenue, given that a maximum revenue policy is followed, can be obtained by replacing \( X_s \), \( X_b \), and \( X_w \) in Eq. (9.0) by the maximum revenue tax rates at the sample mean. Differentiating with respect to \( Y \) and \( X \) indicates that a $100 increase in per capita income increases the alcoholic beverage revenue per adult by $0.90 and a $100 increase in per capita money stocks increases the revenue by $3.91. The conditions underlying the time trend appear to increase the revenue per adult by around $0.04 a year. At every level of demand the consumption of
each beverage, under this maximum revenue tax policy, will be just one-half the level in the absence of a tax.

Tax rates and revenues were also derived from a variant of the maximum revenue policy which allows for the cross-product effects of the tax rates. These rates are determined by replacing \( \hat{Q}_b(t) \), \( \hat{Q}_b(t) \), and \( \hat{Q}_w(t) \) in Eq. (8.6) by the reduced form equations of the basic model. The cross-product effects between spirits and beer are sufficiently weak that the taxes derived by a joint maximization are very close to the rates derived by independent
Fig. 9 -- Expected Total Revenues as a Percentage of Actual Revenues
Fig. 10 -- Public Revenues as a Function of the Tax Rate (1947 dollars)
maximization; the spirits rates from this policy average $0.11 higher than the rates from the simple policy, and the beer rates average $0.02 higher. The perplexing relation between beer and wine, however, manifest in both the reduced form equations and the structural equations of the basic model, causes the joint maximum wine rate to average $1.57 less than the rates derived by independent maximization; this wine rate also averages $0.36 less than the actual rate. Expected total revenues from this joint maximization policy are virtually identical to the revenues from a maximization of the revenues from each source. The weak cross-product relations indicate that largely independent policies can be followed in setting the three rates without a significant effect on the revenues from the other beverages.

A Maximum Revenue Policy with a Constraint on Consumption

An unconstrained maximum revenue policy, it appears, would lead to higher consumption of spirits and lower consumption of beer and wine than experienced during the post-Repeal period; an additional calculation indicates that the equivalent consumption of alcohol would be somewhat higher than experienced in most of the years of this period. Public acceptance of high tax rates on alcoholic beverages is, unquestionably, due to a general belief that the tax structure is an effective instrument for reducing some of the social costs of alcoholic beverage consumption, by reducing the general level of consumption or by shifting consumption to beverages with lower alcoholic content. The actual spirits tax, for example, has averaged around three times the beer tax and around five times the wine tax, per unit of alcoholic content. A tax policy which increases the equivalent consumption of alcohol and increases the consumption of spirits relative to beer and wine may be inconsistent with one of the major objectives of the alcoholic beverage tax policy.
The desire to control the social costs of alcoholic beverage consumption suggests a tax policy which maximizes revenue subject to a constraint on these social costs. A number of social cost functions have been investigated to estimate the effect of the consumption of each beverage on two measures of social cost: the death rate from alcoholism and the estimated rate of alcoholism. The time series observations of the death rate and the rate of alcoholism manifest no significant relation with the average consumption of any of the three alcoholic beverages. A cross-section sample of the rate of alcoholism, however, indicates a positive and highly significant relation with the average consumption of each beverage. The spirits, beer, and wine coefficients in this cross-section test are in a 20:1:25 relation. Investigation of these relations has produced some interesting results but has not contributed much to the selection of the appropriate social cost function. One would be tempted to use the cross-section estimates to describe this function if these estimates were more consistent with the time series estimates. For this study, a "neutral" function, the sum of the equivalent amount of alcohol in the average consumption of each beverage, has been used, although the historical evidence does not support this relation. This function is given by

\[
\hat{C}(t) = 0.43 \hat{C}_s(t) + 0.05 \hat{C}_b(t) + 0.16 \hat{C}_w(t),
\]

\(\hat{C}_s(t), \hat{C}_b(t), \hat{C}_w(t)\)

where the parameters are the average amount of alcohol (by volume) in one
gallon of each beverage. The parameters are approximately in a 9:1:3 relation.
The technique used to determine the appropriate tax rates, of course, could
incorporate any such linear relation.

Tax rates for this constrained maximum revenue policy are derived by
maximizing the revenue function, Eq. (8.0), subject to the social cost func-
tion, Eq. (10.0), with \( \mathcal{C}_s(t) \), \( \mathcal{C}_b(t) \), and \( \mathcal{C}_w(t) \) in both equations replaced by
equations of the alternate model. The value of \( C(t) \) is set equal to the
actual equivalent amount of alcohol consumed in each year. This procedure
yields the set of equations given by

\[
\begin{bmatrix}
\mathcal{A}_s(t) \\
\mathcal{A}_b(t) \\
\mathcal{A}_w(t) \\
C^*(t)
\end{bmatrix}
= 
\begin{bmatrix}
0.88634 & -0.19056 \\
102.70742 & -2.56769 \\
0.78582 & -0.06287 \\
-0.19056 & -2.56769 & -0.6287
\end{bmatrix}
\begin{bmatrix}
X_s(t) \\
X_b(t) \\
X_w(t) \\
\lambda_1(t)
\end{bmatrix},
\]

where \( C^*(t) \) is the difference of the estimated consumption of alcohol in the
absence of any taxes and the actual consumption in each year, and \( \lambda_1 \) is
the Lagrangian multiplier; the value of \( \lambda_1 \) turns out to be the incremental
revenue per adult which could be collected if the constraint \( \mathcal{C}_s(t) \) is increased
by one gallon. Each tax rate is given by the relation

\[
(11.2) \quad X_i(t)_{\text{max}} = \frac{c_i}{2} \lambda_1(t) + \frac{\kappa_i(t)}{2b_i},
\]

where \( c_i \) is the parameter on \( \mathcal{C}_i(t) \) in the social cost function, and \( b_i \)
is the parameter on \( X_i \) in the reduced form equation. The right-hand component
of the above equation is recognized as the tax rate from the unconstrained maximum revenue policy; the rates which maximize revenue subject to the constraint \( C(t) \), thus, are equal to the maximum revenue rate plus the product \( \frac{c_i}{z} \lambda_1(t) \). These rates are illustrated by curve C on Figs. 6, 7, and 8. 

The average value of \( \lambda_1 \) during the years since 1934 is $1.20, so the rates from this policy are slightly higher than the maximum revenue rates. The average spirits tax from this policy is $0.25 higher than the maximum revenue rate but is still $1.79 less than the actual rate. The beer and wine rates are $0.03 and $0.09 higher than the maximum revenue rates. These rates are approximately in a 15:1:5 relation; the spirits and wine taxes, thus, are set at a level around two-thirds higher than the beer tax, per unit of alcoholic content.

Expected revenues from this constrained maximum revenue policy average 9.3 per cent higher than the actual revenues during the whole period and 10.3 per cent higher than the actual revenues in the sample years. Over the whole period this policy would have yielded $6.1 billion more than the actual policy, with a difference in the present value of the revenues of $8.6 billion dollars. Compared with the maximum revenues policy, the net cost to the government (in 1960 present value) of maintaining consumption at the actual levels would have totaled only $400 million. The relation of the expected revenues from this policy and actual revenues is illustrated in the middle section of Fig. 9. The tax authorities, it appears, could have increased revenues by around 10 per cent without increasing the expected consumption of alcohol in any year. A policy to reduce the consumption of alcohol, of course, would yield lower revenues and would shift consumption from spirits to beer and wine.
A Maximum Revenue Policy with Controls on Consumption and Illegal Spirits

A final policy considered adds one more constraint on the tax authorities: the elimination of the illegal production and distribution of spirits. Without a general control on consumption, this objective could be accomplished by independently reducing the spirits tax to a level where the expected volume of illegal spirits is zero. With a general control on consumption this policy results in a further increase in the beer and wine tax rates to maintain the equivalent amount of alcohol consumed. The relation between the proxy for the volume of illegal spirits and the spirits tax rate is

\[ S(t) = S(t) + 0.1608 X_s(t), \]

where \( S(t) \) is the expected volume of seized stills, in the absence of a tax on legal spirits. Tax rates for this policy are derived by maximizing the revenue function, Eq. (8.0), subject to the constraint on consumption, Eq. (10.0), and the constraint on the illegal spirits, Eq. (12.0), with \( S(t) \) set equal to zero. This procedure yields the set of equations

\[
\begin{bmatrix}
A_s(t) \\
A_b(t) \\
A_w(t) \\
G(t) \\
S(t)
\end{bmatrix} \begin{bmatrix}
0.88634 \\
102.70742 \\
0.78582 \\
-0.19056 \\
0.01608
\end{bmatrix} \begin{bmatrix}
X_s(t) \\
X_b(t) \\
X_w(t) \\
\lambda_1(t) \\
\lambda_2(t)
\end{bmatrix},
\]

*This relation is the reduced form equation of the alternate model. The coefficient on \( X_s(t) \) in the reduced form equation in the basic model is somewhat higher, requiring a smaller reduction in the spirits tax to eliminate the illegal production of spirits.*
where $\lambda_2(t)$ is the Lagrangian multiplier on the illegal spirits constraint and is equal to the incremental revenue per adult which could be collected if this constraint were increased by one gallon. An independent solution for the spirits tax yields the rates illustrated as line D in Fig. 6. For 10 years, from 1934 through 1943, the elimination of illegal spirits would have required a spirits tax averaging 80.68 lower (in 1947 dollars) than the maximum revenue tax and 81.92 lower than the actual tax. In 1934 the combined federal and state tax per wine gallon would have had to be 81.50 or less (in 1934 dollars) to effectively eliminate the illegal traffic. Since 1944, however, the maximum revenue spirits tax would have been sufficiently low to discourage the re-entry of the illegal producers. A joint solution for the other tax rates, incorporating the consumption constraint, yields the beer and wine tax rates illustrated as curve D in Figs. 7 and 8. During the period in which the spirits tax is below the maximum revenue tax, the beer and wine tax rates of this policy average, respectively, 8C.10 and 8C.55 higher than the maximum revenue rates, because of the high value of $\lambda_1$.

Expected revenues from this policy average 7.1 per cent higher than actual revenues during the whole period and 8.1 per cent higher during the sample years. During the 10-year period these rates differ from the Policy C rates, the expected revenues from this policy are approximately equal to the actual revenues. Total revenues from this policy would have been $5.5 billion higher than the actual revenues with a difference in the present value of these revenues of $6.7 billion. Compared to the maximum revenues, the net cost to the government of eliminating the illegal traffic (in 1960 present value), given the constraint on consumption of alcohol, would have totaled only 81.3 billion.
The relation of the expected revenues from this policy and actual revenues during the years since 1934 is illustrated in the lower section of Fig. 9. The tax authorities, it appears, could have increased revenues by 7 to 8 per cent, maintained the expected consumption of alcohol at the actual levels, and eliminated the illegal spirits industry by a more careful selection of the tax rates.

**Apparent Objectives of the Actual Tax Policy**

Objectives of the actual tax policy are identified by comparing the correlations of the actual tax rates and those derived from the above policies. These correlations strictly identify only the relation of the changes in the actual and derived rates; the objectives for the absolute difference between these rates, thus, can only be surmised. Table 9 presents the simple and partial correlation coefficients between the actual tax rates and the rates derived from each of the above policies.

The actual spirits tax is independently correlated with the rates of each of the three policies. Only one policy, however -- the maximization of revenue subject to a constraint on consumption -- significantly explains the actual rates when the rates are considered jointly. The positive difference between the actual rates and those of Policy C may be due to an underestimate by the tax authorities of the (absolute) effect of the tax, or may reflect a much higher parameter on spirits in the social cost function.

Only one policy -- the maximization of revenue subject to constraints on consumption and illegal spirits -- is a significant explanation of the actual beer tax, whether the rates are considered independently or jointly. This result appears to be inconsistent with the correlations on the spirits tax. The low rates of the actual beer tax may be due to an overestimate of
the (absolute) effect of the tax or may reflect a much lower parameter on beer in the social cost function.

The actual wine tax is independently correlated with the rates of each policy. Considered jointly, the wine tax appears to be negatively related to the Policy E rates and positively related to the Policy C rates. Of the

<table>
<thead>
<tr>
<th>Item</th>
<th>Correl Coeff</th>
<th>Policy and Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spirits</td>
<td>simple</td>
<td>-.046</td>
</tr>
<tr>
<td></td>
<td>partial</td>
<td>-.236</td>
</tr>
<tr>
<td>Beer</td>
<td>simple</td>
<td>-.569</td>
</tr>
<tr>
<td></td>
<td>partial</td>
<td>-.475</td>
</tr>
</tbody>
</table>

NOTE: Critical values at 5 per cent:

R = .381 for n = 25,
       .423 for n = 26.

three actual tax rates, only the wine tax has consistently been set at a level which returns less than 90 per cent of the maximum revenues. The low rates of the actual wine tax may be due to an overestimate of the (absolute) effect of the tax or may reflect a much lower parameter on wine in the social cost function.
A rationale for the apparent overtaxation of spirits relative to beer may be found in the distribution of political powers. The production of spirits is highly concentrated in a few states which have little Congressional representation; beer production, in contrast, is distributed among all but a few states. The consumption of spirits is also more concentrated relative to the consumption of beer among groups in the population. This political hypothesis, however, does not explain the apparent undertaxation of wine, since both its production and consumption are highly concentrated.

**TOWARD A RATIONAL ALCOHOLIC BEVERAGE TAX POLICY**

**A Basis for the Alcoholic Beverage Taxes**

Henry Simons, one of the last great liberals, wrote concerning the alcoholic taxes,

> Reliance on ... tobacco, beer, and liquor excises, i.e., on levies whose burdens few voters apprehend, makes for irresponsible government and irresponsible finance. It is a policy of necessity for insecure governments and backward countries. It is a proper technique in advanced nations where a government aspires to permanent and irresponsible power.***

He proposed the

> Elimination or radical reduction of excise taxes (especially on beer, liquors, tobacco, admissions, etc.) as an element of the federal revenue system,***

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**Ibid.,* p. 36.
commenting that

These taxes, to my mind, are the worst elements in our revenue system. They are much more regressive than sales taxes. They are almost wholly concealed, precluding real awareness by individuals of their actual annual burden. They pander to misguided demands for sumptuary legislation, deriving strong support from alleged purposes which they are carefully designed not to serve. They pose as levies upon "luxuries", while serving to divert expenditures not from the objects taxed but from "necessities." Like corporation taxes, they are the revenue devices of political cowards who live in terror of voter-taxpayers and of government by intelligent discussion. The only cogent defense of them rests on the Calvinist premise that poor consumers of the objects in question are obviously damned for the next life and may properly be prepared now for their fate, by carrying what would otherwise be tax burdens of the elect. The large-yield federal excises are superior, by democratic standards, only to our margarine taxes and protective tariff duties!*

Does Simons overstate his case? Is there a rational basis for continued federal and state excises on alcoholic beverages? Possibly. Most of the increases of the taxes on these products have occurred during periods of rapidly increasing government expenditures, but the need for revenue is not a sufficient basis for taxing these products, since the tax rates on other products or the basic sources of income could have been increased. A rationale for these taxes must be based on one of two arguments that have been offered in their defense: the consumption tax argument and the social cost argument.

During World War II a system of federal excises was developed as a substitute for a general consumption tax Congress had rejected. These excises were designed to increase revenues, but also to restrict current consumer expenditures as part of an anti-inflationary program. Whatever the merits

*Ibid., p. 37.*
of a general consumption tax, few of the arguments in its support apply to the actual system of excises developed. * An effective tax structure should have the following properties:

(a) Economic neutrality. The tax should not distort the allocation of resources among products.

(b) Equity. The tax should be an equal burden among people with comparable income and differ among income groups in a manner corresponding to the expressed political consensus.

(c) Minimum collection costs. The tax should be set at such a level and administered in such a manner that collection costs are minimized and tax enforcement is effective.

An excise on a specific product will misallocate resources by an amount corresponding to the effect of the tax rate on consumption, unless excises are levied on all products and services in such a way as not to change the relative prices. During World War II the demand for the three alcoholic beverages was relatively inelastic, so the major effect of the excises in this period was an increase in expenditures and public revenues. At the lower levels of demand in the peacetime years, however, consumption of the three beverages, particularly spirits, has been very sensitive to the tax rates. The state cross-section data suggest that the consumption of alcoholic beverages and the resulting public revenues vary widely within the same income groups; the time series data indicate that the absolute expenditures for beer and the proportion of income spent for spirits and wine falls as income increases. The resulting distribution of the tax burden is clearly


* John F. Due, Government Finance, Richard D. Irwin, Inc., Homewood, Illinois, 1954, p. 113; or see most any public finance textbook.
inconsistent with the accepted criterion of equity. Costs to the government of collecting the alcoholic beverage revenues have been relatively small, but compounding of the tax rates has resulted in additional costs to the consumer. Enforcement of the beer and wine excises has been very successful, but the spirits tax has been set at a level which makes its enforcement prohibitive and creates the conditions for a thriving illegal industry. A rationale for taxing these products obviously must be based on some other argument.

A wide range of activities in our interdependent society impose some costs on those not directly engaged in the activities. Since a free choice by those directly engaged would result in an undesirably high level of these activities, our society uses a mixture of informal and legal procedures to restrict these activities — social opprobrium, extra-legal coercion, deed restrictions, zoning laws, the law of torts, and taxes on the specific activities. The appropriate procedure and the particular person or group that should bear the full costs are not always obvious. A tax on such activities can often be used to serve two purposes — to restrict the activities and to provide revenues to alleviate or correct for their social costs.

A structure of taxes on alcoholic beverages could be supported by three interpretations of the social cost of consumption of these beverages:

(a) An increase in consumption results in social costs at all levels of consumption. A tax which reduces average consumptions, thus, will reduce the social costs whether or not the tax affects extreme consumption behavior.

(b) An increase in consumption results in social costs only at high levels of consumption. A tax may not directly reduce the consumption of

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interperate consumers but will indirectly influence their behavior through a "demonstration effect" or by reducing the probability that a drinker will become an alcoholic.

(c) An increase in consumption results in social costs only at high levels of consumption and a tax will directly reduce the consumption of the interperate consumers.

Evidence for any one of these three positions is remarkably scarce. The first and second positions suggest that there is a positive relation between the average consumption of alcoholic beverages and the various measures of social cost. The evidence for this position, at best, is inconsistent. A careful investigation of this relation and the reasons for the disparity of these estimates is obviously required. The "temperance" organizations, which generally maintain the first position, also contend that the expenditures for alcoholic beverages divert expenditures for household "necessities," and thus cause hardships for the families of drinkers; the demand functions discussed in Chapter 1, however, indicate that any tax on beer or wine will increase the expenditures for these beverages.

The third position suggests that there is a negative relation between tax rates on alcoholic beverages and the various measures of social cost. The time series data, again, fail to support this position. If the consumption behavior of alcoholics can be described by a rightward shift of the linear demand functions discussed above, the price elasticity of their demand is almost zero; in this case, an increase in the tax rates has almost no effect on consumption and only serves to increase their alcoholic beverage expenditure. The third position, even if valid, is a relatively weak case for a general tax on alcoholic beverages, since the large majority of temperate drinkers would be forced to pay a tax designed to restrict the consumption
of the 5 to 10 per cent of drinkers with intemperate behavior. Only the first and second positions provide an equitable basis for the use of a tax to reduce the relevant social costs.

In summary, the taxation of alcoholic beverages may be an effective and satisfactorily equitable instrument to reduce the social costs if these costs are more or less proportionate to consumption at all levels, or if intemperate consumption behavior is closely related to the average levels of consumption. Such taxes may directly reduce the social costs due to intemperate consumption behavior, but the use of the tax system for this purpose is singularly inequitable. One final point is relevant: the use of federal taxes for explicit regulatory purposes, whatever its merits, has sometimes been rejected by the courts as inconsistent with the Constitutional restrictions on the taxing powers of Congress.

Formulation of a Rational Tax Program

A rational tax program based on the social cost argument implies two explicit objectives:

(a) Tax rates should be set at such a level that the prices faced by consumers reflect the true marginal costs (private plus social costs) of their consumption of each beverage.

(b) Total tax revenue should be equal to the estimated total social cost of alcoholic beverage consumption.

Tax rates which meet the first objective minimize the misallocation of resources among products and the inequity among drinkers. Tax rates which meet the second objective minimize the inequity between drinkers and the general population. Of the various tax policies considered in this chapter, only this social cost policy meets either of these objectives.
Only one set of tax rates meets both of these objectives: the tax rate on each beverage which is equal to the marginal social cost of consumption. The critically important problem is to estimate the total social cost of alcoholic beverage consumption and to determine the relation between this cost and the average consumption of each beverage.

Estimates of the total social cost of alcoholism have been prepared by Benson Landis for 1940 and 1946. These estimates include the costs of medical and hospital treatment of alcoholics, losses from accidents and property damage, maintenance of courts and jails, support of the dependents of inebriates, and the potential income losses of the intemperate drinkers. The estimated total cost for 1940 is $779 million and for 1946, $1,168 million (both in current dollars). Only a portion of the income losses representing the loss of tax revenues should properly be included in the estimated social cost, since the loss of disposable income is borne entirely by the drinker and his family. Subtracting 80 per cent of the estimated loss of income reduces the 1940 total to $433 million; a breakdown of the 1946 estimate is not available. One should note, without depreciating the extent of personal tragedy due to alcoholism, that the total social cost of alcoholism, including the full loss of income, was around one-half the total revenues from alcoholic beverages in these years.

As discussed above, a satisfactory relationship between the various measures of social cost and the average consumption of each beverage has not been established. If the relative effect of each beverage on a non-monetary

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measure of social cost can be established, the Landis estimates can be used
to derive a social cost function in monetary terms. Again, without direct
supporting evidence, the alcoholic content of each beverage is used to repre-
sent its relative effect on social cost. Dividing the 1946 estimate, includ-
ing the full income loss, among the three beverages, weighted by their
respective alcoholic content, yields the relation

\[(14.0) \quad C(46) = 2.039 \, Q_s(46) + 0.237 \, Q_b(46) + 0.759 \, Q_w(46),\]

where \(C(46)\) is the total social cost in 1946 and \(Q_s(46)\), \(Q_b(46)\) and \(Q_w(46)\)
are the gallons of each beverage consumed. Use of this relation for a dif-
ferent year assumes a constant relation of the average consumption of each
beverage to the number of alcoholics and a constant relation of the prices
of the components of the social cost estimate to the general price level.
With these two heroic assumptions, the above relation can be considered to
be a social cost function. This function, expressed in 1960 dollars, is
given by

\[(14.1) \quad \hat{C}(t) = 2.942 \, \hat{Q}_s(t) + 0.342 \, \hat{Q}_b(t) + 1.095 \, \hat{Q}_w(t).\]

Since these parameters include the full income loss, this function will
probably overestimate the true social cost, but some margin in this direc-
tion is probably desirable. The parameters of this function, of course,
are the appropriate tax rates. These rates are constant in real terms if
the above assumptions are valid, and, unlike the maximum revenue rates, are
independent of the general demand conditions. A comparison of the rates and
consequences of this policy with those of other policies is discussed in the
next section.
A Recommended Tax Program for Alcoholic Beverages

Three major tax policies have been discussed in this chapter: the actual policy, the maximum revenue policy, and the social cost policy. Table 10 summarizes the consequences of these three policies for the conditions prevailing in 1960.

Table 10

CONSEQUENCES OF THREE TAX POLICIES IN 1960

<table>
<thead>
<tr>
<th>Item</th>
<th>Actual Policy</th>
<th>Maximum Revenue Policy</th>
<th>Social Cost Policy</th>
</tr>
</thead>
<tbody>
<tr>
<td>1960 Dollars per Wine Gallon</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tax rates</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spirits</td>
<td>$11.124</td>
<td>$8.626</td>
<td>$2.942</td>
</tr>
<tr>
<td>Beer</td>
<td>.380</td>
<td>.494</td>
<td>.342</td>
</tr>
<tr>
<td>Wine</td>
<td>.812</td>
<td>2.949</td>
<td>1.095</td>
</tr>
<tr>
<td>Wine Gal per Adult</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Consumption</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spirits</td>
<td>2.178</td>
<td>2.934</td>
<td>4.867</td>
</tr>
<tr>
<td>Beer</td>
<td>25.077</td>
<td>19.502</td>
<td>25.482</td>
</tr>
<tr>
<td>Wine</td>
<td>1.510</td>
<td>.839</td>
<td>1.448</td>
</tr>
<tr>
<td>1960 Dollars per Adult</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Revenues and costs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Revenues</td>
<td>34.983</td>
<td>37.564</td>
<td>24.622</td>
</tr>
<tr>
<td>Social costs</td>
<td>16.640</td>
<td>16.278</td>
<td>24.622</td>
</tr>
<tr>
<td>Loss of consumer surplus</td>
<td>21.966</td>
<td>14.171</td>
<td>--</td>
</tr>
</tbody>
</table>

Tax rates, consumption, and revenue of the actual policy are historical data. If the alcoholic content of each beverage is the appropriate weight in the true social cost function, the actual tax rates are seriously inequitable among drinkers, penalizing spirits relative to beer and wine. Revenues from this policy are over twice the social cost of consumption estimated.
from Eq. (14.1); in this year drinkers as a group contributed a net of $18 per adult to the general revenue. A significant social cost of a different nature is the result of the actual policy — the continued high volume of illegal spirits production. A final consequence, the misallocation of resources, is measured by the estimated loss of consumer surplus resulting from the difference between the actual tax rates and the marginal social cost of consumption. The estimated loss of consumer surplus from the actual policy, a function of the square of the difference in these rates, is around $22 per adult.°

Tax rates of the maximum revenue policy are determined by the procedures outlined earlier in this chapter. For the year 1960 the tax rates of the unconstrained maximum revenue policy are identical to those of the two constrained maximum revenue policies. These rates correspond more closely with the relative social cost of each beverage, but they penalize spirits and wine somewhat relative to beer. With no change in the state tax rates on these beverages, the maximum revenue in this year would be achieved by reducing the federal spirits tax from $10.50 per proof gallon to $8.00, by raising the beer tax from $9.00 per barrel to around $13.00, and by raising the tax on wine from $0.17 per gallon to $1.15 for table wine and from $0.67 per gallon to $3.40 on dessert wine.

Consumption and revenues of the maximum revenue policy are estimated by using the reduced form equations of the alternate model and the corresponding revenue function. This policy would cause a significant change in the mix of

° The loss of consumer surplus is determined from the relation

\[ L = \frac{bc - x^2}{2} \]

where \( L \) is the loss in dollars, \( b \) is the derivative of consumption on the tax rate, \( c \) is the derivative of price on the tax rate, and \( X \) is the tax rate per gallon.
consumption: a 35-per-cent increase in the consumption of spirits, a 22-per-cent decrease in that of beer, and a 41-per-cent decrease in that of wine. The estimated revenues of this policy are around 7.5 per cent higher than the actual revenues for this year. The consumption of alcohol and the corresponding social cost of consumption under this policy would be slightly less than the actual cost; drinkers would contribute a net of $21 to the general revenue. The maximum revenue spirits tax is sufficiently low to eliminate nearly all illegal production. The loss of consumer surplus from this policy is around 35 per cent lower than the actual loss; this increase in allocative efficiency is the result of a reduction of the price on the price elastic beverage and an increase in the prices of the inelastic beverages. The tax burden of this maximum revenue policy may not be considered acceptable since it increases the expenditures and revenues from each beverage, but on other counts this policy is clearly superior to the actual policy.

Tax rates of the social cost policy are equal to the parameters of the social cost function. These rates penalize the consumption of each beverage by the dollar amount of their estimated contribution to social costs. With no change in the state tax rates on these beverages, these rates would be achieved by reducing the federal spirits tax from $10.50 per proof gallon to $1.50, by reducing the beer tax from $9.00 per barrel to $8.00, and by raising the tax on wine from $0.17 to $0.65 for table wine and from $0.67 to $1.00 on dessert wine. A good case could be made for the complete elimination of the federal alcoholic beverage taxes, since the state and local governments support most of the programs to counter or alleviate the social costs of alcoholism. If federal excises are maintained in order to minimize administrative costs, most of the federal revenue should be returned to the states
in proportion to the consumption in each state. Simons' proposal, the "elimination or radical reduction of excise taxes ... in the federal revenue system," was not far off the mark.

Consumption and revenue of the social cost policy are also estimated using the reduced form equations of the alternate model and the corresponding revenue function. This policy would cause a considerable increase in the consumption of spirits — around 125 per cent — and no significant change in the consumption of beer and wine. The spirits estimate may be in serious error since it is considerably outside the range of sample experience, but it is not inconsistent with the consumption experience before national Prohibition. Revenues from this policy are around 30 per cent lower than the actual revenues and are equal to the social costs. One of the necessary consequences of this policy, given that the actual policy yields more revenue than the estimated social costs, is an increase in the social costs of alcoholism — in this case, around 50 per cent. Any increase in these costs will be considered unacceptable by many people, but the equality of public revenues and social costs, if these costs are accurately measured, is the only equitable relation between drinkers and the general population. Only a much higher estimate of social costs — with the difference attributable only to spirits — would justify the actual tax rates. The spirits tax rate of the social cost policy would clearly eliminate any illegal traffic.

The social cost policy, by definition, would minimize the misallocation of resources, since the prices faced by consumers would reflect the true marginal costs of their behavior. The loss of consumer surplus of the actual and maximum revenue policies has, thus, been measured from the rates of the social cost policy rather than from the no-tax condition. With no tax on
alcoholic beverages, drinkers as a group would have a gain of consumer surplus of around $12.00 per adult, but would incur social costs of around $33 per adult on the general population.

A long-run tax program for alcoholic beverages must be based on more accurate and current estimates of the total social cost and a much deeper understanding of the relation between these costs and the consumption of each beverage. When such estimates are available a set of tax rates can be determined which are constant in real terms and invariant to the levels of demand; revenues from these taxes will increase by an amount equal to the increase in social costs. Until such estimates are available, the analysis of this chapter should be regarded as suggesting the directions for change rather than the precise characteristics of the long-run program. With this caveat in mind, the analysis of this chapter suggests the following tax policies for alcoholic beverages:

(a) Reduce the federal excise on spirits in one step to $6.00 per proof gallon. If subsequent experience confirms the consumption and social cost relations used in this analysis, a second reduction of the federal excise to $1.50 per proof gallon is indicated.

(b) Do not change the present federal excise on beer. This rate is sufficiently close to the indicated marginal social cost until better evidence of these costs is available.

(c) Increase the federal excise on table wine to $0.65 per gallon and on dessert wine to $1.00 per gallon.

(d) Change the alcoholic beverage tax rates only when the unit costs of the items in the social cost estimate change or when a new relation between the social costs and consumption is established. These rates should not be changed as a consequence of a change in the level of demand.
(e) Revenues from both federal and state alcoholic beverage taxes should be used only for such public programs as alcohol education, the care and treatment of alcoholics, the support of the dependents of alcoholics, and some part of the costs of the courts, jails, and police system. Any significant diversion of revenue from the alcoholic beverage taxes to the general fund or to special funds not related to the social costs of alcoholism creates special interests which prohibit rational discussion of the tax program.

An increase in the number of intemperate drinkers and the social costs of their behavior would undoubtedly result from these changes. For many years, however, consumers of alcoholic beverages have paid far more into the public treasuries than the highest estimates of these costs. Only when these costs are fully recognized and consumers face the true costs of their behavior will a free society make the correct choices.